Poles

Post Implementation Review

Part of Energy Queensland

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DOCUMENT VERSION

Version Number	Change Detail	Date	Updated by
Draft V0.1	Draft	01/09/2023	Engineer Asset Strategy
Draft V4	Draft review post feedback	30/10/2023	Snr Engineer Asset Strategy
V1.0	Finalised	15/11/2023	Manager Asset Strategy

RELATED DOCUMENTS

Document Date	Document Name	Document Type
DEC 2018	EQL SASP AMP Poles and Lattice Towers 21122018 Public Approved	PDF
NOV 2023	Pole Risk modelling	Docx & Excel
NOV 2023	Poles CBRM/CNAIM Model Rcode	Excel
JUN 2023	RIN 2.2 Compare 2021-22 (Rosetta)	Excel
NOV 2019	Ergon 2018-19 - Category Analysis - RIN Response - Consolidated - 6 November 2019 - PUBLIC D19-174436(v2)	Excel
AUG 2023	Maintenance Activity Frequency (MAF) – Release 2	PDF
JUN 2023	Maintenance Acceptance Criteria (MAC) – Release 11	PDF
OCT 2023	Lines Defect Classification Manual	PDF
JUL 2023	Substation Defect Classification Manual	PDF
OCT 2023	Australian Government, Department of the Prime Minister and Cabinet (Office of Best Practice Regulation) – Best Practice Regulation Guidance Note - Value of a Statistical Life:	PDF
ND	Australian major natural Disasters.xlsx (a compendium of various sources)	Excel

1 SUMMARY

Title	Pole Replacements – Post Implementation Review (PIR)
DNSP	Ergon Energy Network
Expenditure category	☒ Replacement ☐ Augmentation ☐ Connections ☐ Tools and Equipment ☐ ICT ☐ Property ☒ Fleet
Purpose	The purpose of this Post Implementation Review (PIR) is: • to evaluate the benefits of the change to our serviceability calculation that has resulted increased volume of Pole replacements implemented since 2018-19 • to support the ex-post review of Ergon's capital expenditure over the review Period (2018-19 to 2022-23) via a cost benefit analysis.
Identified need	☒ Legislation ☒ Regulatory compliance ☒ Reliability ☐ CECV ☒ Safety ☒ Environment ☒ Financial ☐ Other Ergon Energy is committed to adopting an economic, customer value-based approach when it comes to ensuring the safety and reliability of the network. To demonstrate the advantages of this approach for the community and businesses over the modelling period, we have employed Net Present Value (NPV) modelling. This commitment is in line with our efforts to maximise the value for our customers. Ergon Energy has a regulatory obligation as outlined in the Electrical Safety Code of Practice (ESCOP) Section 5.1 that states "An electricity entity should have a maintenance system that achieves a minimum three-year moving average reliability against the incidence of failure of 99.99 per cent a year. Special consideration should be given to Poles in areas of higher risk, such as cities and towns. In 2018-19, we observed these failures were increasing and we implemented a change to our serviceability calculation to maintain our performance against this requirement. A cost benefit analysis has been conducted to confirm that the volume of Pole replacements are prudent capital investments.
Alternate options	Four alternative replacement/ reinforcement options were evaluated and compared to the counterfactual (the Australian Energy Regulator (AER) Final Determination – Avg 7,450 Poles/year): 1. Historical volume (Continuation with old serviceability calculations) – Avg 8,044/yr. 2. Health Index Based Replacement (HI >=7.5) – Avg 13,250/yr. 3. AER REPEX Live Scenario Average age of 76 years – Avg 11,350/yr. 4. Actual Delivery (Defect based) – Avg 13,610/yr.

Expenditure	The expenditure presented in this PIR relates to the actual investment undertaken to replace/reinforce defective Poles and includes any replacements to structures and equipment on those Poles that occurred because of the replacement of the defective Poles. Consequential replacements of non- defective Poles with other programs, such as reconductoring, are not included in this PIR, and will be included in the PIR relating to those asset classes.

Yearly Direct Expenditure $m nominal	2018-19 $m	2019-20 $m	2020-21 $m	2021-22 $m	2022-23 $m	Total $m
RIN Total Pole Program (defect + non defect)	56.6	94.6	101.9	94.9	104.6	452.7
Total Pole (defect only)* (repl + nail)	40.7	64.2	65.0	68.1	82.5	320.5
Pole Top Consequential Replacement*	14.4	19.9	21.3	24.0	28.1	107.7
Services Consequential Replacement*	1.9	5.6	4.4	5.0	6.4	23.3
Pole Transformer Consequential Replacement*	7.8	17.5	10.4	14.1	11.0	60.8
Switch Consequential Replacement*	3.7	3.2	3.0	2.7	1.8	14.4
Total Cost Benefit Investment (Defect Pole + Consequential)	**68.5**	**110.4**	**104.1**	**113.9**	**129.8**	**526.7**
Cost Benefit Investment (2022/23 real $)	**80.7**	**129.1**	**117.5**	**19.4**	**129.8**	**576.5**
Fuse Consequential Replacement*	2.1	6.1	5.1	5.2	3.7	22.2
PIR Total Investment (Defect Pole + Consequential)	**70.6**	**116.5**	**109.2**	**119.1**	**133.5**	**548.9**
PIR Total Investment (2022/23 real $)	**83.2**	**136.2**	**123.3**	**124.8**	**133.5**	**601.0**

** Expenditure considered under this PIR*

Benefits	This current rate of Pole replacements/reinforcement of around 13,610 Poles per year (average) provide a positive NPV of $576 million over a modelling period of 20 years in comparison to counterfactual option based on AER Final Determination forecast annual volume of 7,450 Poles. The current delivery program is the optimal solution for Ergon Energy to transition towards achieving a minimum three-year moving average reliability against the incidence of failure of 99.99% a year. ***Note****: The models using 2022/23 real $.*

2 PURPOSE AND SCOPE

The purpose of this Post Implementation Review (PIR) is to evaluate the benefits of the change to our serviceability calculation that has resulted in an increased volume of Pole replacements and reinforcements since 2018-19. This review explores the actual replacements and reinforcements we undertook, and the possible alternative options we could have undertaken. A financial NPV modelling to evaluate and compare alternative options was used to validate that the expenditure incurred has been prudent.

This review covers both the costs and benefits directly associated with defective Poles as well as the cost and benefits for the replacements of Pole-top structures, service lines, transformers and distribution switchgear that occurred while replacing these defective Poles. Costs and benefits of Pole replacements that occurred as a part of other projects or programs, such as reconductoring, are included in their respective PIR.

An independent expert reviewer EA Technology was commissioned to evaluate the effectiveness of Ergon Energy's Pole serviceability calculation methodology. The review focused on data collection through to Pole serviceability rating calculations with the goal of identifying ways in which the process can help reduce unassisted Pole failures by accurately assessing a Pole's ability to withstand its design loadings. The review confirms the following:

Pole assessment serviceability calculation used is consistent with world best practice.

The Pole assessment methodology and active Pole replacement to reduce the unassisted Pole failure rate are a necessary response for Ergon Energy to fulfil its obligation set out in the Electrical Safety Act (Qld).

This document is to be read in conjunction with the Poles and Lattice Towers Asset Management Plan.

3 BACKGROUND

In response to an increasing number of unassisted Pole failures, a review of Ergon's asset management practice was undertaken to ensure alignment to good industry practice and to identify improvement opportunities. In relation to Pole replacements, the quality of data capture, Pole inspection practice and data systems were found to be areas for improvement.

In addition, it was identified that the low number of replacements/reinforcements during the 2010-15 period has caused a significant increase in the number of unidentified poor condition Poles which has led to an increase in failure rates. Accordingly, Ergon Energy reviewed the Pole inspection criteria, assessment processes and methodologies to ensure that they aligned with industry best practice and were accurate and reliable to provide maximum value to customers.

The review identified some deficiencies in the serviceability calculation of residual Pole strength. This resulted in that some Poles at or past the end of their serviceable life were not being identified for remediation, leading to increased unassisted failures. To meet Australian standard AS/NZS7000:2016, improved serviceability calculations and minimum strength criteria were developed and implemented to improve the identification of unserviceable Poles. Upon completion of the review we, implemented the following:

- Reduced the Pole inspection cycles of six and eight years to five years. This is in alignment with the legislative requirement to identify defects early.
- Improved field staff training in data capture and collection.

- Improved Pole serviceability calculations which increase the accuracy in the estimation of residual Pole strength, the classification of unserviceable Poles and the estimation of Pole health and probability of failure in current and future years.

These actions have resulted in higher Pole replacement/reinforcement volumes than historic levels due to timely identification of defects that could result in unassisted in-service failures. Encouraging sign of the higher replacements is demonstrated by the flattening out of the failure curve between 2020 and 2023.

3.1 Asset Population

In 2018-19, Ergon Energy Pole population was 968,754 including 862,402 wood Poles of which 144,220 Poles were over 50 years of age, and 49,834 Poles were over 60 years of age.

Figure 1 shows the age profile of the Pole population.

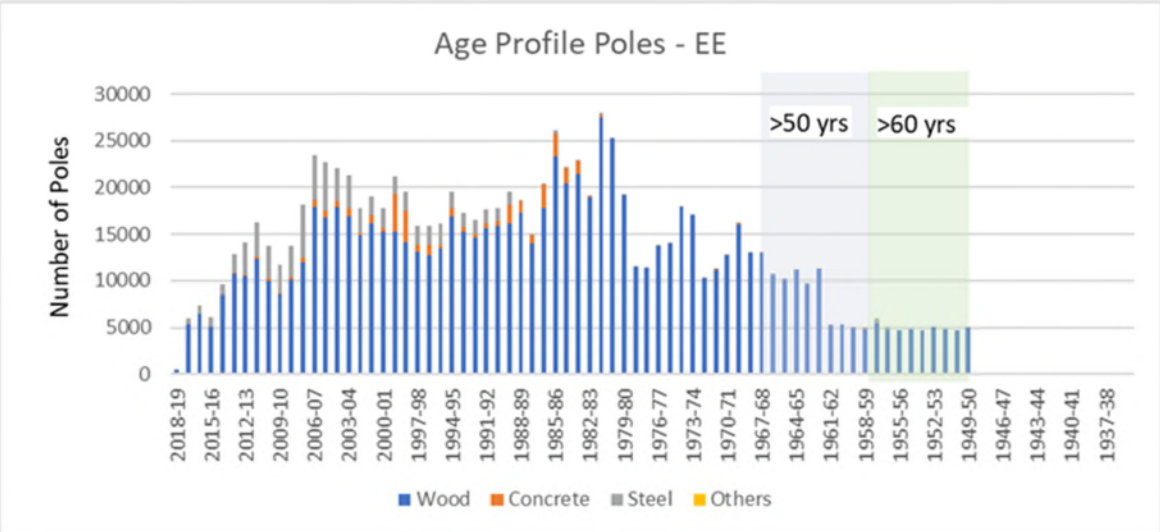

Figure 1: Age Profile – Poles

3.2 Asset Management Overview

Poles are very high volume, relatively low individual cost asset, and are managed on a population basis through periodic inspection for condition and serviceability. Poles are currently inspected and tested every five years and assessed for serviceability based on clear criteria set out in the Network Schedule of Maintenance Activity Frequency Master 2024-25 in compliance with our Poles and Towers Asset Maintenance Strategy. Pole serviceability is driven by well-established inspection programs which identify severe structural strength degradation. Structural strength is determined in accordance with AS/NZS7000:2016.

All the Poles reinforced or replaced are based on their condition failing to meet the acceptance criteria through visual inspection assessment or serviceability calculation and are classified as defective as per descriptions in Standard for Classifying the Condition of Network Assets. Pole reinforcement by nailing/staking is considered effective to prevent failure and replacement due to decay caused by the soil and hostile ground conditions and hence providing a life extension of 10-

15 years. Under the Electrical Safety Code of Practice 2020 Works, Poles identified as defective require rectification with standard timeframes as set out in Section 5.3.4 of the ESCOP.

This post implementation review relates only to Pole replacements / reinforcements based on serviceability criteria identifying imminent failures, with the objective of reducing Pole failures to below the ESCOP limits. Replacement of non-defective Poles is also undertaken with other work such as feeder reconductoring programs which allow for bundling of work into logical groups for efficiency of delivery and cost. Replacement work practices are optimised to achieve bulk replacement to minimise overall replacement expenditure and customer impacts. These replacements are captured and justified in the relevant PIR for the primary assets being replaced, such as conductor replacements.

3.3 Asset Performance

The two main functional failures considered in this PIR and the associated modelling are defined in Table 1.

Functional Failure Type	Description
Catastrophic **(Unassisted Failure)**	Loss of structural integrity of a Pole, excluding any associated hardware or crossarm mounted plant, such that the residual strength of the component required immediate intervention. Functional failure of this asset under normal operating conditions not caused by any external intervention such as abnormal weather or human.
Degraded (**Defect**)	A Pole asset deemed defective based on serviceability calculation criteria and if not rectified within a prescribed timescale (P0/P1/P2) could cause to an unassisted catastrophic failure.

Table 1: Description of Functional Failure

Identified defects are scheduled for repair according to a risk-based priority scheme (P0/P1/P2/C3/no defect). The P0, P1 and P2 defect categories relate to priority of repair, which effectively dictates whether normal planning processes are employed (P2), or more urgent repair works are initiated (P1 and P0) in compliance to Electrical Safety Code of Practice 2020.

Internal and external rot decay and termites are the most common cause of deteriorated Pole condition defects, leading to loss of strength in the timber. If left unaddressed eventually these defects will cause an unassisted failure of the Pole.

Figure 2 depicts the number of unassisted Pole failures since 2015-16. The data indicates high number of failures around 100 per year with some yearly fluctuations.

Historical failure volumes have been back cast due to improved analysis of failure data, improved delineation between unassisted and assisted failures and more thorough investigation processes.

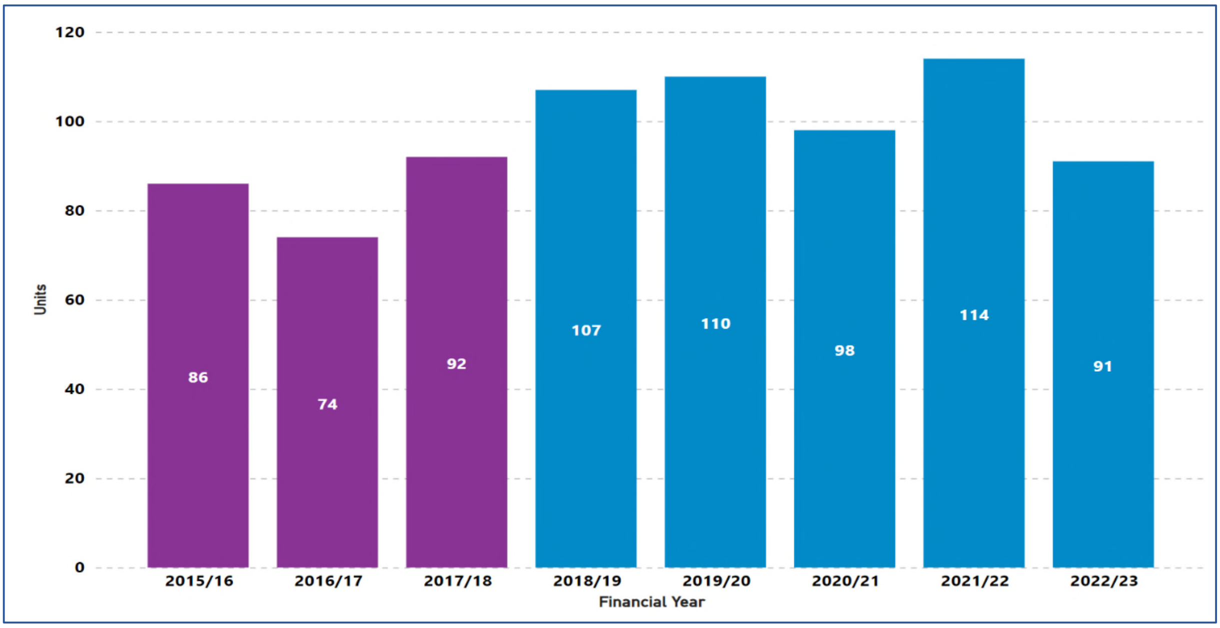

Figure 2: Unassisted Pole Failures

The defect data in Figure 3 indicates a continuous increase since 2015-16 with a step-up increase in 2016-17 followed by another step change in 2019-20 and remaining consistent during last four years, with marginal increases though. The initial increase is attributed to improved data recording during that period. The step change in 2019-20 was driven by the serviceability calculation change.

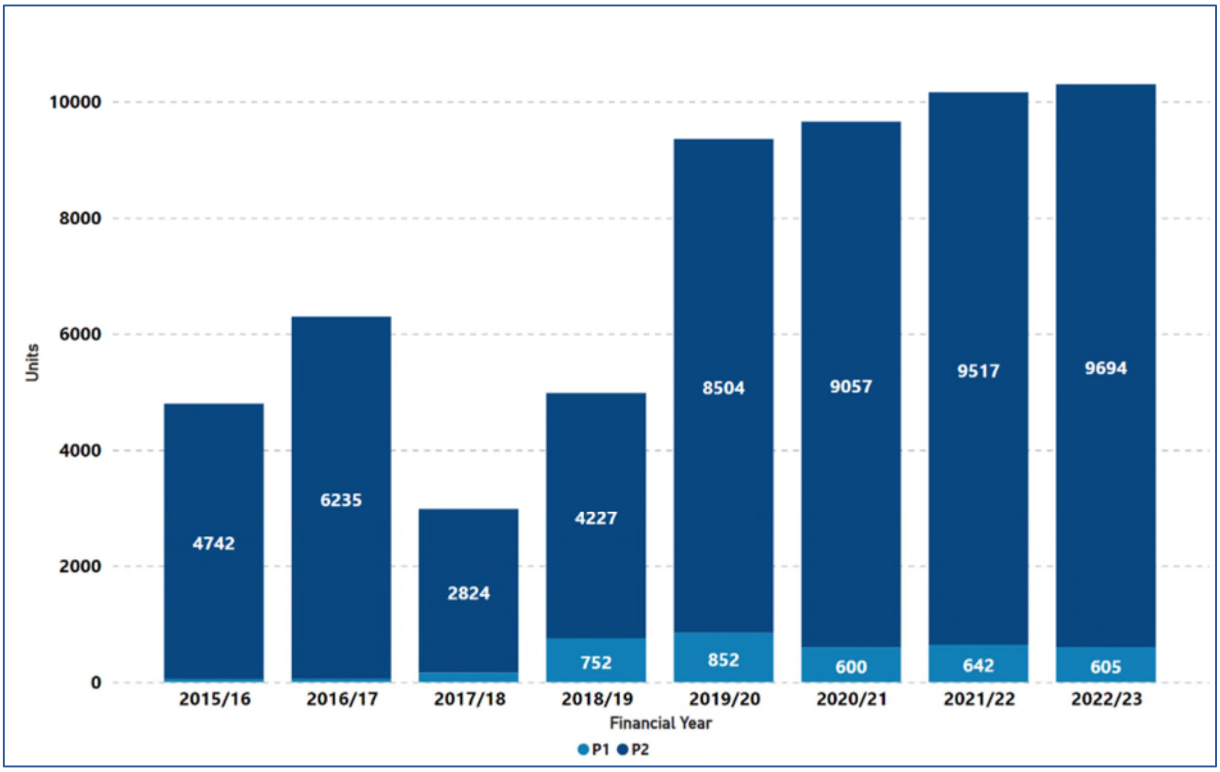

Figure 3: Pole Defects

4 RISK ANALYSIS

In evaluating the risks associated with our Pole assets, we model each Pole individually, with location and condition data specific to each Pole, while also factoring to the extent possible other factors such as the electrical load the feeder the Pole support carries and locational factors that are important to outcomes from an unassisted Pole failure.

Our cost benefit analysis is aimed at calibrating our serviceability calculation at the program level, so that on average we will be able to maximise the benefits to customers. As such, following the cost benefit analysis through NPV modelling, the most positive NPV of the volumes considered will form the basis for selecting the preferred option about reinforcement/replacement. In the case of this PIR, the most positive NPV validates the volume of reinforcement/replacement undertaken over the review period is a prudent approach.

The monetised risk calculation is outlined in Figure 4.

Figure 4: Monetised Risk Calculations

Ergon Energy broadly considers five value streams for investment justifications regarding replacement of widespread assets as shown in Figure 5.

For Pole replacements, four of the value streams are considered; the ‘Export’ is not material to Pole replacements and hence not considered further.

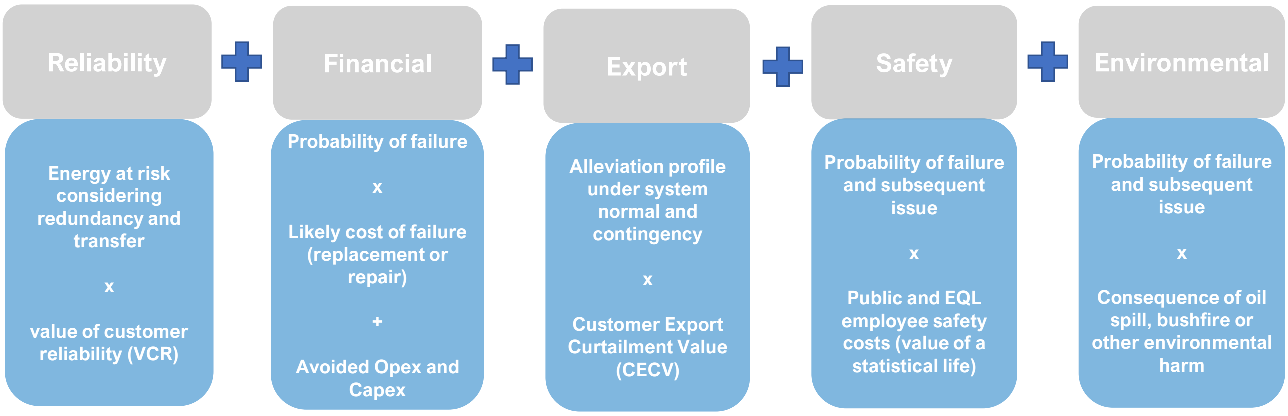

Figure 5: Total Risk Cost Calculation

4.1 Health Index and Probability of Failure (PoF) - Poles

Ergon Energy utilises EA Technology’s Condition Based Risk Management (CBRM) and Common Network Asset Indices Methodology (CNAIM) principles to determine the condition of our Pole population. These models utilise condition data such as observed ground level deterioration and Pole rot condition and measured condition data such as strength ratio and sound wood measurement to determine the Health Index (HI) of a Pole asset. The condition data is collected through our inspection program.

Each Pole in our population has an individual HI score, which means that the type of Pole, location and condition is factored into the HI calculations.

Condition based risk management model combines asset information, engineering knowledge and practical experience to define the current and future condition and performance for network assets as shown in Figure 6 and Figure 7 below. The HI is calculated on a scale of 0 to 10 which represents the extent of condition degradation:

- 0 indicating best condition or a new Pole.
- 10 indicating the worst condition.

The relationship between HI and PoF is not linear, an asset can accommodate significant degradation with very little effect on the risk of failure. Conversely, once the degradation becomes significant or widespread, the risk of failure rapidly increases. A HI of 7.5 is typically used as the point at which assets are identified as candidates for requiring an intervention.

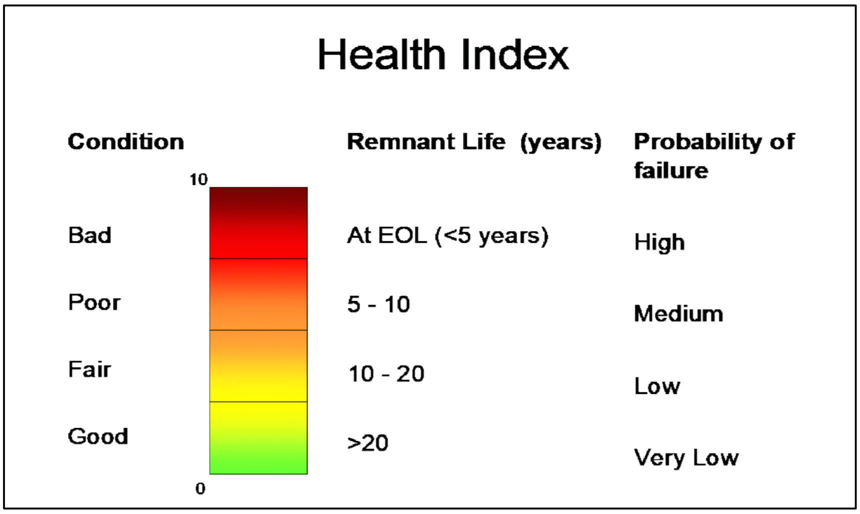

Figure 6: PoF/HI Relationship

Figure 7 shows the typical graphical relationship between HI and PoF in our CBRM model.

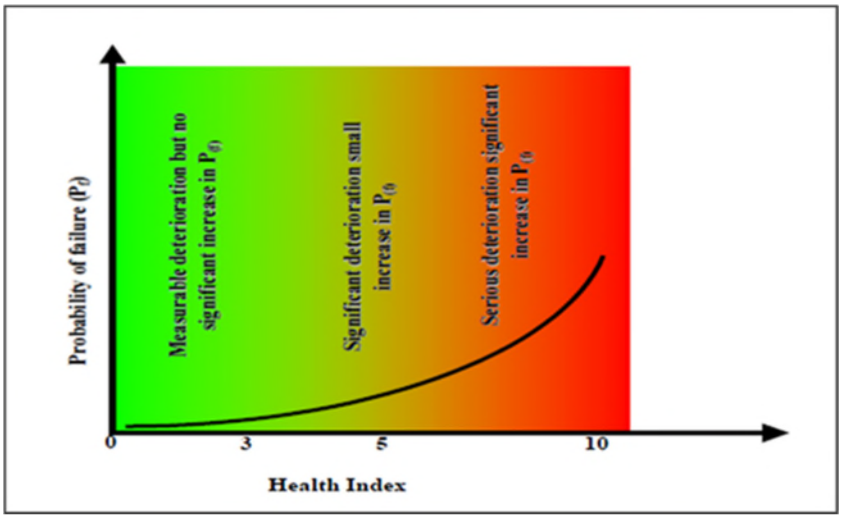

Figure 7: Health Index and PoF Relationship Graph

The current HI for Ergon Energy’s wood Poles is shown in Figure 8.

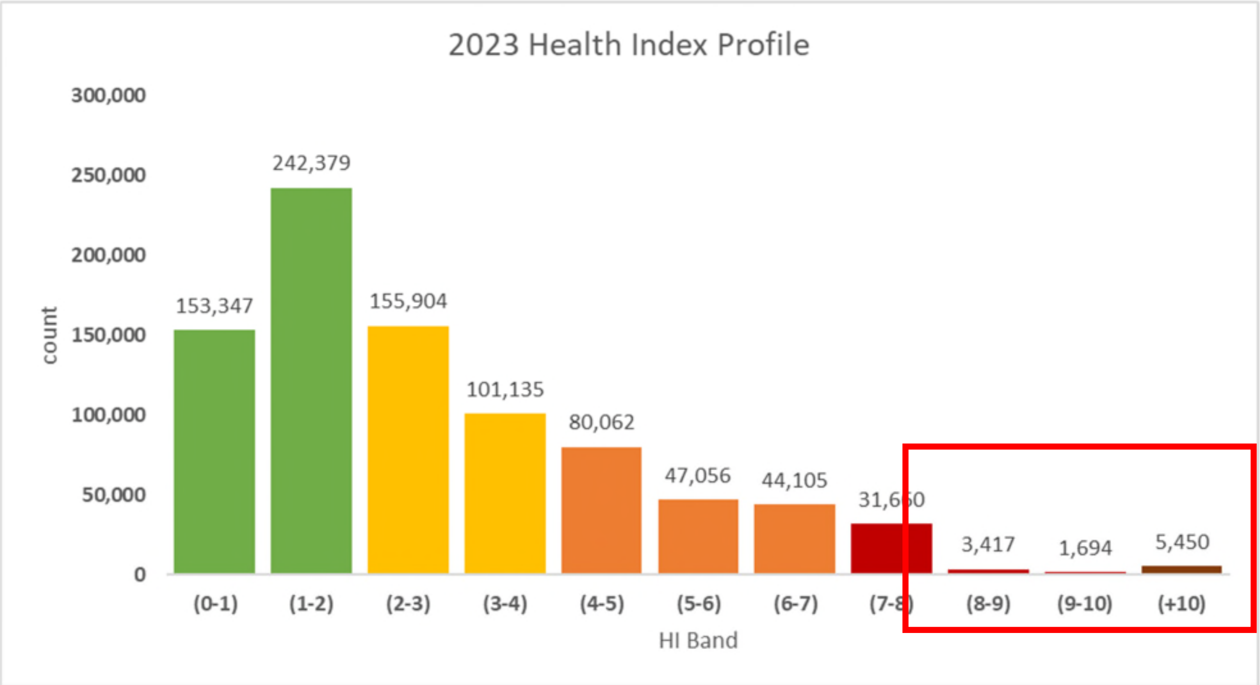

Figure 8: Current HI Profile for Wooden Poles

Figure 8 illustrates that approximately 26,400 Poles are assessed with a HI of over 7.5, based on the condition-based asset health indices model. Typically, an asset requires an intervention when the health index is greater than 7.5, however our cost benefit analysis for various replacement options has been taken on a range of HI value to ensure that we maximise the value to customers from our intervention levels and chosen option.

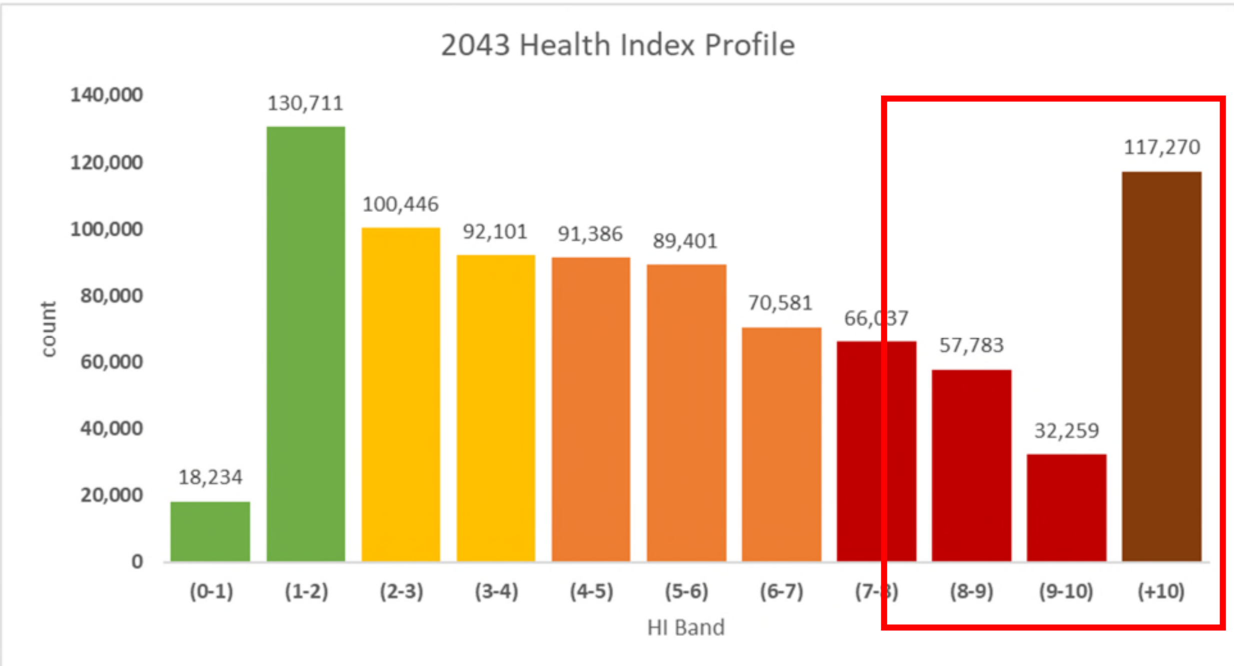

Figure 9: Future HI Profile for Wood Poles

Based on the 20-years cost benefit analysis period, a forecast HI was developed for the Pole population in 2043 if there were no interventions taken. Figure 9 shows that in 2043 approximately 265,000 Poles are forecast to exceed a HI of 7.5 with no intervention including a few Poles sitting at threshold. To avoid this outcome, an average of 13,250 Poles per year would require an intervention over the next 20 years. This closely aligns with the current rate of our intervention program.

4.2 Consequence of Failure (CoF) and Likelihood of Consequence (LoC)

The key consequence of Pole failures that have been modelled are reliability, financial, safety and environmental. The CoF refers to the financial or economic outcomes if an event were to occur.

The LoC refers to the probability of a particular outcome or result occurring because of a given event or action. To estimate the LoC, Ergon Energy has utilised a combination of historical performances and researched results. Ergon Energy has analysed past events, incidents, and data to identify patterns and trends that can provide insights into the likelihood of similar outcomes occurring in the future. Additionally, Ergon Energy also has conducted extensive research to gather relevant information and data related to the respective risk criteria such as bushfire.

To the extent possible the CoF and LoC are Pole specific. This is particularly the case for the reliability and benefits stream, where the site-specific load and bushfire risk informs the benefits calculations for preventing unassisted Pole failures.

4.2.1 Reliability

Reliability represents the unserved energy cost to customers of network outages and is based on an assessment of the amount of Load at Risk during three stages of failure: fault, initial switching, and repair time. The following assumptions are used in developing the risk cost outcome for a Pole failure:

- **Lost load:** Each Pole in our network is modelled individually, with the relationship developed between a Pole and the feeder that it is connected to. The historical average load on each feeder in our network is utilised to determine the kW that would on average be lost following a Pole failure. We have utilised half of the historic average load on the feeder, which represents the most likely outcome, as the data regarding the exact electrical location of the Pole in a feeder is not available.
- **Load transfers and Restoration timeframe:** the average loss of supply has been estimated for a period of average 6 hours to 24 hours based on the locality, with respective staged restoration periods, on the basis of historical data for outages/durations. This is based on the average load on our fleet of feeders, divided under five categories from ‘Rural Short, rural long, urban, sub-transmission and transmission in between.
- **Value of Customer Reliability Rate:** We have used the Queensland average VCR rate.
- **Probability of Consequence:** all in-service Pole failures result in an outage to customers.

4.2.2 Financial

Financial cost of failure is derived from an assessment of the likely replacement costs incurred by the failure of the asset, which is replaced under emergency. The following assumptions have been used in developing the financial risk costs for a Pole failure:

- **Pole replacement:** different unit cost of Pole replacement has been taken based on voltage level and type of Pole varying approximately between nominal 5 years average $5,400 (LV Pole) to $11,600 (sub-transmission).
- **Pole Reinforcement:** Unit cost of Pole reinforcement (nailing) has been taken as nominal 5 years average $1,843 per Pole.
- **Pole Nailing:** has been assumed as 30% of total Pole remediation program (Replacement + Reinforcement) for modelling purposes.
- **Probability of Consequence:** all in-service Pole failures result in a need to replace the Pole under emergency.

4.2.3 Safety

The safety risk for a Pole failure is primarily that a member of the public is in the presence of a fallen conductor which was caused by Pole failure. This could result in a fatality or injury. For our modelling we have used October 2023 published document from *Australian Government, Department of the Prime Minister and Cabinet (Office of Best Practice Regulation)* – Best Practice Regulation Guidance Note - Value of a Statistical Life:

- Value of a Statistical Life: $5.4m
- Value of an Injury: $1.35m
- **Disproportionality Factor:** 6 for members of the public.
- **Probability of Consequence:** Following an unassisted Pole failure, there is a 0.05 chance of causing a fatality and 0.15 chance of a serious injury based on historical data evidence. The average number of safety incidents has been derived by analysing 20 years of Significant Electrical Incident data comprising 4 incidents where unassisted Pole failure has driven a safety incident of the appropriate severity.

4.2.4 Environmental - Bushfire

The value of a Bushfire Event consists of the safety cost of a fatalities and the material cost of property damage following a failed Pole causing downed conductor and fire. For our modelling we have used:

- **Value of Bushfire:** $22.3m – which includes average damage to housing and fatalities following a bushfire being started. In Queensland *as per Australian major natural Disasters.xlsx (a compendium of various sources)*, there were 122 homes lost and 309 buildings lost during bushfires between 1990 and present (2021) across 12 significant fire records. Homes were estimated an average cost of $400,000 while the buildings were estimated at an average cost of $80,000. The weighted average cost of bushfire consequence per Pole has been estimated as $6,765.
- **Safety Consequence of bushfire -** Safety consequences are evaluated on same assumptions as safety incident consequence in 4.2.3 with a frequency of 0.5 per incident as there has been six fatalities recorded across those 12 bushfire incidents in Queensland.

- **Probability of Consequence:** Following the failure of a Pole, we have estimated that there is a 0.0260 chance of causing a fire. This is based on a historical full year when there were 22 fires recorded due to electrical asset failures in Ergon Energy. In that year there were 114 Pole failures, 265 cross-arm failures and 467 conductor failures that had potential to cause fire ignition, giving a probability of 0.0260 (22/846). Also, bushfire consequence weighting and probability of containing/non-containing the fire has been incorporated into calculations along with % number of days considerations during no-forecast to extreme/catastrophic danger rating forecasts.

5 CONSEQUENTIAL REPLACEMENT

Following the identification of a defective Pole, we also conduct an evaluation of the condition of the equipment affixed to the Pole and determine whether it is feasible and cost-effective to replace them. This equipment encompasses crossarms, transformers, service lines, and switches. Please refer to Table 4 in Section 5.1 for further details on benefit assumptions. When evaluating the advantages of this approach for our customers, in the cost-benefit analysis that considers the replacement of these equipment as an integral part of Pole replacement. In other words, we have factored in the investments and benefits associated with these consequential replacements into the analysis to ensure that the overall replacements are factored into the analysis. Table 2 provides the consequential asset volume replaced under Pole replacement program under the Actual Delivery Option.

Actual Delivery Consequential Replacement Volume	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Pole Top	6,690	9,714	7,719	8,619	8,445	41,187
Services	2,427	4,861	2,904	3,181	4,366	17,739
Pole Transformer	266	608	431	473	264	2,042
Switch	395	309	310	296	371	1,681

Table 2: Consequential Asset Volume – Actual Delivery

In undertaking a comparison between the alternative options to our actual delivery, we have utilised the same ratios of replacement of the items listed in Table 2. Accordingly, a ratio table has been used as summarised in Table 3 to determine the volumes for other options.

Actual Delivery Consequential Ratio Table	2018-19	2019-20	2020-21	2021-22	2022-23
Pole Top	1.20	0.94	0.73	0.79	0.80
Services	0.43	0.47	0.27	0.29	0.41
Pole Transformer	0.05	0.06	0.04	0.04	0.02
Switch	0.07	0.03	0.03	0.03	0.03

Table 3: Consequential Asset Replacement Ratio

5.1 Benefit Assumptions

In accounting for the costs and benefits from the consequential of replacement of switchgear, Pole top structure and transformer and services with replacement of a defective Pole, we have utilised our cost benefit modelling outlined in the PIRs for each of these four asset categories.

We acknowledged that the consequential replacement of the four asset categories is an "advancement" or brought forward of the replacement of the assets than would otherwise be required later. An estimate of the already used service life of these assets at the time the replacement is provided in Table 4.

Consequential Replacement Asset Description	Average failure age in Years as per Weibull Analysis	Estimated Average Age at Pole replacement time (at 58 year)	% Life already Used at Pole replacement time	% Remaining Life at Pole replacement time
Pole Top Structure	41.5	16.5	40%	60%
Services	37	21	57%	43%
Pole Transformers	33	25	76%	24%
Switches	21	16	76%	24%

Table 4: Expected Used life of Consequential Assets

As can be seen in Table 4 above, the remaining life of the various asset categories ranges from 24 percent to 60 percent. However, our conservative approach is to assume that all the consequential assets are replaced at 75% of remaining life. On that basis, we allocate 25% of the benefits as identified in the PIR for these consequential assets. This is likely to understate the benefits that our customers will see from these consequential replacements.

The following are assumptions used in the analysis of NPV of consequential replacements:

- Estimated average age of Pole at the time of replacement is 58 years.
- Allocate 25% of the average benefit of replacement of these assets as the benefits attributable to replacing these assets with our defective Poles.
- Consequential benefits only applicable to Pole replacement and not for Pole reinforcements.

Additionally, fuse replacements are required during distribution transformer replacements. While there are additional costs associated with fuse replacements, there are no additional benefits. As all the options will have a similar cost impact, fuse replacement costs have been excluded from the NPV analysis.

6 IDENTIFIED NEED

6.1 Problem Statement

From 2015 onwards, Ergon Energy experienced an increasing level of unassisted Pole failures. As a result, we reviewed our asset management practices with respect to Poles. Following the extensive analysis undertaken through this review, it was identified that our serviceability calculation needed to be changed to better reflect the likelihood of our Poles failing in-service. It also identified a need to change our inspection frequency to five years. This has resulted in an increased rate of Pole defects being identified through our inspection and maintenance process, resulting in an increase in Pole replacements.

This PIR looks back at this level of replacement and evaluates the benefits to customers from these replacements. Other options that would have been available at the time are identified and benefits evaluated and compared to demonstrate the prudency of our approach.

The purpose of this PIR is to ensure that we delivered the maximum benefits to customers through ensuring the right level of investment was undertaken to efficiently limit the reliability, safety, environmental and financial risks from Pole failures.

6.2 Compliance

Ergon Energy's Pole assets are subject to several legislative and regulatory standards. While many are general in nature, the key regulatory obligation for Poles that has specific targets is the Queensland Electrical Safety Code of Practice 2020 Works (ESCOP). The key relevant clauses are:

- ESCOP s5.1 - An electricity entity should have a maintenance system that achieves a minimum three-year moving average reliability against the incidence of failure of 99.99 per cent a year.
- ESCOP s5.2.1 – each Pole should be inspected at intervals deemed appropriate by the entity. In the absence of documented knowledge of Pole performance, Poles should be inspected at least every five years.
- ESCOP s5.3.4 – a suspect Pole must be assessed within three months; an unserviceable Pole must be replaced or reinstated within 6 months.

With a Pole population of 968,754 Poles and towers, including 862,402 wood Poles, we are required to limit our rolling three-year unassisted Pole failure rate to below 97 per annum to meet the ESCOP target of 99.99%.

Figure 10 shows the number of unassisted Pole failures we have had over the last eight years.

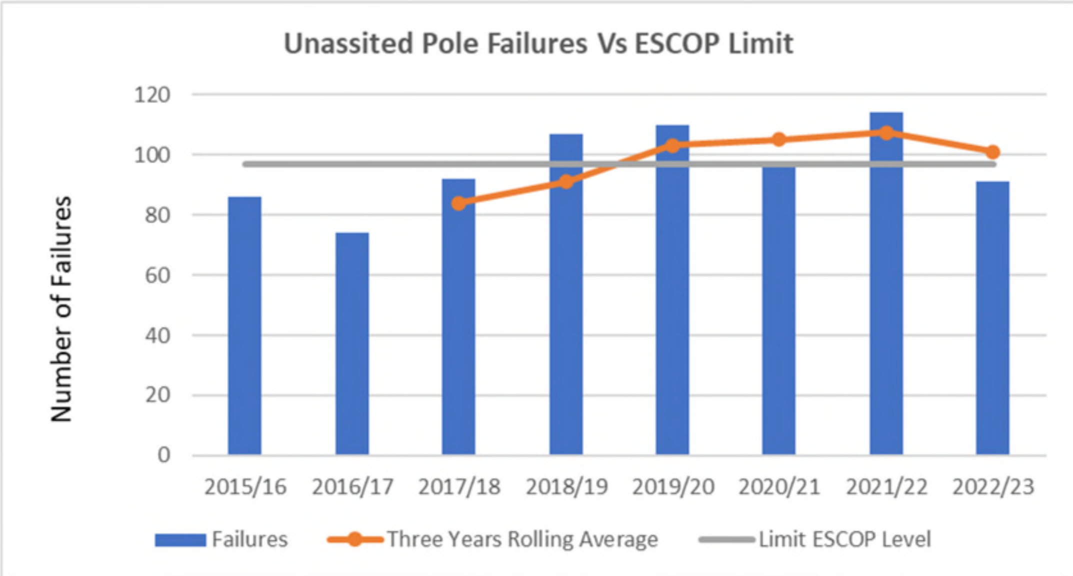

Figure 10: Unassisted Pole Failures Vs ESCOP Level

Figure 10 shows that from 2015-16 to 2022-23 we have had an increasing unassisted Pole failure rate. While there will be fluctuations year on year, we are encouraged to by the significantly low failure rates of 2022-23 and the flattening of the 3-year rolling average failure rate. This trend towards the ESCOP level can be attributed to the increase in our Pole replacements driven by the change in serviceability calculation.

6.3 Counterfactual (Base Case Scenario) – AER Final Determination

To provide a comparison of the potential alternatives to our actual delivery for our cost benefit analysis, we have set the counterfactual to AER Final Determination on volumes for Pole replacement/reinforcement program estimated using final determination Pole repex forecast divided by actual unit cost.

6.3.1 Costs/Volumes

The replacement volumes and costs that have been modelled under this approach are outlined in Table 5 and Table 6.

Counterfactual Volume Pole and Consequential Replacement	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Pole Replacement & Reinforcement	**6,366**	**6,901**	**7,443**	**7,992**	**8,550**	**37,252**
Pole Replacement	5,319	4,644	5,207	5,422	6,101	**26,693**
Pole Reinforcement	1,047	2,257	2,236	2,570	2,449	**10,559**

Pole Top (Consequential)	6,799	4,128	3,833	4,323	4,913	**23,996**
Services (Consequential)	2,466	2,066	1,442	1,595	2,540	**10,110**
Pole Transformer (Consequential)	270	258	214	237	154	**1,134**
Switch (Consequential)	401	131	154	148	216	**1,051**

Table 5: Counterfactual - Replacement Volume

Counterfactual Direct Expenditure (nominal $) **Pole and Consequential**	**2018-19 $m**	**2019-20 $m**	**2020-21 $m**	**2021-22 $m**	**2022-23 $m**	**Total $m**
Pole Replacement	**32.3**	**34.9**	**36.8**	**38.8**	**43.1**	**185.9**
Pole Top (Consequential)	14.6	8.4	10.6	12.0	16.4	**62.0**
Services (Consequential)	1.9	2.4	2.2	2.5	3.7	**12.7**
Pole Transformer (Consequential)	7.9	7.4	5.2	7.1	6.4	**34.0**
Switch (Consequential)	3.8	1.4	1.5	1.3	1.0	**9.0**
Consequential Total	**28.2**	**19.6**	**19.5**	**22.9**	**27.5**	**117.7**

Table 6: Counterfactual - Replacement Expenditure

6.3.2 Risk Quantification

Utilising the modelling approach outlined in Section 4.2, Ergon Energy has determined the risk values for a twenty-year time horizon as a period representative of the expected period of realisable benefits from any interventions. The forecast for Pole failures under this scenario shown in Figure 11. The forecast indicates that this scenario is inadequate to bring down the failure rate in the near future leaving continued non-compliances to ESCOP levels and compromising public safety and network reliability.

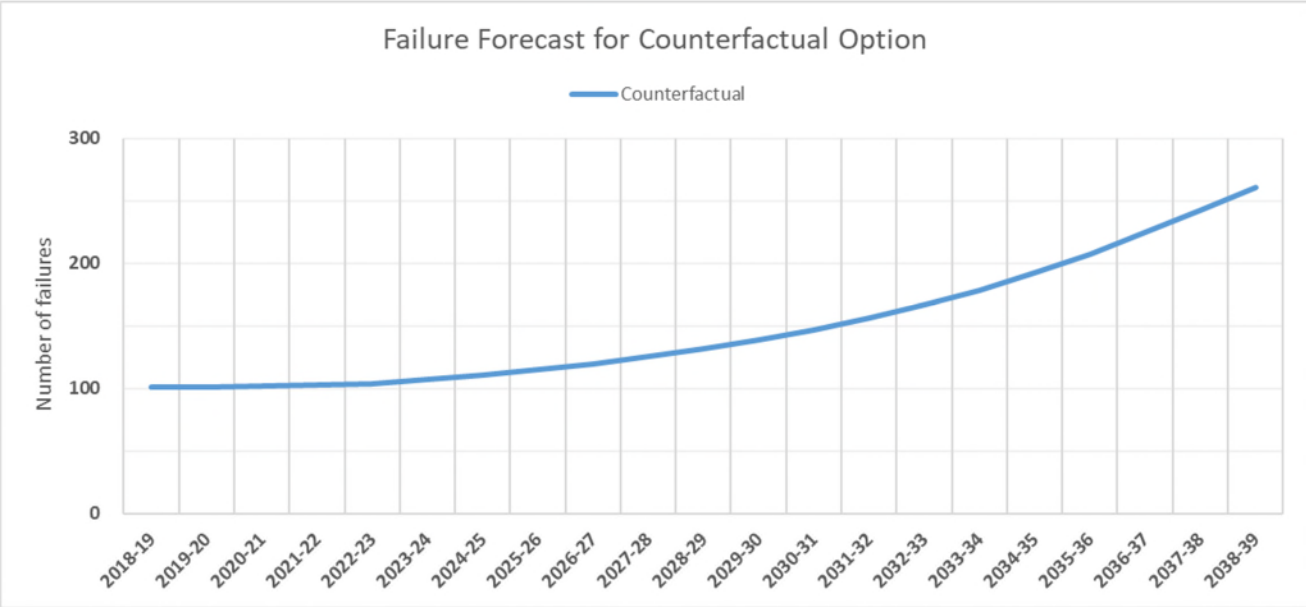

Figure 11: Failure Forecast – Counterfactual (AER Final Determination)

Figure 12 provides the results of a quantitative forecast of the emerging risks if our intervention volumes were at the rate of the AER determination.

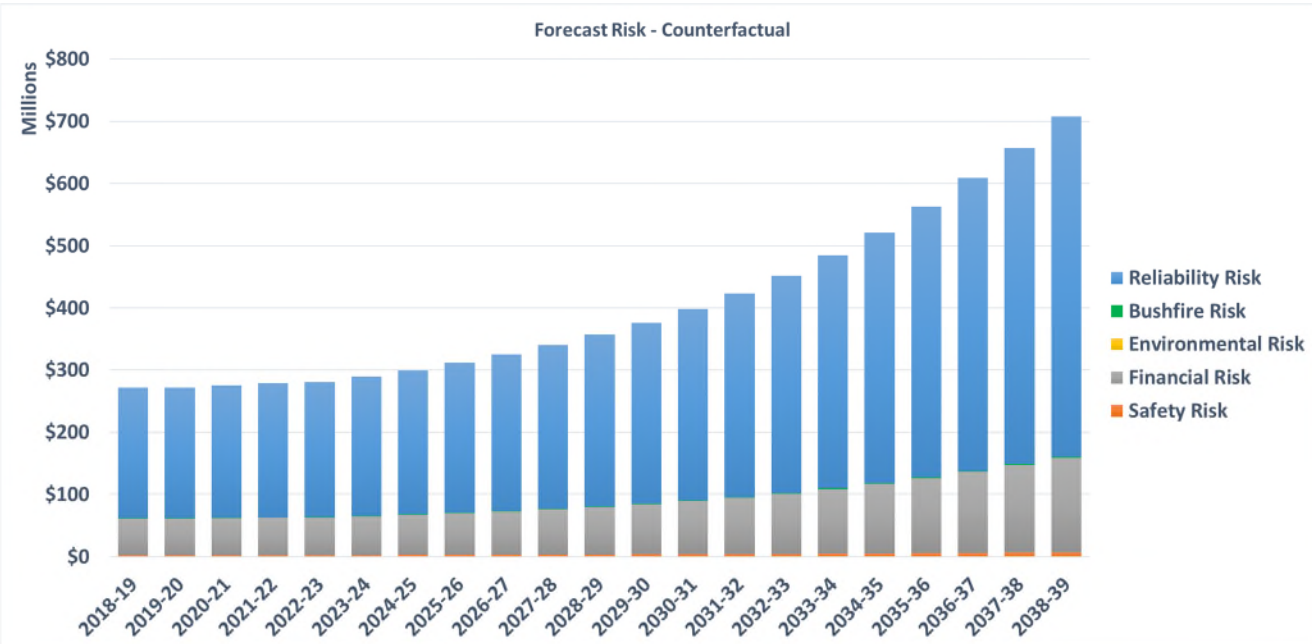

Figure 12: Counterfactual Quantitative Risk

As Figure 12 shows, there would have been significant risk costs associated with maintaining the replacement/reinforcement volumes within the AER budget allocations. The cost of these risks increases substantially over the 20-year period shown.

7 OPTIONS ANALYSIS

In assessing the prudency and efficiency of our actual delivery, we have compared a range of interventions against the counterfactual (AER Final Determination) to assess the options that would have maximised value to our customers. We have sought to identify a practicable range of technically feasible, alternative options that would have satisfied the network requirements in a timely and efficient manner.

It is notable that fuse replacements are required during distribution transformer replacements. While there are additional costs associated with fuse replacements, there are no additional benefits. As all the options will have a similar cost impact, fuse replacement costs have been excluded from the NPV analysis.

7.1 Option 1 – Historical Volumes (Continuation of program with old serviceability calculations)

This option includes the prioritised replacement/reinforcement based on our former serviceability calculation. We have taken the average historical replacement volumes for three years between 2015-16 to 2017-18 to forecast the volume rate for this PIR period.

7.1.1 Costs and Volumes

The volumes and costs that have been modelled in Option 1 are outlined in Table 7 and Table 8.

Historical Volume Pole and Consequential Replacement	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Pole Replacement & Reinforcement	**8,044**	**8,044**	**8,044**	**8,044**	**8,044**	**40,220**
Pole Replacement	6,721	5,414	5,628	5,457	5,740	**28,959**
Pole Reinforcement	1,323	2,630	2,416	2,587	2,304	**11,261**
Pole Top (Consequential)	8,591	4,812	4,143	4,351	4,622	**26,519**
Services (Consequential)	3,116	2,408	1,559	1,606	2,390	**11,079**
Pole Transformer (Consequential)	342	301	231	239	145	**1,257**
Switch (Consequential)	507	153	166	149	203	**1,179**

Table 7: Option 1 - Replacement Volume

Historical Direct Expenditure (nominal $) Pole and Consequential	2018-19 $m	2019-20 $m	2020-21 $m	2021-22 $m	2022-23 $m	Total $m
Pole Replacement	**40.6**	**40.7**	**39.4**	**40.0**	**40.0**	**200.7**
Pole Top (Consequential)	18.5	9.8	11.4	12.1	15.4	**67.2**
Services (Consequential)	2.4	2.8	2.3	2.5	3.5	**13.5**
Pole Transformer (Consequential)	10.0	8.7	5.6	7.1	6.0	**37.4**
Switch (Consequential)	4.8	1.6	1.6	1.3	1.0	**10.3**
Consequential Total	**35.7**	**22.9**	**20.9**	**23.0**	**25.9**	**128.4**

Table 8: Option 1 - Replacement Expenditure

7.1.2 Risks/Benefits

In this option, our modelling shows that the unassisted Pole failures are projected to remain comparable to those in the counterfactual option. Similarly, this level of performance does not reduce our failure rate below ESCOP standards or maximise customer benefits. Furthermore, opting for this approach will result in a growing need for substantial investment in the near term due to the escalating rate of asset failures. This is primarily because our former serviceability calculations result in having defective Poles in active service, causing a flow on effect of investment requirements and poor asset performance.

7.2 Option 2 – Health Index Based Replacement (HI > 7.5)

This option is a proactive replacement of all Poles assessed with HI over 7.5. This is viable option as the increase in replacement/reinforcement volumes compare to counterfactual leading to considerable reduction in failure risks including safety and reliability risks. It's important to mention that the model's estimated volume falls slightly short of the actual delivery in Option 4 because the model cannot account for the influence of factors such as termite infestation damage and the spread of timber rot.

7.2.1 Cost/Volumes

The volumes and costs that have been modelled in Option 2 are outlined in Table 9 and Table 10.

Health Index Based Volume Pole and Consequential Replacement	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Pole Replacement & Reinforcement	**13,250**	**13,250**	**13,250**	**13,250**	**13,250**	**66,250**
Pole Replacement	11,071	8,917	9,270	8,989	9,454	**47,701**
Pole Reinforcement	2,179	4,333	3,980	4,261	3,796	**18,549**
Pole Top (Consequential)	14,150	7,926	6,824	7,167	7,614	**43,681**
Services (Consequential)	5,133	3,966	2,568	2,645	3,936	**18,249**
Pole Transformer (Consequential)	563	496	381	393	238	**2,071**
Switch (Consequential)	835	252	274	246	334	**1,942**

Table 9: Option 2 - Replacement Volume

Health Index Based Direct Expenditure (nominal $) Pole and Consequential	2018-19 $m	2019-20 $m	2020-21 $m	2021-22 $m	2022-23 $m	Total $m
Pole Replacement	**67.3**	**65.0**	**66.4**	**67.2**	**67.9**	**333.8**
Pole Top (Consequential)	30.4	16.2	18.8	20.0	25.4	**110.8**
Services (Consequential)	4.0	4.6	3.9	4.2	5.8	**22.5**
Pole Transformer (Consequential)	16.4	14.3	9.2	11.7	9.9	**61.5**
Switch (Consequential)	7.9	2.6	2.7	2.2	1.6	**17.0**
Consequential Total	**69.8**	**44.7**	**41.1**	**45.1**	**50.7**	**251.4**

Table 10: Option 2 - Replacement Expenditure

7.2.2 Risks/Benefits

Under this approach, our modelling predicts that the occurrence of unassisted Pole failures will be notably reduced in comparison to the counterfactual option. This transition aims to bring the failure rate below ESCOP standards, ensuring a satisfactory level of reliability and mitigating public safety risks. While this option requires more resources and investment compared to the counterfactual, the advantages to customers are more substantial than the extra cost of the initiative.

7.3 Option 3 – AER REPEX Model Lives Scenario

This option volume is based on REPEX model lives scenario output, includes prioritised replacement of all the oldest Poles in the network over 76 years old with reinforcement of Poles at an appropriate time to achieve a service life of 76 years. We have estimated that this option would have required approximately 11,350 Poles per year to complete the age cycle for all wood Poles in the network.

7.3.1 Cost/Volumes

The volumes and costs that have been modelled in Option 3 are outlined in Table 11 and Table 12.

REPEX Model Live Scenario Volume **Pole and Consequential Replacement**	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**Total**
Pole Replacement & Reinforcement	**11,347**	**11,347**	**11,347**	**11,347**	**11,347**	**56,735**
Pole Replacement	9,481	7,637	7,939	7,698	8,096	**40,850**
Pole Reinforcement	1,866	3,710	3,408	3,649	3,251	**15,885**
Pole Top (Consequential)	12,118	6,788	5,844	6,138	6,520	**37,408**
Services (Consequential)	4,396	3,397	2,199	2,265	3,371	**15,628**
Pole Transformer (Consequential)	482	425	326	337	204	**1,774**
Switch (Consequential)	715	216	235	211	286	**1,663**

Table 11: Option 3 - Replacement Volume

REPEX Model Live Scenario Direct Expenditure (nominal $) **Pole and Consequential**	**2018-19 $m**	**2019-20 $m**	**2020-21 $m**	**2021-22 $m**	**2022-23 $m**	**Total $m**
Pole Replacement	**59.3**	**58.5**	**57.6**	**59.3**	**59.0**	**293.7**
Pole Top (Consequential)	26.1	13.9	16.1	17.1	21.7	**94.9**
Services (Consequential)	3.4	3.9	3.3	3.6	5.0	**19.2**
Pole Transformer (Consequential)	14.1	12.2	7.9	10.0	8.5	**52.7**
Switch (Consequential)	6.8	2.3	2.3	1.9	1.4	**14.7**
Consequential Total	**50.4**	**32.3**	**29.6**	**32.6**	**36.6**	**181.5**

Table 12: Option 3 - Replacement Expenditure

7.3.2 Risks/Benefits

Under this option, our modelling indicates that unassisted Pole failures are expected to be fewer compared to the counterfactual option. Nevertheless, this level of performance is unlikely to reduce the failure rate below ESCOP standards or maximise customer benefits. Additionally, our recent failure and defect analysis shows that treated Poles are not achieving the same level of lifespan as untreated Poles. Treated Poles are the majority of our population and are failing mainly due to timber integrity issues. Moving to an aged based replacement philosophy may not result in a significant lowering of unassisted Pole failures given our Pole failures are not directly related to the age of the Poles. Recent failure and defect analyses have also confirmed this issue. Therefore, choosing this approach will necessitate a significant increase in near-term investments due to the rising rate of asset failures.

7.4 Option 4 – Actual Delivery (Selected Option)

This option includes corrective replacement of all the Poles identified as unserviceable, assessed through observed and/or measured conditions as per the improved serviceability calculation.

7.4.1 Cost/Volumes

The volumes and costs that have been modelled in Option 4 are outlined in Table 13 and Table 14.

Actual Delivery Volume Pole and Consequential Replacement	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Pole Replacement & Reinforcement	**6,694**	**15,282**	**15,122**	**16,082**	**14,870**	**68,050**
Pole Replacement	5,593	10,285	10,580	10,910	10,610	**47,978**
Pole Reinforcement	1,101	4,997	4,542	5,172	4,260	**20,072**
Pole Top (Consequential)	6,690	9,714	7,719	8,619	8,445	**41,187**
Services (Consequential)	2,427	4,861	2,904	3,181	4,366	**17,739**
Pole Transformer (Consequential)	266	608	431	473	264	**2,042**
Switch (Consequential)	395	309	310	296	371	**1,681**

Table 13: Option 4 - Replacement Volume

Actual Delivery, Direct Expenditure (nominal $) Pole and Consequential	2018-19 $m	2019-20 $m	2020-21 $m	2021-22 $m	2022-23 $m	Total $m
Pole Replacement & Reinforcement (Defect only)	40.7	64.2	65.0	68.1	82.5	320.5
Pole Top (Consequential)	14.4	19.9	21.3	24.0	28.1	107.7
Services (Consequential)	1.9	5.6	4.4	5.0	6.4	23.3
Pole Transformer (Consequential)	7.8	17.5	10.4	14.1	11.0	60.8
Switch (Consequential)	3.7	3.2	3.0	2.7	1.8	14.4
Total Expenditure	**68.5**	**110.4**	**104.1**	**113.9**	**129.8**	**526.7**

Table 14: Option 4 - Replacement Expenditure

7.4.2 Risks/Benefits

In this option, our modelling shows that unassisted Pole failures are projected to be reduced compared to the counterfactual option. This option is the most effective choice for moving towards lowering the failure rate below ESCOP standards and maximizing customer benefits.

While this option requires more resources and investment than the counterfactual, the benefits for customers outweigh this extra cost. Although this option transitions towards ESCOP standards at a gradual pace, it's essential to maintain the same level of investment in the future to continue improving customer benefits and avoid the need for a significant increase in near-term investments.

8 OUTCOMES OF OPTIONS ANALYSIS

8.1 Pole Failure Forecast

The Pole failure rate forecast for all the main options have been provided in the Figure 13.

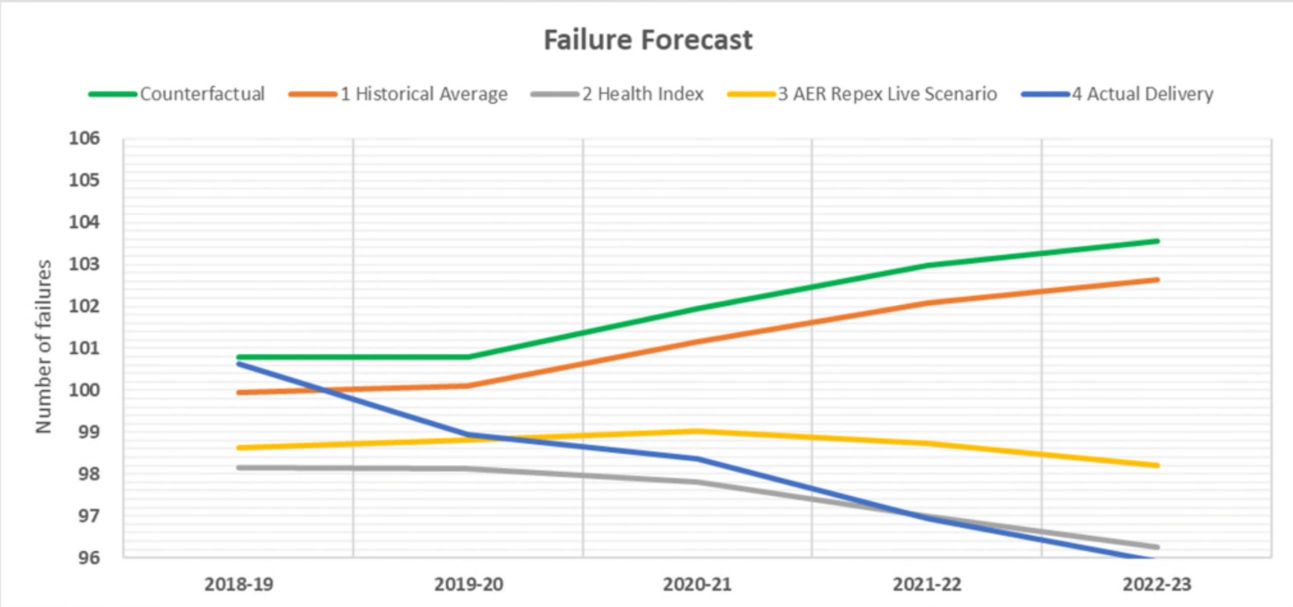

Figure 13: Failure Forecast - Intervention options

The projected failure forecast shows difference among all options during the PIR period with substantial increase for option 1 and option 2 including the counterfactual. Also, option 3 indicate slight increase in failures. All these three options are expected to remain above the ESCOP limit.

Option 2 and option 4 shows the reduction in failure rates to achieve the safety targets as required by ESCOP but option 2 is not customer friendly in terms of cost impact leaving the option 4 as the best option.

8.2 Economic Analysis

The NPV of cost benefit analysis of the options is summarised in Table 15 which demonstrates the following:

- Option 4 - Actual Delivery, compared to the counterfactual is NPV positive, indicating the benefits to customers of the program that we have undertaken.
- Other options also provide a positive NPV however Option 4 results in the best outcome in terms of costs and customer benefit.

Base Case including CCPEX							
NPV Analysis to Counterfactual							
		Rank	Net NPV incl CCPEX	CAPEX (NPV)	Benefit (NPV)	CCPEX NPV	CCPEX Benefits NPV
	Counterfactual	5	0	0	0	$0	$0
Option 1	Historical Average	4	$98,387,777	-$18,685,033	$121,587,710	-$6,792,145	$2,277,244
Option 2	Health Index	2	$572,938,131	-$173,262,304	$785,651,889	-$55,517,083	$16,065,629
Option 3	AER REPEX Live Scenario	3	$460,587,755	-$114,172,656	$601,437,875	-$37,714,124	$11,036,659
Option 4	Actual Delivery	1	$575,523,301	-$184,382,291	$797,401,422	-$51,223,639	$13,727,809

Table 15: NPV Modelling and Consequential Benefits

Replacement Volumes						
		2018/19	2019/20	2020/21	2021/22	2022/23
	Counterfactual	6,366	6,901	7,443	7,992	8,550
Option 1	Historical Average	8,044	8,044	8,044	8,044	8,044
Option 2	Health Index	13,250	13,250	13,250	13,250	13,250
Option 3	AER REPEX Live Scenario	11,347	11,347	11,347	11,347	11,347
Option 4	Actual Delivery	6,694	15,282	15,122	16,082	14,870

Table 16: Replacement Volumes – All Options

Table 17 shows the additional details about consequential NPV benefits for the options considered due to consequential replacements in conjunction with Pole replacements program. Undertaking replacements of these assets concurrently is efficient from a delivery perspective due to the small incremental costs associated with materials.

Including cost and benefits of consequential replacements in analysis confirms that option 4 is still NPV positive and provided higher customer benefits.

NPV Analysis to Counterfactual				Pole		Consequential (25% Benefit Factor)		
Options		Rank	Net NPV incl CCPEX	CAPEX (NPV)	Benefit (NPV)	ole Attached Asset	CCPEX NPV	CCPEX Benefits NPV
Counterfactua	**AER Determination**	**5**	**$0**	**$0**	**$0**		**$0**	**$0**
						Pole Top	$0	$0
						Services	$0	$0
						Pole Top Transform	$0	$0
						Switches	$0	$0
Option 1	**Historical Average**	**4**	**$98,387,777**	**-$18,685,033**	**$121,587,710**		**-$6,792,145**	**$2,277,244**
						Pole Top	-$2,597,966	$871,340
						Services	-$755,232	$416,056
						Pole Top Transform	-$1,931,239	$598,110
						Switches	-$1,507,707	$391,738
Option 2	**Health Index**	**2**	**$572,938,131**	**-$173,262,304**	**$785,651,889**		**-$55,517,083**	**$16,065,629**
						Pole Top	-$23,534,893	$6,496,025
						Services	-$5,371,768	$2,718,882
						Pole Top Transform	-$15,725,429	$4,259,438
						Switches	-$10,884,992	$2,591,283
Option 3	**REPEX Live Scenario Avg A**	**3**	**$460,587,755**	**-$114,172,656**	**$601,437,875**		**-$37,714,124**	**$11,036,659**
						Pole Top	-$15,875,949	$4,441,871
						Services	-$3,684,322	$1,877,532
						Pole Top Transform	-$10,685,437	$2,925,602
						Switches	-$7,468,416	$1,791,655
Option 4	**Actual Delivery**	**1**	**$575,523,301**	**-$184,382,291**	**$797,401,422**		**-$51,223,639**	**$13,727,809**
						Pole Top	-$22,113,227	$5,518,129
						Services	-$5,235,173	$2,452,553
						Pole Top Transform	-$15,925,691	$4,007,107
						Switches	-$7,949,549	$1,750,020

Table 17: NPV Modelling and Detailed Consequential Benefits

Finally, Figure 14 compares the net NPV progression and gains over the modelling period compared to counterfactual option. This indicates significant NPV gains for Option 3 with NPV increasing at approximately more than double compared to the rate of additional investment.

Further increase in investment with Option 2 still achieves higher NPV gains but at a slower incremental rate.

Option 4 achieves the comparable gains among options and reaches towards most optimum solution in terms of investment and net NPV gains. Considering that this is the only option which is highly likely to achieve network standard compliances with reductions in the public safety risk, this is the most prudent option.

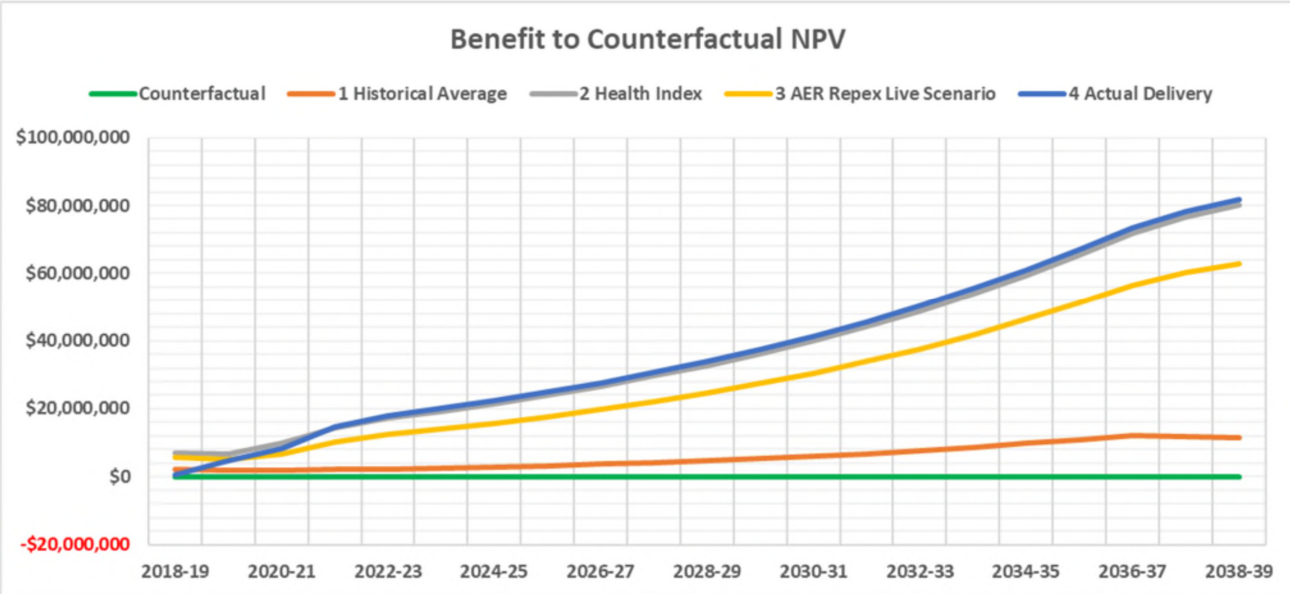

Figure 14: Benefit to Counterfactual NPV

Table 18 provides the summary of key points of investment, customer benefits, net benefits and risks associated with each intervention option.

The analysis presented here compares the options to their respective counterfactual alternatives.

Criteria	Option 1 – Historical Volume (Old Serviceability calc)	Option 2 – Health Index >7.5HI	Option 3 – REPEX Live Scenario Model volume	Option 4 – Actual Defect Replacement (Selected Option)
Net NPV	$98m	$573m	$461m	$576m
Benefits	Low	High	Medium	High
Delivery Constraint	Low	Med	Med	Med
Detailed analysis – Advantage	• A Do-Minimal scenario similar to counterfactual with minimum additional expenditures $26m • Almost matches the AER replacement forecast expenditure. • Additional $124m customer benefits.	• Additional $802m Customer Benefit • Removes majority of defective assets from the network • Medium level impact on delivery requirement.	• Additional $612m Customer Benefit • Achieve average Pole life as aligned with AER proposal for Live Scenario • Maintains the current failure rate up to some extent.	• Investment requirement is within the top-down constraints. • Additional $811m Customer Benefit • Removes all defective assets from the network. • Improves overall asset performance meeting ESCOP and public safety requirements. • Represents a balanced replacement volume aimed at avoiding the need for significant investments in the future.
Detailed analysis – Disadvantage	• A large number of defective Poles left in service, leads to higher risk of Pole failures and public safety • Will lead to significant investment in future • Not meeting ESCOP level, increasing unassisted failure.	• Additional investment of $229m • Higher resource requirement.	• Replacement life 76 years • Not meeting ESCOP level • Additional investment of $152m.	• Additional investment of $236m • Double the resource requirement.

Table 18: Options Analysis Scorecard

9 SUMMARY

We have assessed and modelled four feasible options that we could have undertaken over the review period from 2018-19 to 2022-23 period. To ensure that the analysis is robust and comprehensive, we have included the consequential replacements of assets undertaken at the time of Pole replacements:

- The modelling confirms that the total investment in defective and consequential Pole replacements of $236M as described in Option 4, provided a positive NPV benefit of $576M compared to the counterfactual option of the AER's forecasted volume replacement.
- Detailed quantitative risk analysis for the counterfactual option has shown an escalating trend of expected Pole failures and increasing customer safety and reliability risks. The risk reduction value over the next 20 years of undertaking this program is $811M. This equates to around NPV of $576M including asset failure reduction, demonstrating the value of the total program for our customers. This is the optimum option and has resulted in containing the increasing trend in Pole failures seen since 2017-18. It is noted that we are starting to see a reversing trend as demonstrated by the Pole failures data in 2022-23.
- A comparison with the alternative option of the previous serviceability calculation (Option 1) also confirms that additional benefits of the actual delivery.

While Option 4 has not resulted in Pole failure rates reductions initially but now showing some signs of reductions it is the minimum level required to avoid the escalating trend and provide a path to achievement of the target level over the medium term.

It is noted that the modelled result for Option 4 shows that Pole failure rates are likely to maintain at current level as a minimum or possibly reduce the rate in the long terms. Hence, we forecast that the current level of remediation programs will be required in the next regulatory control period to bring the failure rate below the ESCOP levels.

9.1 Sensitivity Analysis

To further test the effectiveness and prudency of the preferred option, a number of sensitivity analysis criteria have been applied, with ± 25% values, to compare the outcomes of the modelling in different scenario. The main sensitivity criteria are:

- Annual Risk cost
- Weighted Average Capital Cost (WACC)
- Probability of Failure (PoF).

In most of the sensitivity analysis outcomes, the Actual Delivery option has been demonstrated as the most prudent option.

10 CONCLUSION

The Option 4 Actual delivery is reflective of our commitment to provide maximum customer benefit. It provides a tolerable risk position which balances the achievement of asset management objectives and customer service levels. Further this option ensures a level of investment which avoids future consequences based on the uncertainty associated with the capability new technologies may bring.