Overhead Conductors

Post Implementation Review

Part of Energy Queensland

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DOCUMENT VERSION

Version Number	Change Detail	Date	Updated by
Draft V0.1	Draft	22/09/2023	Engineer Asset Strategy
Draft V0.2	Finalised draft post Network Investment Strategy review	03/10/2023	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 Overhead Conductor 21122018 Public Approved	PDF
NOV 2023	Risk Modelling - Overhead Conductor v0.1	Docx & Excel
NOV 2023	OH Conductors 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	Overhead Conductor – 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 increased replacement volume of Overhead Conductors over the review period[1] • to support the ex post review of Ergon's capital expenditure over the 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 business 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 observed that, prior to the 2018-19 period, there was a substantial number of Overhead Conductor unassisted failures. These failures consistently exceeded 900 incidents per year, with 25% of them resulting in conductors falling to the ground which are significant safety hazards to the public. These incidents also impact the reliability of service to our customers and the community. Key factors of the high unassisted failure rates were: • The historical levels of targeted Conductor replacement were insufficient to improve the performance of our assets. To mitigate safety and reliability risks, a step change in replacement volumes was necessary. • A significant length of problematic Conductors, approximately over 7,000km of Hard Drawn Bare Copper (HDBC), is still in operation. Consequently, the selected step change in replacement program must be maintained throughout the next regulatory period.

[1] The review period as defined in NER S6.2.2A(a1) is 2018-19 to 2022-23 for the upcoming 2025-30 distribution determination

Alternate options	Four alternative options were evaluated and compared to the counterfactual (the AER 2020-25 final determination – Average 376 km/year): 1. Historical volumes – Average 160 km/year 2. Health Index Based Replacement (=> 7.5) – Average 1,200 km/year 3. AER REPEX Live Scenario – Average 1,714 km/year 4. Actual Delivery (Targeted) – Average 518 km/year.
Expenditure	The expenditure presented in this PIR relates to the actual investment undertaken to replace targeted Conductors. It also includes the replacements of associated structures/poles and equipment on those structures/poles (pole top structures, transformers, switches, and services) that occurred as a consequence of the replacement of the targeted Conductors.

Year $m nominal/direct	2018-19	2019-20	2020-21	2021-22	2022-23	Total
OH Conductor RIN Total	16.7	19.6	26.1	49.8	53.5	165.7
Pole Consequential Replacement*	2.8	4.9	8.5	19.1	18.8	54.1
Pole Top Consequential Replacement*	1.3	3.9	6.2	8.5	12.1	32.0
Services Consequential Replacement*	0.6	1.3	2.5	5.3	2.5	12.2
Pole Transformer Consequential Replacement*	1.1	3.4	5.3	6	8.1	23.9
Switch Consequential Replacement*	0.5	2.0	3.4	5.2	4.2	15.3
#Cost Benefit Investment (Reconductoring + Consequential)	23.0	35.1	52	93.9	99.2	303.2
Cost Benefit Investment (2022/23 real $)	27.1	41.0	58.7	98.4	99.2	324.4
Fuse Consequential Replacement	0.3	1.3	2.4	2.7	3.1	9.8
Total Investment (including Fuse)	**23.3**	**36.4**	**54.4**	**96.6**	**102.3**	**313.0**
(2022/23 real $)	**27.5**	**42.6**	**61.4**	**101.2**	**102.3**	**335.0**

#Expenditure considered for this business case

Benefits	This rate of conductor replacement we undertook over the review period of around 518 km/year (average) provided a positive NPV of $208m with a total community benefit of $302m over the modelling period of 20 years in comparison to the counterfactual option based on the AER final determination forecast. This option was the optimal solution for Ergon Energy to transition towards achieving stable reliability and safety outcomes for our community. ***Note****: The model uses 2022/23 real $.*

2 PURPOSE AND SCOPE

The purpose of this Post Implementation Review (PIR) is to evaluate the benefits of the increased volume of targeted conductor's replacements during the regulatory period 2018-19 to 2022-23. This review explores the possible alternative options using Net Present Value (NPV) modelling to evaluate and compare alternative options and to validate that the expenditure incurred has been prudent.

This review covers both the costs directly associated with targeted conductors as well as the cost and benefits for the consequential replacements of associated poles, pole-top structures, services, transformers, and distribution switchgear that were incurred while replacing the overhead conductor.

This document is to be read in conjunction with the Overhead Conductor Asset Management Plan.

3 BACKGROUND

In response to a consistently high failure rate of overhead conductors, with a growing number of these conductors falling to the ground and posing significant safety risks to the public, an evaluation of asset management and replacement strategies was conducted. The aim was to ensure alignment with industry best practices and identify areas for improvement.

During this review, it became evident that the limited number of targeted replacements between 2010 and 2015 had led to a substantial increase in the population of aged and deteriorated conductors. This led to elevated failures and conductor fall incidents. After a comprehensive examination of unassisted failures, increasing the number of targeted replacements was identified as the most cost-effective strategy to manage in-service failures, aligning with the SFAIRP (So Far as Is Reasonably Practicable) approach outlined in the Asset Management Plan (AMP) associated with overhead Conductors.

The Electricity Network Association (ENA), representing gas and electricity distribution and transmission across Australia, also recognised the global aging of Conductor populations. According to the ENA, despite technological advancements, there has been limited progress in cost-effective monitoring of Conductor conditions.

Ergon Energy sought to reassure itself, regulatory authorities, and both internal and external stakeholders that their asset management strategies for overhead conductors would deliver long-term value to the community and shareholders. This would be achieved by ensuring the safety and reliability of the overhead network and providing a more secure electricity supply to consumers in rural and regional Queensland.

However, maintaining the historical replacement rate of 160 kilometers per year was deemed unsustainable. At this pace, it would take an astonishing 890 years to replace the entire Conductor population, resulting in an average Conductor age of 890 years. Even the problematic HDBC Conductors, which are already 70 years old or approaching this age, would require an additional 43 years for elimination from the network. Consequently, Ergon Energy had to make a significant shift in its replacement policy, urgently increasing replacement volumes.

As a result of this strategic change, Ergon Energy has made substantial efforts to increase the replacement volumes and intends to further increase them in the future. This proactive approach aims to prevent a scenario where failures of these aging and problematic conductors increase rapidly. Such rapid conductor failures, including conductor breakages, could pose a significant risk to public safety and the reliability of the network.

3.1 Asset Population

In 2018–19, Ergon Energy overhead conductor population was 143,301 km, installed throughout our network at distribution, sub-transmission, and transmission voltages. Approximately 36% of overhead conductor assets are installed at distribution voltages less than or equal to 11kV. An additional 43% of the overhead conductor population is installed as part of the single wire earth return (SWER) distribution network.

The age profile of our OH conductors reflect that 40,859 km, 17,634 km, and 4,073 km Conductors were over 50 years, 60 years and 70 years in 2018-19. Figure 1 below shows the age profile of our OH Conductor population.

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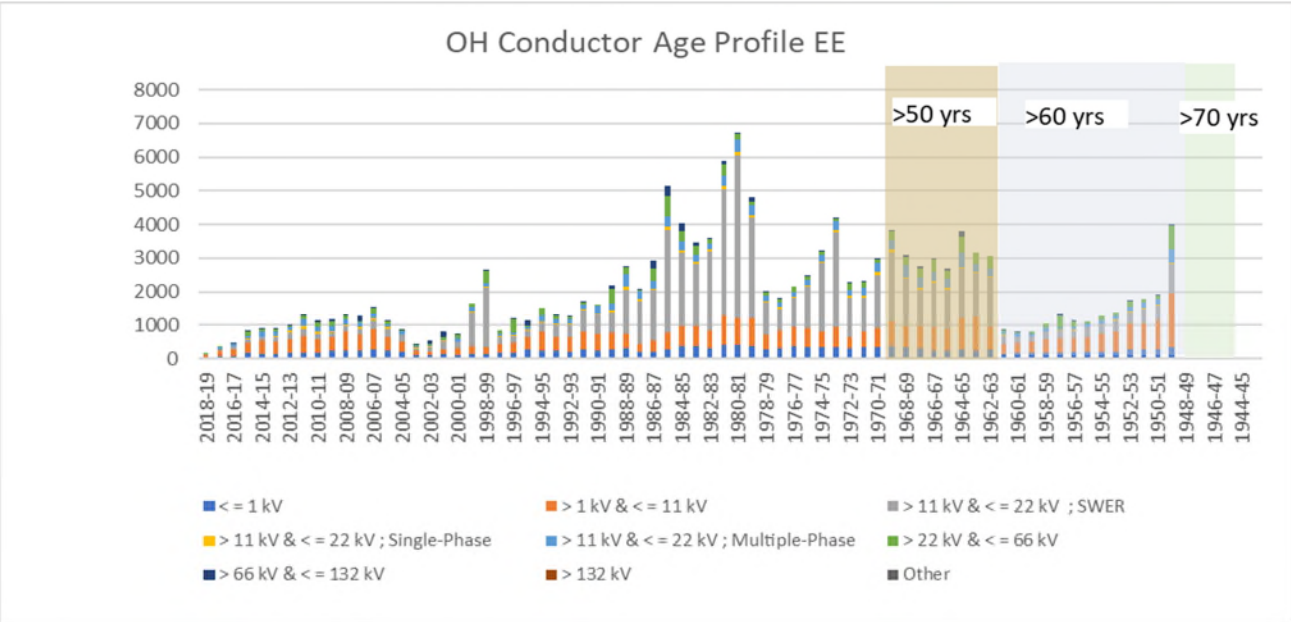

Figure 1: Age Profile OH Conductors

3.2 Asset Management Overview

Overhead conductors are an asset of strategic importance to Ergon Energy (ERG) as they provide the physical connection and electrical continuity to allow for the safe and reliable transmission and distribution of electrical power. Failure of overhead Conductor assets to perform their function results in negative impacts to our business objectives related to safety, customer and compliance, including System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI) targets.

Overhead conductors are very high volume, relatively low individual cost assets, and are typically managed on a population basis through periodic inspection for condition. End of asset life is determined by reference to the benchmark standards defined in the Line Defect Classification Manuals and Maintenance Acceptability Criteria in line with best industry benchmark practices.

Additionally, Ergon Energy has been continuously improving the recording system for all failures, incorporating a requirement to record the asset component (object) that failed, the damage found, and the cause of the failure. This Maintenance Strategy Support System (MSSS) record history is building over time and now provides the information necessary to support improvements in inspection, maintenance, and asset management practices.

Replacement work practices are optimised to achieve bulk replacement to minimise overall cost and customer impact. Conductors are proactively replaced based on condition-based risk management process, with asset performance trends being the key input, where criteria indicates that assets are either at or near the end of their serviceable life.

To meet the regulatory obligations of operating an electrically safe network, Ergon has commenced a step change in targeted conductor replacement programs to remove high risk, aged conductor from the network, with a particular focus on small diameter HDBC Conductor due to poor performance. We have significantly increased the volume of replacements of aged, small diameter HDBC in high-risk areas to manage this risk. The addition of aging Galvanised Steel (SC/GZ) and Steel Reinforced Aluminum Conductor (ACSR) into these targeted programs is also proposed and prioritised based on safety risk and the influence of coastal environments. The targeted program consists of:

- All known remaining hard drawn bare copper 7/0.064" and smaller.
- Coastal hard drawn bare copper 7/0.064" <= 7/0.104" imperial aged 70+
- Coastal galvanised steel 3/12 SC/GZ Conductor aged 55+
- Coastal ACSR and Aluminum imperial Conductor aged 70+.

3.3 Asset Performance

Two functional failure modes of OH Conductors defined in this model are found in Table 1.

Functional Failure Type	Description
Catastrophic **(Unassisted)**	Loss of structural integrity of any component associated with an overhead Conductor, joints and armour rods excluding any associated pole or pole top hardware or pole mounted plant, such that the residual strength of the component required immediate intervention. Functional failure of an OH Conductor asset under normal operating conditions not caused by any external intervention such as abnormal weather or human intervention.
Degraded **(Defect)**	A Conductor asset deemed defective based on observed/measured condition 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). The P0, P1 and P2 defect categories relate to priority of repair, which dictates whether normal planning processes are employed (P2), or more urgent repair works are initiated (P1 and P0).

Figure 2 shows the number of unassisted conductor failures since 2015-16. The significantly high failure rates of 850 on average since 2019-20 has persisted throughout the ex post period. The high failure rate is the result of a low targeted replacement prior to 2018-19 which has led to an accumulation of poor condition conductors. However, it is starting to show some encouraging trend of slowing down but is still at a relatively high-level due to risks to public safety and reliability.

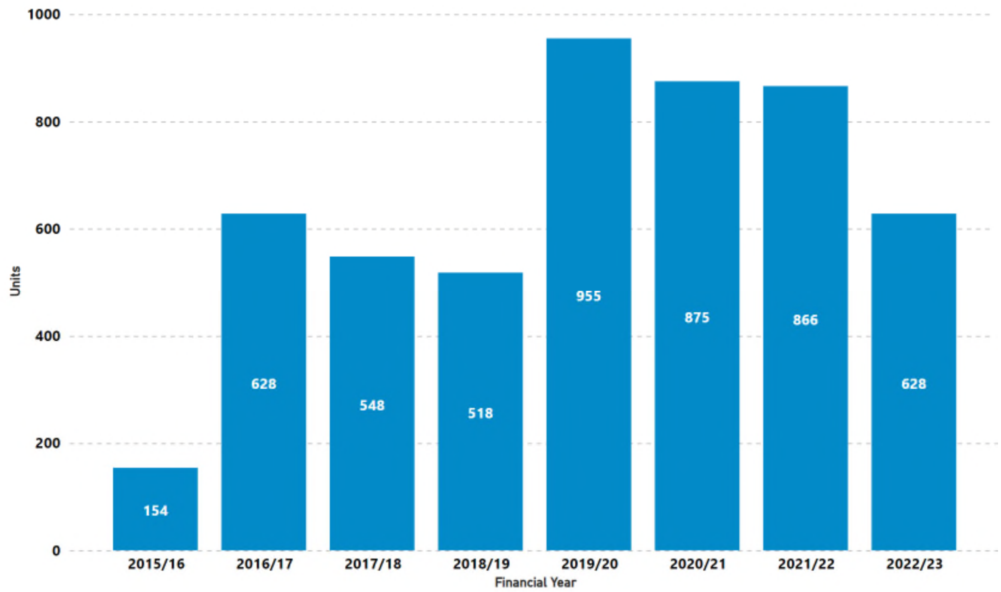

Figure 2: Unassisted OH Conductor Failures

Figure 3 shows the number of defects identified since 2015-16 where approximately 11,000 defects are identified per year. Considering that we still have over 7000km of vulnerable conductors still in service, the failures are not expected to reduce anytime soon. Also, failure reductions are not indicated by the modelling and failure graph as per Figure 11 in section 6.3.3 (Risk quantification, counterfactual option) is showing a slow gradual increase, contrarily to actual failures. It is notable that modelling considers failure rate based on historical average failures and the current conditions of OH Conductors, rather than year to year fluctuations.

The main causes of defects are the corrosion and loss of strands resulting in loss of strength in the conductor, which if left unaddressed will eventually cause an unassisted failure of the conductor. Also, number of joints in a span could cause additional deterioration at joints due to normal wear and tear. In our effort to improve the condition data and better management of conductors, we are now recording the number of joints in a span. The number of joints increases over a period with every failure of a Conductor.

Despite the step change in targeted replacement volume from 2020-21, the impact in asset performance regarding failures will not be immediate. This is due to higher volume of overhead network assets operating well beyond their expected useful life as shown in the age profile and predictive model.

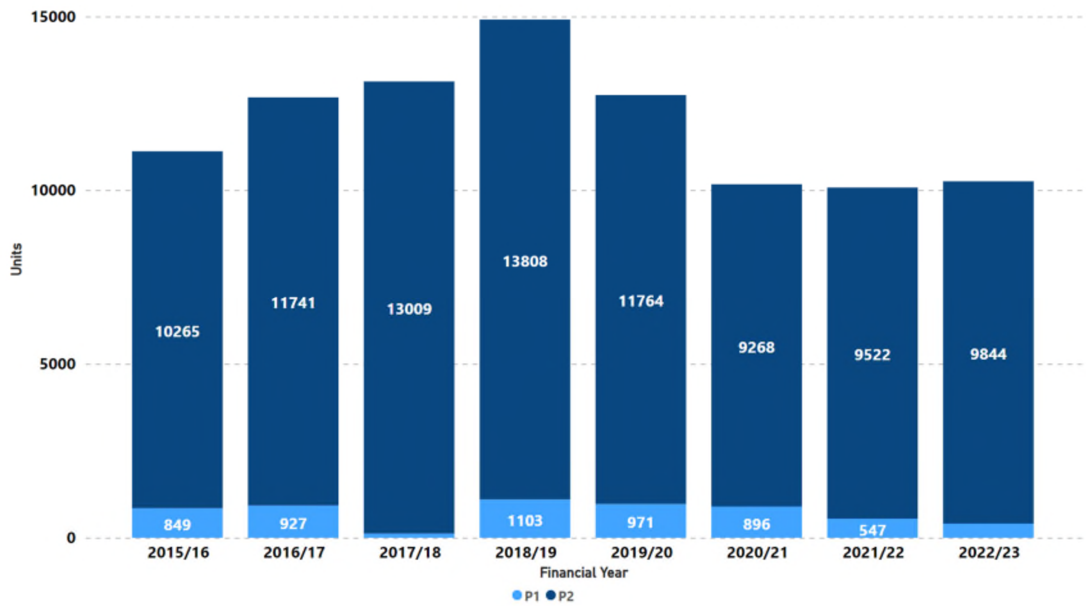

Figure 3: OH Conductor Defects

4 RISK ANALYSIS

In evaluating the risks associated with our Conductor assets we model each segment individually with age, type, location, performance and applicable limited condition data specific to each Conductor segments.

As such, our cost benefit analysis is aimed at calibrating our risk calculation at the program level, so that on average we will be able to maximise the benefits to customers. 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.

The monetised risk is simply calculated as per the calculation in Figure 4.

Figure 4: Monetised risk calculation per category

Ergon Energy broadly considers five value streams for investment justifications regarding replacement of widespread assets. These are shown in Figure 5. For Conductors, only four of the value streams are considered as the ‘Export’ stream is not material.

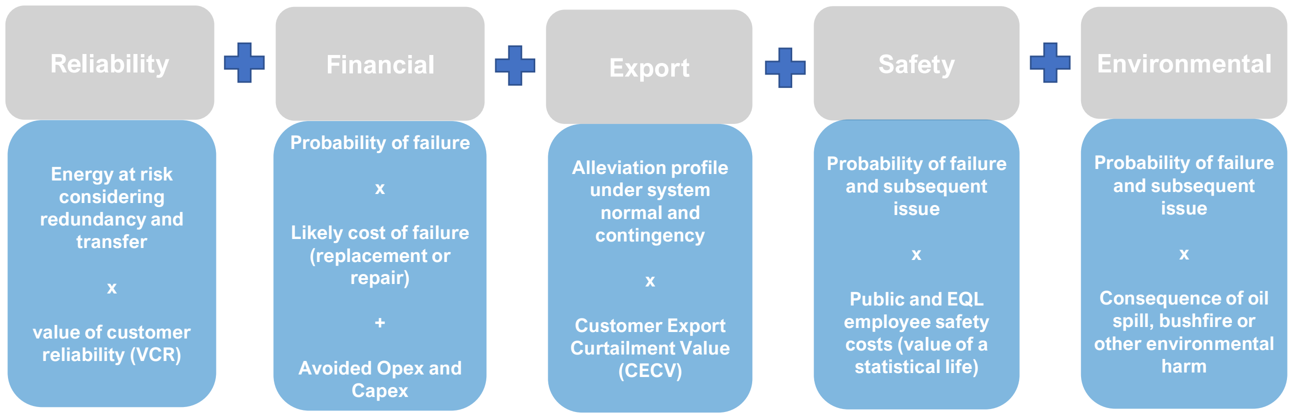

Figure 5: Total risk cost calculation

4.1 Health Index (HI) and Probability of Failure (PoF)

To determine the assets condition several contributing factors have been considered, including appropriate probabilistic impact scales in line with Condition Based Risk Management (CBRM) and Common Network Asset Indices Methodology (CNAIM) principles. The Health Index (HI) for all Conductor segments calculated by incorporating information such as the number of joints in a span. Where this information is limited, analysed damage and cause data from defects and failure trends and problematic types of Conductor identified using localised knowledge from subject matter experts. Wherever condition data is limited, the Conductor types asset performance trend has been considered primarily while developing the HI. Each Conductor segment in our population has an individual HI score. This approach would allow for an estimation of the future probability of failure.

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

- 0 indicating new Conductor with the best condition.
- 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. With enough evidence from historical failures and defect data of Conductors breaking down and falling on the ground, such as a small HDBC Conductor, has been allocated an HI of 7.5.

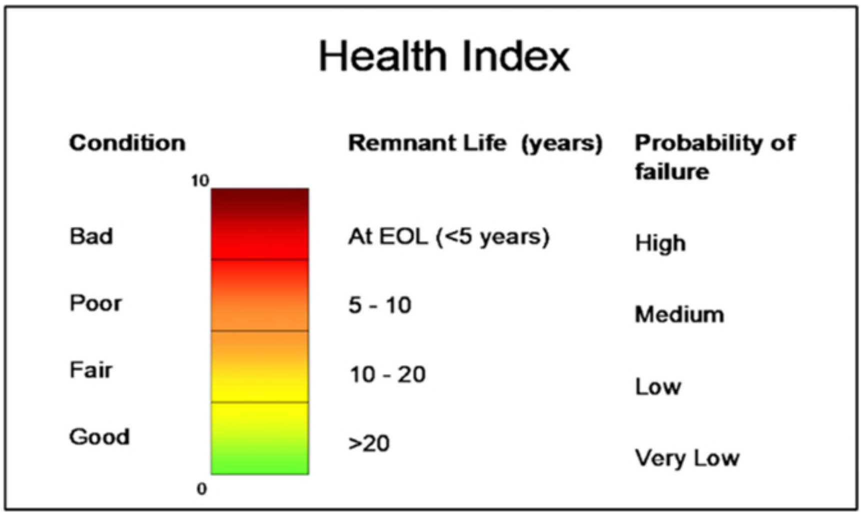

Figure 6: HI and PoF Relationship

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

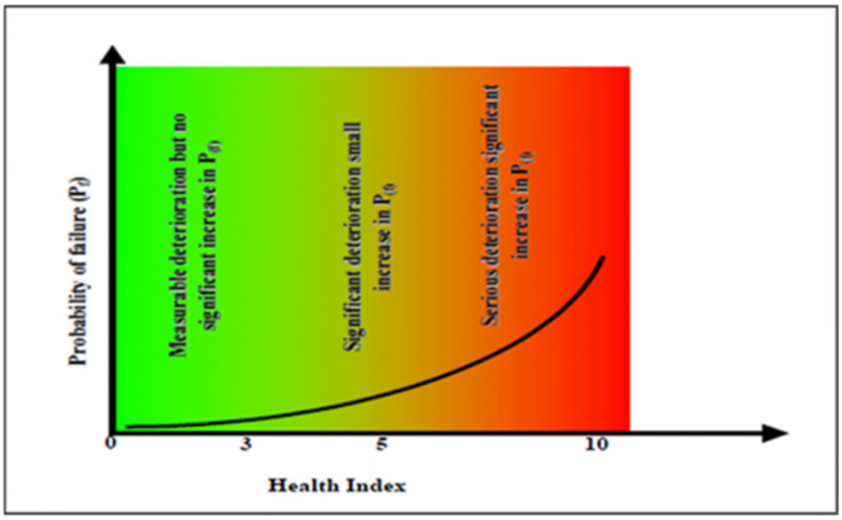

Figure 7: HI and PoF Relationship Graph

Figure 8 illustrates that approximately 2,000km of Conductor was identified in 2019 with an HI of over 7.5. Typically, an asset requires an intervention when the health index is greater than 7.5, as mentioned above. Our cost benefit analysis for various replacement options has been taken on a range of HI values to allow us to evaluate the best option and maximize the value to customers.

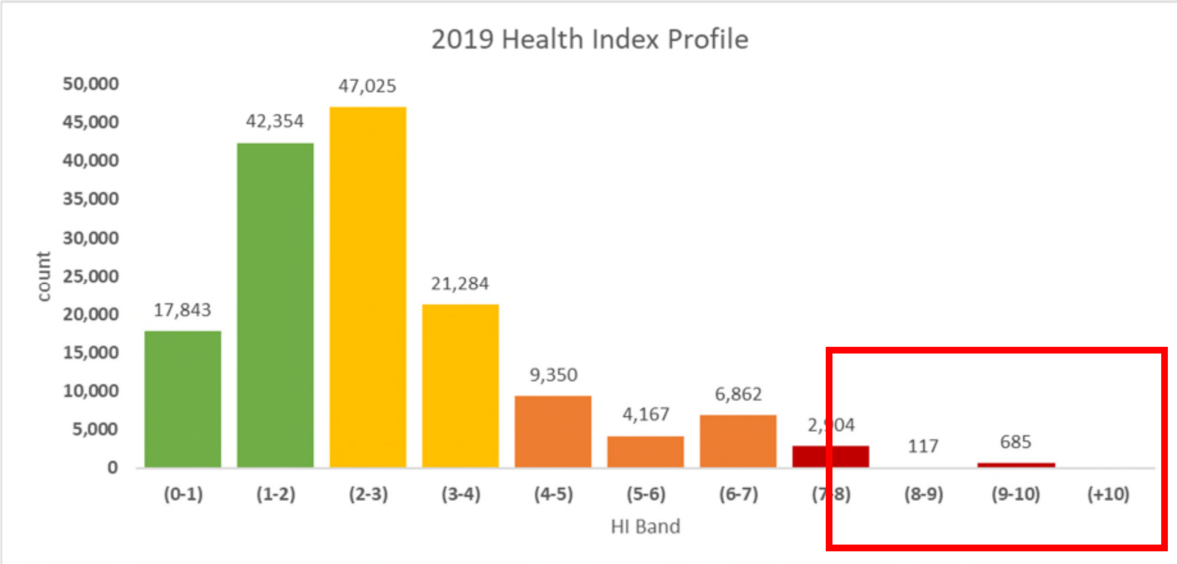

Figure 8: Year 2023 HI Profile for OH Conductor

Figure 9 shows the estimated forecast HI summary of Conductors at the end of the modelling period (year 2039) as per CBRM if we have no change in our intervention program. The model estimates that approximately 25,000km of Conductor will exceed a HI of 7.5. To avoid this outcome, an average of 1,200 km of Conductor per year would require an intervention over the next 20 years. This is significantly higher than the current rate of our intervention program and is considered under option 2. It is noted that this option is very close to option 3 - AER REPEX Lives scenario, with an average replacement age of 84 years.

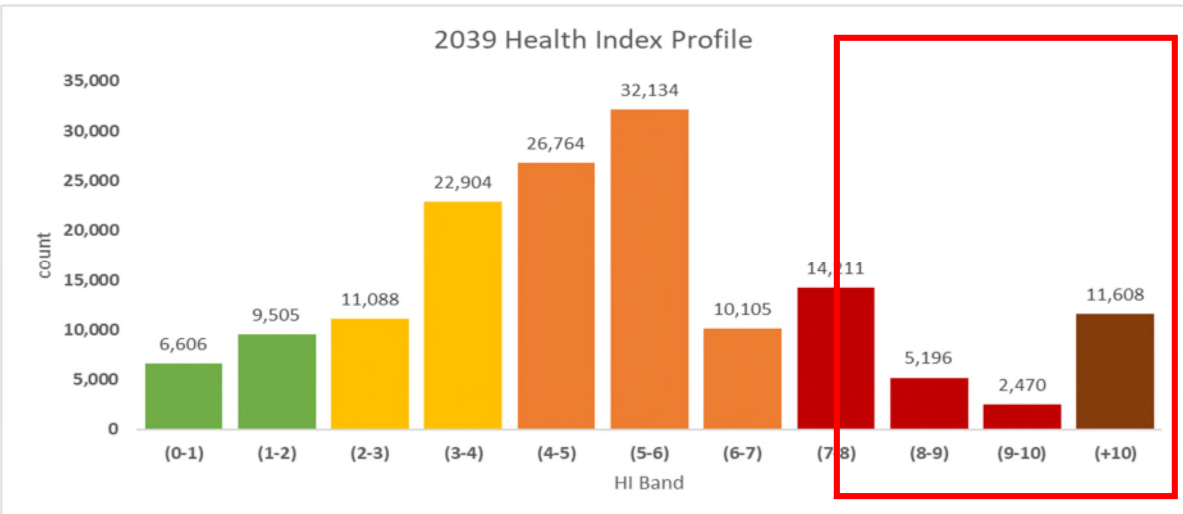

Figure 9: Future HI for OH Conductor ERG

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

In identifying the value of our level of intervention over the 2018-2023 period, the key consequence of Conductor failures that have been modelled are reliability, financial, safety and environmental (bushfire). 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 utilized a combination of historical performances and researched results. Ergon Energy has analyzed past events, incidents, and data to identify patterns and trends that can provide insights into the likelihood of similar outcomes occurring in the future.

To the extent possible the CoF and LoC are Conductor specific. This is particularly the case for the reliability and benefits stream, where the feeder specific load and bushfire risk informs the benefits calculations for preventing unassisted Conductor 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 Conductor failure:

- **Lost load:** Each Conductor segment in our network is modelled individually with feeder that it is connected to. The historical unplanned feeder outage, customer kWh loss, and duration due to an unplanned event is utilised to determine the lost load.
- **Load transfers and Restoration timeframe:** The average loss of supply has been estimated for a period of average 3 to 8hours based on locality, with staged restoration approach, on the basis of historical data for outages/durations. This is based on the average load on our fleet of distribution feeders, divided under different categories such as Rural short, rural long, urban, and sub-transmission.
- **Value of Customer Reliability Rate:** We have used the Queensland average VCR rate.
- **Probability of Consequence:** All in-service Conductor 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 safety risk costs for a Conductor failure:

- **Conductor replacement:** Ergon Energy Networks have assumed that the average replacement cost per kilometer for a Conductor is $65,000 estimated from historical average. This is the same whether proactive, defective replacement or replacement following a failure.
- **Probability of Consequence:** All in-service Conductor failures result in emergency work by adding another joint in the Conductor segment or replacement of the segment all together subjected to number of joints already in the segment.

4.2.3 Safety

The safety risk for a Conductor failure is primarily that a member of the public is in the presence of a fallen Conductor which was caused by the Conductor failure. This could result in a fatality or injury. For our modelling we have used August 2022 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: $1.3m
- **Disproportionality Factor:** 6 for members of the public
- **Probability of Consequence**: Following an unassisted Conductor failure, that there is a 1 in 20 years chance of causing a fatality and 25 in 20 years chance of a serious injury based on historical data evidence. The average number of safety incidents has been derived by analyzing 20 years of Significant Electrical Incident data comprising 26 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 and falling Conductor on ground resulting in a fire. For our modelling we have used the following:

- **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 2020 across 12 significant fire records. Homes were estimated an average cost of $400,000 while the buildings were estimated at an average cost of $80k. The weighted average cost of bushfire consequence per Conductor segment has been estimated as $11,228.
- **Safety Consequence of bushfire -** Safety consequences are evaluated on the same assumptions as the safety incident consequence in 4.2.3 with a frequency of 0.5 per incident as there have been 6 fatalities recorded across those 12 bushfire incidents in Queensland.
- **Probability of Consequence:** Following the failure of a Conductor, we have estimated that there is a 0.0260 chance of causing a fire. This is based on recent full one-year historical data 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 REPLACEMENTS

While replacing an OH conductor, we also conduct an assessment on the condition of the supporting structure (poles) and other equipment (crossarms, transformers, service lines, and switches) affixed to the supporting structure/pole to determine whether it is feasible and cost-effective to replace them.

When evaluating the advantages of this approach for our customers, the cost-benefit analysis considers the replacement of these equipment as an integral part of OH conductor replacement. In other words, we have factored in the costs and benefits associated with these consequential replacements into the analysis to ensure that the total replacements are factored into the analysis.

Table 2 provides the consequential asset volume replaced under OH conductor replacement program under the Actual Delivery Option.

Actual Delivery Consequential Replacement Volume	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Pole	423	744	1,279	2,835	2,358	7,639
Pole Top	1,033	1,645	3,197	5,373	4,431	15,679
Services	388	885	2,012	3,151	1,848	8,283
Pole Transformer	38	127	202	249	220	836
Switch	93	87	157	314	244	895

Table 2: Consequential Asset Volume in Reconductor Program – Actual Delivery

5.1 Benefit Assumptions

In accounting for the costs and benefits from the consequential of replacement of poles, switchgear, pole top structure and transformer and services with replacement of a targeted conductor, we have utilised the cost benefit modelling outlined in the PIRs for each of these five asset categories. For instance, we have undertaken an analysis of the benefits of replacing pole-top structures in a similar way to conductors. We have utilised this analysis to understand the benefits associated with a consequential replacement of a pole-top structure as we are replacing a segment of conductor.

The consequential replacement of the five asset categories is an “advancement” or bring forward of the replacement of the assets that would otherwise be required to be replace later because of their condition. An estimate of the already used service life of these assets at the time the replacement is provided in Table 3.

Consequential Replacement Asset Description	Average failure age in Years as per Weibull Analysis	Estimated Average Age at the time of Conductor replacement with pole age of 55	% Life already Used at Conductor replacement time	Remaining Life at Conductor replacement time
Poles	58	03	95%	5%
Switches	21	13	62%	38%
Pole Top Structure	41.5	13.5	32.5%	67.5%
Pole Transformers	33	22	66%	34%
Services	37	18	49%	51%

Table 3: Estimated Used life of Consequential Assets

As can be seen in Table 3, the average remaining life of the various asset categories that we typically replace as part of our proactive conductor replacement program ranges from five percent to 67.5 percent. However, our conservative approach is to assume that all 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 understates the benefits that our customers will see from these consequential replacements and in reality, customers will experience higher benefits than those outlines in this PIR. This conservative approach ensures confidence in our assessment of the benefits of the program overall.

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

- Estimated average age of pole at the time of replacement is 55 years.
- Allocate 25% of the average benefit of replacement of these assets as the benefits attributable to replacing these assets with our defective Conductors.

The replacement of consequential assets has been obtained from historical data as per Table 4.

Consequential Asset Replacement Volume Ratio					
Asset Description	2018/19	2019/20	2020/21	2021/22	2022/23
Pole	3.85	4.93	4.21	5.13	5.35
Pole Top	9.40	10.89	10.53	9.71	10.05
Conductor	1.00	1.00	1.00	1.00	1.00
Services	3.53	5.86	6.63	5.70	4.19
TD Pole Transformers	0.35	0.84	0.67	0.45	0.50
Switch	0.85	0.58	0.52	0.57	0.55

Table 4: Consequential Replacement Volume Ratios – Actual History

In undertaking a comparison between the alternative options to our actual delivery, we have utilised the same ratios of replacement of the items as listed in Table 4. For example, the number of consequential pole replacement for years 2018-19 for all options have been calculated based on a ratio of 3.85 poles per km of reconductoring. Similarly, for 2019-20 the ratio was 4.93 poles per km of reconductoring.

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

Ergon Energy initiated a review of its targeted replacement and asset management procedures regarding conductors due to an increasing unassisted conductor failure rate, which averaged 850 catastrophic failures per year. This high failure rate led to a significant number of conductors falling to the ground upon failure, thereby posing a substantial safety risk to the public.

We also noted that the AER REPEX modelling predicted a need for a significantly higher volume of replacements compared to our historical volume of overhead Conductor replacement.

The historical low volume of replacements resulted in:

- The accumulation of many aging assets that were in critical need of replacement.
- Reduced forecast requirements for expenditure based on a historical spending profile that didn't reflect the real need for replacements. This allocation, although initially enough to replace double the volume compared to historical averages, proved inadequate for the requirements later identified by Ergon Energy.

Nonetheless, in recent years, substantial efforts have been made to improve the quality of health profile modelling. This includes obtaining more detailed information about failures, defects, and observed condition data. Additionally, there has been a dedicated push to significantly increase replacement volumes through targeted replacements. This initiative aims to reduce conductor failures, thereby minimizing incidents of conductors falling to the ground and improving safety and reliability for the public and the community.

The asset performance data over the recent years clearly indicates a growing rate of unassisted conductor failures, necessitating an increase in targeted replacements.

6.2 Compliance

Ergon Energy has a duty to comply with all current legislative requirements and regulatory obligations as detailed in Asset Management Plan for 'Overhead Conductors'. Some of the key regulations are described in following paragraphs.

- The Electrical Safety Act 2002 (Qld) s29 places an obligation on an electricity entity to ensure that its works and assets are electrically safe and operated in a way that is electrically safe. This includes the requirement that the electricity entity inspects, tests, and maintains its assets.
- Under the Electricity Regulation 2006 (QLD) an electricity entity must, in accordance with recognised practice in the electricity industry, periodically inspect and maintain its assets to ensure the assets remain in good working order and condition. Division 4, part 9 of the Electricity Safety Regulations 2013 (Qld) contains general obligations related to

safety of works of an electrical entity with regards to this asset class, specifically obligations regarding clearances to ground and nearby structures, including vegetation clearing and management. Schedules 2 and 4 of the Regulations specify the distances required for exclusion zones and clearances.

- Good industry practice including degradation mechanisms, and holistic lifecycle management of overhead lines, is described in AS/NZS7000 Overhead Line Design Standard and previous versions of C (b) 1 – Guidelines for the Design and Maintenance of Distribution and Transmission Lines. Ergon Energy under the Electrical Safety Regulation 2013 (Qld) are required to notify the Electrical Safety Office in the occurrence of any Serious Electrical Incident (SEI) or Dangerous Electrical Event (DEE).

The desired level of service for conductors in the Ergon network is to minimise the in-service conductor failure numbers which deliver a safety risk outcome which is considered SFAIRP, and as a minimum, maintains current performance standards. The following recommendations and guidelines are also considered:

- Electricity Network Association (ENA), the peak national body representing gas and electricity distribution and transmission throughout Australia has acknowledged that Conductor's population is ageing globally and despite technological changes, there had been little change in cost-effective monitoring of conditions of Conductors.
- Ergon Energy has a strategic objective to ensure a safe, cost effective, and reliable network for the community. Performance targets associated with these asset classes, aim to reduce in-service failures to levels which deliver a safety risk outcome which is considered SFAIRP and as a minimum maintains current reliability performance standards consistent with AER SAIDI and SAIFI targets.

6.3 Counterfactual (Base Case Scenario) – AER Final Determination

6.3.1 Summary

To provide a comparison of the potential alternatives to our actual delivery for our cost benefit analysis, we have set the counterfactual to be the AER final determination forecast REPEX for Conductor replacement program. The volume has been calculated using the AER forecast REPEX for Conductor asset group and our actual unit cost.

6.3.2 Costs/Volumes

The replacement volumes and costs that have been modelled under this approach are outlined in Table 5 and Table 6. Please note that all the expenditures in counterfactual and in following sections (Option Analysis) are direct and nominal values.

Counterfactual Volume Reconductoring and Consequential Replacement	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Reconductoring	**328**	**327**	**375**	**427**	**428**	**1,885**
Pole (Consequential)	364	684	870	1,840	1,748	**5,506**
Pole Top (Consequential)	889	1,512	2,175	3,487	3,284	**11,348**
Services (Consequential)	334	813	1,369	2,045	1,370	**5,930**
Pole Transformer (Consequential)	33	117	137	162	163	**612**
Switch (Consequential)	80	80	107	204	181	**651**

Table 5: Counterfactual - Replacement Volume

Counterfactual Direct Expenditure (nominal $) Reconductoring and Consequential	2018-19 $m	2019-20 $m	2020-21 $m	2021-22 $m	2022-23 $m	Total $m
Reconductoring	**25.0**	**25.7**	**25.4**	**27.4**	**34.8**	**138.3**
Pole (Consequential)	2.4	4.5	5.8	12.4	14.0	**39.1**
Pole Top (Consequential)	1.1	3.5	4.2	5.5	9.0	**23.3**
Services (Consequential)	0.5	1.2	1.7	3.4	1.9	**8.7**
Pole Transformer (Consequential)	0.9	3.1	3.6	4.7	6.3	**18.6**
Switch (Consequential)	0.7	0.7	0.9	1.7	1.5	**5.5**
Consequential Total	**5.6**	**13.0**	**16.2**	**27.7**	**32.7**	**95.2**

Table 6: Counterfactual – Replacement Costs/Expenditure

6.3.3 Risk quantification

We have determined the risk values for a twenty-year time horizon as a period representative of the expected period of realisable benefits from any program interventions.

The key attributes of our modelling approach in determining the counterfactual risks are set out in Section 4.2. The results of a quantitative forecast of emerging risk are depicted in Figure 10 which shows that there would have been significant risk costs associated with maintaining the replacement volumes within the AER forecast. The cost of these risks increases substantially over the 20-year period shown.

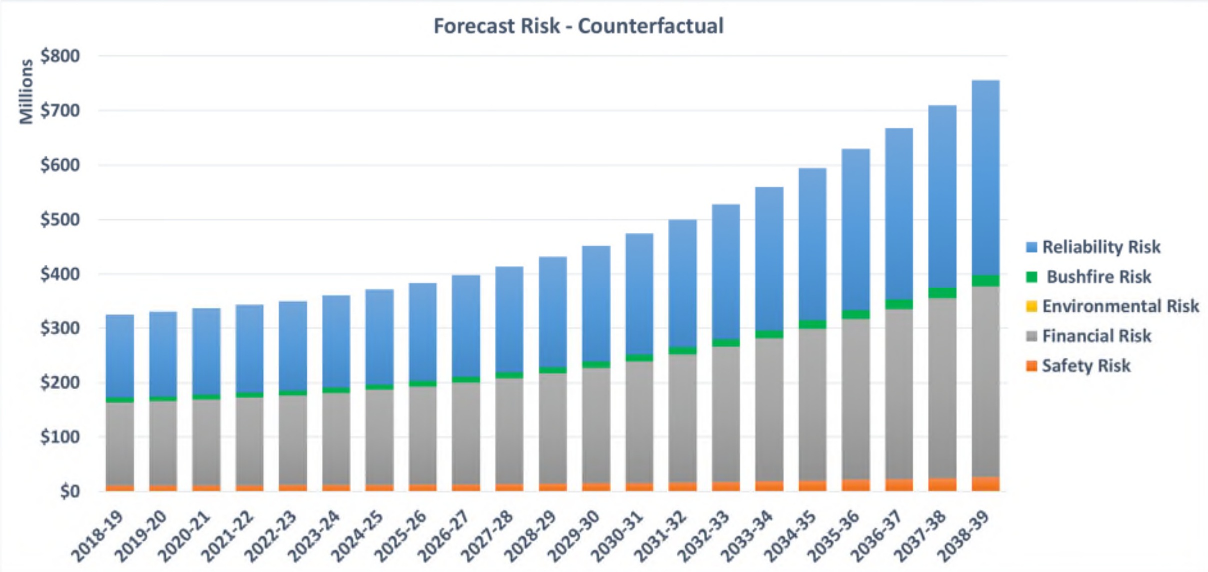

Figure 10: Counterfactual quantitative risk

Figure 11 represents the failure forecast where the rate continues to rise. This leads to a number of Conductors falling on the ground which could increase exponentially with a large volume of problematic Conductors in the network breaking frequently and increasing public safety risks and reducing the current reliability of the network.

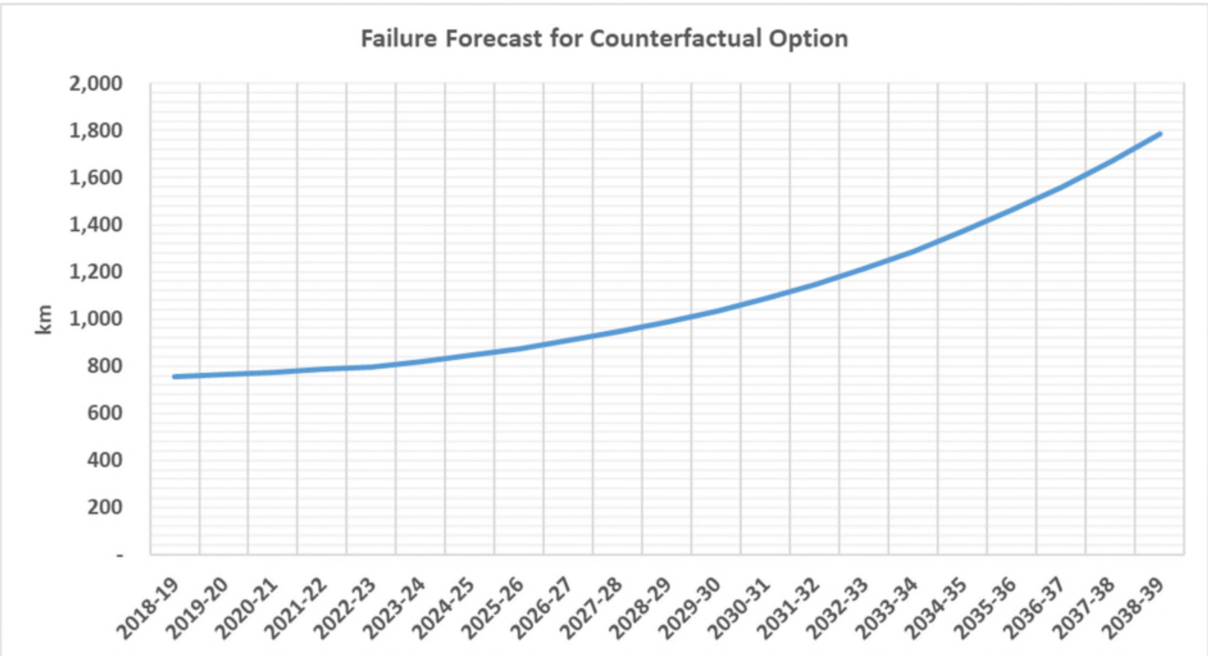

Figure 11: Conductor failure forecast - Counterfactual

7 OPTIONS ANALYSIS

In assessing the prudency 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

The historical volume option involves maintaining the targeted average replacement volume that was replaced between 2015-16 and 2017-18. We note that this rate of replacement led to a significant decline in asset performance over time, outlined in previous sections.

7.1.1 Costs and Volumes

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

Historical Volume Reconductoring and Consequential Replacement	2018-19 (km)	2019-20 (km)	2020-21 (km)	2021-22 (km)	2022-23 (km)	Total (km)
Reconductoring	**160**	**160**	**160**	**160**	**160**	**800**
Pole (Consequential)	178	335	371	689	653	**2,226**
Pole Top (Consequential)	434	740	928	1,307	1,228	**4,636**
Services (Consequential)	163	398	584	766	512	**2,423**
Pole Transformer (Consequential)	16	57	59	61	61	**253**
Switch (Consequential)	39	39	46	76	68	**268**

Table 7: Option 1 - Replacement Volume

Historical Direct Expenditure (nominal $) Reconductoring and Consequential	2018-19 $m	2019-20 $m	2020-21 $m	2021-22 $m	2022-23 $m	Total $m
Reconductoring	**12.0**	**12.6**	**12.3**	**12.4**	**12.6**	**61.9**
Pole (Consequential)	1.2	2.2	2.5	4.6	5.2	**15.7**
Pole Top (Consequential)	0.6	1.7	1.8	2.1	3.3	**9.5**
Services (Consequential)	0.3	0.6	0.7	1.3	0.7	**3.6**
Pole Transformer (Consequential)	0.4	1.5	1.5	1.8	2.4	**7.6**
Switch (Consequential)	0.3	0.3	0.4	0.6	0.6	**2.2**
Consequential Total	**2.8**	**6.3**	**6.9**	**10.4**	**12.2**	**38.6**

Table 8: Option 1 - Replacement Costs

7.1.2 Risks/Benefits

In this option, our modelling shows that unassisted conductor failures are projected to remain significantly higher than those in the counterfactual option providing a worse outcome for the community and our customers in both the short and long term. Furthermore, this approach would have resulted in a growing need for substantial investment in the near future due to the escalating rate of asset failures. This is primarily due to the large volume of problematic conductors in active service for longer periods. Accordingly, this is the worst option among all options and not considered further.

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

This option includes replacement of all Conductors assessed with HI over 7.5. This is a possible option which involves a substantial increase in replacement volumes leading to considerable improvement in asset performance and risk reduction to the community. However, significant investment requirements for this option have higher costs than alternative options and would have seen practical difficulties in delivering this work through the ex post period.

7.2.1 Cost/Volumes

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

Health Index Volume **Reconductoring and Consequential Replacement**	**2018-19 (km)**	**2019-20 (km)**	**2020-21 (km)**	**2021-22 (km)**	**2022-23 (km)**	**Total (km)**
Reconductoring	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**	**6,000**
Pole (Consequential)	1,332	2,510	2,785	5,170	4,901	**16,698**
Pole Top (Consequential)	3,254	5,550	6,960	9,799	9,209	**34,771**
Services (Consequential)	1,221	2,985	4,379	5,747	3,840	**18,172**
Pole Transformer (Consequential)	120	428	440	454	457	**1,899**
Switch (Consequential)	293	294	342	573	507	**2,008**

Table 9: Option 2 - Replacement Volume

Health Index Direct Expenditure (nominal $) **Reconductoring and Consequential**	**2018-19 $m**	**2019-20 $m**	**2020-21 $m**	**2021-22 $m**	**2022-23 $m**	**Total $m**
Reconductoring	**91.1**	**87.7**	**103.3**	**91.0**	**81.0**	**454.1**
Pole (Consequential)	8.7	16.7	18.6	34.8	39.2	**118.0**
Pole Top (Consequential)	4.1	13.0	13.5	15.5	25.1	**71.2**
Services (Consequential)	1.9	4.5	5.4	9.6	5.2	**26.6**
Pole Transformer (Consequential)	3.3	11.3	11.5	13.2	17.7	**57.0**
Switch (Consequential)	2.4	2.4	2.8	4.8	4.2	**16.6**
Consequential Total	**20.4**	**47.9**	**51.8**	**77.9**	**91.4**	**289.4**

Table 10: Option 2 - Replacement Costs

7.2.2 Risks/Benefits

Our modelling predicts that this approach would result in unassisted Conductor failures being notably reduced in comparison to the counterfactual option. This transition aims to bring the failure rate within desirable limits and ensuring a satisfactory level of reliability and reducing public safety risks.

7.3 Option 3 – AER REPEX Live Scenario

This option volume is based on REPEX model live scenario output, to achieve a service life of 84 years. This is a viable option of replacing approximately 1,714 km of Conductor per year. Even though this option forecasts the best asset performance improvement, the significant investment requirements of this option has higher costs than alternative options and would have seen practical difficulties in delivering this work through the ex post period.

7.3.1 Cost/Volumes

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

AER REPEX Live Scenario Reconductoring and Consequential Replacement	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Reconductoring	**1,714**	**1,714**	**1,714**	**1,714**	**1,714**	**8,570**
Pole (Consequential)	1,903	3,585	3,977	7,385	7,000	**23,850**
Pole Top (Consequential)	4,647	7,927	9,941	13,996	13,153	**49,665**
Services (Consequential)	1,744	4,263	6,255	8,209	5,485	**25,956**
Pole Transformer (Consequential)	171	612	628	649	653	**2,713**
Switch (Consequential)	418	419	488	818	724	**2,868**

Table 11: Option 3 - Replacement Volume

AER REPEX Live Scenario Direct Expenditure (nominal $) Reconductoring and Consequential	2018-19 $m	2019-20 $m	2020-21 $m	2021-22 $m	2022-23 $m	Total $m
Reconductoring	**124.3**	**143.8**	**126.5**	**120.6**	**117.3**	**632.5**
Pole (Consequential)	12.4	23.8	26.5	49.7	55.9	**168.3**
Pole Top (Consequential)	5.9	18.6	19.3	22.1	35.9	**101.8**
Services (Consequential)	2.8	6.4	7.7	13.7	7.5	**38.1**
Pole Transformer (Consequential)	4.8	16.2	16.5	18.9	25.3	**81.7**
Switch (Consequential)	3.5	3.5	4.1	6.8	6.0	**23.9**
Consequential Total	29.4	68.5	74.1	111.2	130.6	413.8

Table 12: Option 3 - Replacement Costs

7.3.2 Risks/Benefits

Under this option our modelling indicates that unassisted Conductor failures would have been significantly lower compared to the counterfactual option in the long term. However, it involves a significant step up in investment costs.

Additionally, our recent failure and defect analysis shows that problematic conductors can’t achieve the same level of lifespan as other conductors. Moving to an aged-based replacement philosophy may not result in a significant lowering of unassisted conductor failures in the short term, given we have over 7,000 km of problematic conductors in the network. However, this option would be effective after the elimination of all problematic conductors.

7.4 Option 4 – Actual Delivery (Selected Option)

This option involves replacement of targeted conductors assessed through historical performance and health index model outcome. This is the optimum option as it provides significant benefits to the community and our customers with moderate additional investment compared to counterfactual.

7.4.1 Cost/Volumes

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

Actual Delivery Volume **Reconductoring and Consequential Replacement**	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**Total**
Reconductoring (km)	**381**	**356**	**551**	**658**	**577**	**2,523**
Pole (Consequential)	423	744	1,279	2,835	2,358	**7,639**
Pole Top (Consequential)	1,033	1,645	3,197	5,373	4,431	**15,679**
Services (Consequential)	388	885	2,012	3,151	1,848	**8,283**
Pole Transformer (Consequential)	38	127	202	249	220	**836**
Switch (Consequential)	93	87	157	314	244	**895**

Table 13: Option 4 - Replacement Volume

Actual Delivery Direct Expenditure (nominal $) **Reconductoring and Consequential**	**2018-19** **$m**	**2019-20** **$m**	**2020-21** **$m**	**2021-22** **$m**	**2022-23** **$m**	**Total** **$m**
Reconductoring	**29.1**	**28.0**	**35.1**	**50.8**	**45.6**	**188.6**
Pole (Consequential)	2.8	4.9	8.5	19.1	18.8	**54.1**
Pole Top (Consequential)	1.3	3.9	6.2	8.5	12.1	**32.0**
Services (Consequential)	0.6	1.3	2.5	5.3	2.5	**12.2**
Pole Transformer (Consequential)	1.1	3.4	5.3	6.0	8.1	**23.9**
Switch (Consequential)	0.5	2.0	3.4	5.2	4.2	**15.3**
Consequential Total	**6.3**	**15.5**	**25.9**	**44.1**	**45.7**	**137.5**

Table 14: Option 4 - Replacement Costs

7.4.2 Risks/Benefits

In this option, our modelling indicates an improved asset performance compared to the counterfactual option. This option stands out as the most effective choice to gradually transition towards the objective of lowering the failure rate. The delivery of our program demonstrated that we have the resourcing capability to undertake this level of investment increase.

Although this option transitions towards improvements at a gradual pace, it's essential to have a step change of investment in the future to continue improving customer benefits and avoid the need for a significant increase in near-term investments.

8 OUTCOME OF OPTIONS ANALYSIS

8.1 Failure Forecast Analysis

The failure rate forecast for all the options have been provided in Figure 12. For option 4 (actual delivery), the five-year failure forecast rate from our model for the ex post period is equal to the actual volume of failures we saw through the ex post period. That is, our model predicted the approximate 770 failures / year that we saw over the same period.

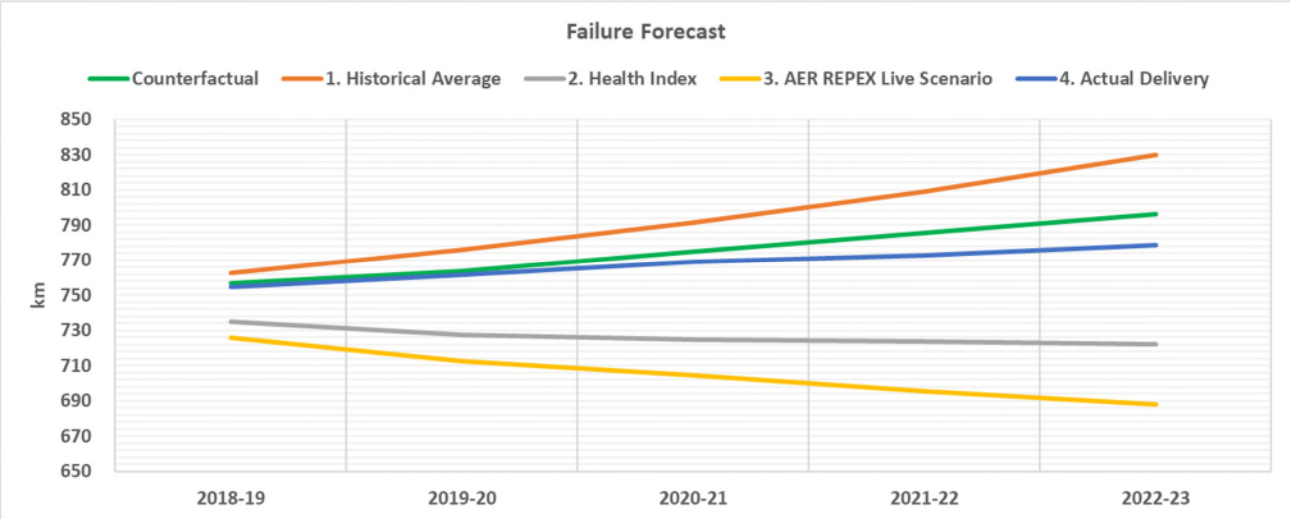

Figure 12: Failures Forecast – Intervention Options

As shown, Option 2 and 3 are the best options for asset performance improvement. However, they also require a massive step change in investment and resources. The counterfactual and historical average options would not have been prudent as they would have resulted in an escalation of the already high failure rates.

The actual delivery (Option 4) maintains the current failure rate and provides a path to gradually reducing failure rates in the future.

8.2 Economic Analysis

The NPV of cost benefit analysis of the options are summarised in Table 15. This 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.
- Option 1 – Historical Average volume, which was already been identified unsustainable as per Ergon Energy review (section 3 and section 6.1). This has been further confirmed by the negative NPV from the modelling.

- An increased volume of replacements over Option 2 and 3, as per Volume Summary Table 16, would have delivered even higher benefit, however this would have had a major impact on our resource capability.

Base Case including CCPEX							
NPV Analysis to Counterfactual						Consequential (25% Benefit Factor)	
		Rank	Net NPV incl CONPEX	CAPEX (NPV)	Benefit (NPV)	CCPEX NPV	CCPEX Benefits NPV
	Counterfactual	4	0	$0	$0	$0	$0
Option 1	Historical Average	5	-$166,194,198	$52,004,469	-$233,858,809	$42,009,194	-$26,349,053
Option 2	Health Index	2	$481,398,107	-$464,784,378	$1,013,082,717	-$147,633,287	$80,733,055
Option 3	AER REPEX Live Scenario	1	$552,681,267	-$637,442,672	$1,314,044,279	-$243,493,048	$119,572,708
Option 4	Actual Delivery	3	$207,945,350	-$67,132,098	$284,963,905	-$27,302,378	$17,415,920

Table 15: NPV Modelling and Consequential Benefits

Replacement (km)						
		2018-19	2019-20	2020-21	2021-22	2022-23
	Counterfactual	328	327	372	427	428
Option 1	Historical Average	160	160	160	160	160
Option 2	Health Index	1,199	1,199	1,199	1,199	1,199
Option 3	AER REPEX Live Scenario	1,714	1,714	1,714	1,714	1,713
Option 4	Actual Delivery	380	355	549	656	577

Table 16: Replacement Volumes – All Options

Table 17 shows the NPV data including the consequential costs and benefits (CCPEX), with details for consequential assets individually, providing further insight into the options outcomes.

NPV Analysis to Counterfactual				Conductor		Consequential (25% Benefit Factor)		
Options		Rank	Net NPV incl CONPEX	CAPEX (NPV)	Benefit (NPV)	Pole Attached Assets	CCPEX NPV	CCPEX Benefits NPV
Counterfactual	**AER Determination**	**4**	$0	$0	$0		**$0**	**$0**
						Pole	$0	$0
						Pole Top	$0	$0
						Services	$0	$0
						Pole Top Transformer	$0	$0
						Switches	$0	$0
Option 1	**Historical Average**	**5**	**-$166,194,198**	**$52,004,469**	**-$233,858,809**		**$42,009,194**	**-$26,349,053**
						Pole	$19,038,487	-$21,666,343
						Pole Top	$8,791,342	-$2,136,202
						Services	$2,830,844	-$1,265,886
						Pole Top Transformer	$6,487,832	-$1,554,107
						Switches	$4,860,690	$273,485
Option 2	**Health Index**	**2**	**$481,398,107**	**-$464,784,378**	**$1,013,082,717**		**-$147,633,287**	**$80,733,055**
						Pole	-$67,998,161	$58,017,436
						Pole Top	-$30,125,748	$7,514,701
						Services	-$9,627,761	$4,405,043
						Pole Top Transformer	-$22,867,253	$5,640,727
						Switches	-$17,014,364	$5,155,147
Option 3	**AER REPEX Live Scenario**	**1**	**$552,681,267**	**-$637,442,672**	**$1,314,044,279**		**-$243,493,048**	**$119,572,708**
						Pole	-$113,088,398	$83,433,372
						Pole Top	-$49,400,832	$12,270,667
						Services	-$15,785,539	$7,202,711
						Pole Top Transformer	-$37,383,320	$9,175,453
						Switches	-$27,834,958	$7,490,504
Option 4	**Actual Delivery**	**3**	**$207,945,350**	**-$67,132,098**	**$284,963,905**		**-$27,302,378**	**$17,415,920**
						Pole	-$12,315,210	$12,140,467
						Pole Top	-$5,597,725	$1,368,756
						Services	-$2,167,406	$943,830
						Pole Top Transformer	-$4,119,518	$962,686
						Switches	-$3,102,517	$2,000,181

Table 17: NPV Modelling and Detailed Consequential Benefits

Figure 13 compares the net NPV progression and gains over the modelling period compared to counterfactual option. This indicates significant NPV gains for Option 2 and 3.

Option 4 achieves the comparable gains among options and reaches towards most optimum solution in terms of investment and net NPV gains. Further this is the only option that has the practical deliverable plan and achieve asset performance improvement and benefit to customers.

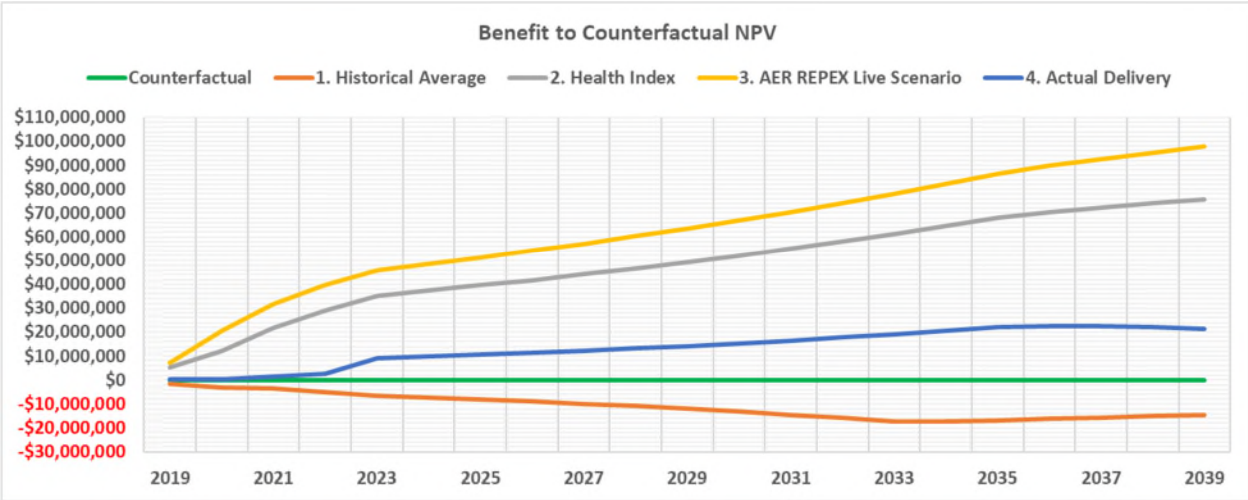

Figure 13: Benefit to Counterfactual NPV

Table 16 provides the summary of key points of investment, customer benefits, net benefits and risks associated with each intervention option.

The analysis presented in Table 17 compares the options to their respective counterfactual alternatives.

Criteria	Option 1 – Historical Volumes	Option 2 – Health Index >7.5HI	Option 3 – AER REPEX Live Scenario	Option 4 – Actual Delivery – **Selected Option**
Net NPV	-$166m	$481m	$553m	$208m
Benefits	Negative	High	Very High	Med/High
Delivery Constraint	Low	Very High	Very High	Med
Detailed analysis – Advantage	• Much lower than the AER replacement forecast determination. • Below AER REPEX model prediction • Do minimal option • Lowest cost option with investment savings of $94m.	• Community benefits of $1b • Removes all defective and poor condition assets (over HI of 7.5) from the network. • Positive NPV	• Customer/community benefit of $1.3b • Removes all significantly older assets from the network. • Best option for safety and reliability performance improvement. • Avoid long term substantial investment.	• Additional $0.3b Customer/Community Benefit • Transition towards improving the asset performance. Medium impact on delivery requirement compared to option 2 and 3 • Lowest additional investment of $94m among NPV positive options.
Detailed analysis – Disadvantage	• Negative NPV • Several defective Conductors left in service - elevated risk level • Leads to more investment in future • Significant risk of increasing unassisted failures.	• Significantly expensive option requiring additional investment of $613m • High impact on delivery requirement • Double the current resource requirement.	• Significantly higher investment requirement of $880m • High impact on delivery requirement • Double the current resource requirement. • Not a practical step change from current delivery plan.	• Medium delivery impact. • Slower transition towards asset performance improvement.

Table 18: Options analysis scorecard

9 SUMMARY

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

The modelling confirms that the total investment in targeted conductor replacement of $94m in actual delivery, provided a positive NPV benefit of $208m compared to the counterfactual option of the AER's forecasted volume replacement.

While Option 4 has not resulted in conductor failure rates reductions, it is the minimum level required to avoid the escalating trend and provide a path to achieving asset performance improvements.

It is noted that the modelled result for Option 4 shows that Conductors failure rates are likely to maintain at current level. Hence, we forecast that the increased level of remediation programs will be required in the next regulatory control period to reduce the failure rate in the future.

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 scenarios. 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 Actual delivery option is reflective of our commitment to provide maximum customer benefit. It provides a tolerable risk position which balances the achievement of our asset management objectives and customer service levels and ensures a sustainable level of investment.