Overhead Conductor Replacements

Business Case

19 January 2024

Part of Energy Queensland

CONTENTS

List of Tables

List of Figures

DOCUMENT VERSION

Version Number	Change Detail	Date	Updated by
Draft v0.1	AER Document Initial release	06/10/2023	Snr Asset Engineer
Draft v0.2	Draft	10/11/2023	Snr Engineer Asset Strategy
V1.0	Approved	16/11/2023	Manager Asset Strategy

RELATED DOCUMENTS

Document Date	Document Name	Document Type
JAN 2024	Asset Management Plan – Overhead Conductor	PDF
NOV 2023	Overhead Conductor Risk Modelling	Docx & Excel
NOV 2023	Overhead Conductor CBRM/CNAIM Model R-code	Excel
JUN 2023	RIN 2.2 Compare 2021-22 (Rosetta)	Excel
NOV 2023	Ergon 2022-23 - Category Analysis - RIN Response - Consolidated - 23 November 2023 – PUBLIC (16058117.2)	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 Replacements
DNSP	Ergon Energy Network
Expenditure category	☒ Replacement ☐ Augmentation ☐ Connections ☐ Tools and Equipment ☐ ICT ☐ Property ☐ Fleet
Purpose	The purpose of this Business Case is: • to evaluate the benefits of the proposed replacement volume of Overhead (OH) Conductors for the 2025-30 regulatory control period. • to support the Ergon Energy's forecast capital expenditure over the regulatory control period through 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 support 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 efforts to maximise the value for our customers. Investment in the replacement of conductors is required to comply with legislation and regulatory obligations and to manage reliability, financial, safety, environmental risks. For the last five years, Ergon Energy has been experiencing a significant number of unassisted failures of our OH conductors; regularly exceeding 850 incidents per year. 25% of which failures resulted in conductors falling to the ground leading to dangerous electrical events (DEE). This posed significant safety hazards to the public and jeopardised the reliability of service for customers and the community. Based on our analysis of defect and fault data, specific types of conductors are being targeted for replacements namely Hard Drawn Bare Copper (HDBC) conductors. Although Ergon Energy has made all efforts to step-up the replacement volumes for the worst condition OH conductors during the last five years, progress is still lagging significantly. Considering more than 6,000 km of this type of conductor is still within the network, continuation of increased replacement volumes is essential over the 2025-30 regulatory control period, with further increment preferred as proposed.

Alternate options	A continuation of our current replacement rate of 550km per year is set as the counterfactual (base case). Four other replacement options were identified as follows: 1. Repex Model – Cost Scenario – Average 601 km/year 2. Based on Health Index of ≥ 7.5 – Average 2020 km/year 3. Repex Model Live Scenario – Average 802 km/year *4.* Proposed Program – Average 750 km/year (**Preferred)**
Expenditure	This business case relates to the targeted OH conductor replacement and associated consequential assets, such as poles, pole-top structures (crossarms) and low voltage services as shown below.

Year $m, direct 2022-23	**2025-26**	**2026-27**	**2027-28**	**2028-29**	**2029-30**	**Total**
Targeted Replacement	34.5	36.2	37.4	38.5	39.1	185.7
Defect	5.3	5.3	5.3	5.3	5.3	26.5
Conductor Reset RIN Total*	**39.8**	**41.5**	**42.7**	**43.8**	**44.4**	**212.2**
Pole	15.8	16.5	17	17.4	17.6	84.3
Pole-top	14.3	14.9	15.4	15.8	16	76.4
Services	3.7	3.8	3.9	4	4.1	19.5
Distribution Transformers	7.7	8.1	8.3	8.5	8.6	41.2
Fuses	4.2	5.3	5.5	5.7	5.8	26.6
Distribution Switches	2.6	2.8	2.8	2.9	2.9	14.0
Consequential Total*	**48.4**	**51.4**	**52.9**	**54.3**	**55.1**	**262.1**
Overall REPEX Investment (this business case)*	88.3	92.9	95.6	98.1	99.5	474.4

** Expenditure considered for this business case.*

Benefits	Utilising our cost benefit model, 'Option 4, which is the replacement of 750km per year is the highest value option, as it provides the best balance of benefits, deliverability capability and risk for the organization. This option provides a positive NPV of $31m and customer benefits of $150m over the 20 year modelling period.

2 PURPOSE AND SCOPE

The purpose of this business case is to evaluate the benefits of the proposed increased volume of targeted conductor replacements over the 2025-30 regulatory control period. A full cost benefit analysis was undertaken to evaluate and compare alternative options to validate that the proposed expenditure is prudent.

This business case 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 occurred while replacing the conductor..

This document is to be read in conjunction with the Asset Management Plan – Overhead Conductors which contains detailed information on the asset class, populations, risks, asset management objectives, performance history, influencing factors, and the lifecycle strategy.

All financial references in this document are based on real $2022-23 and exclude overheads.

3 BACKGROUND

Overhead conductors are an asset of strategic importance to Ergon Energy 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 the Ergon Energy business objectives related to safety, customers, and compliance.

Ergon Energy maintains a diverse population of bare and insulated overhead conductor types and sizes from its six legacy organisations. The length of the asset's operational life, changes in period supply contracts, and advancements in conductor technology further contributed to the variety of the overhead population. Galvanised steel is the predominant active conductor type due to its prevalence on the rural network.

Factors influencing the effective management of overhead conductor assets include the large, geographically dispersed asset population, the age, range and variability of conductor materials, and the diverse environmental and operational conditions.

The overhead conductor targeted replacement program being proposed is determined using historical data of failures and defects. This is due to the high unassisted failure rate, which presents a significant risk to the community. Targeted replacement is necessary to address the root causes of these failures and improve the reliability of the assets. When considering replacement rate, forward planning is essential, as replacing assets on an ad-hoc basis is inefficient and may not be sustainable. By implementing a targeted and strategic replacement plan for the longer term, it will ensure the assets are performing at their optimal level and reduce the risk of future failures.

Additionally, to meet the regulatory obligations of operating an electrically safe network, we have commenced proactive conductor replacement programs to remove poor performance, high risk, aged conductor from the network with particular focus on small diameter hard drawn bare copper (HDBC).

3.1 Asset Population

Ergon Energy maintains a population of approximately 144,815 km of OH conductor route length throughout Queensland at distribution, sub-transmission, and transmission voltages. Approximately 47% of overhead conductor assets are installed at distribution voltages of less than or equal to 11kV. Around 34% (5,000 km) of the overhead conductor population is installed as part of the single wire earth return (SWER) distribution network.

SWER conductors are expected to have a service life ranging from 50 years to 70 years based on type, size, and voltage. By the year 2025, around 27,700 km, 12,600 km and 9,200 km will be greater than 50 years, 60 years, and 70 years old respectively.

Ergon Energy derives conductor age based on the pole installation date, as the installation date of conductors has not historically been recorded. This has proven to be a reasonable representation where the original poles remain in situ. Where pole replacement has occurred, the conductor age is derived from the installation date of the oldest pole supporting that section of conductor. The age profile for the overhead conductor asset base is shown in Figure 1.

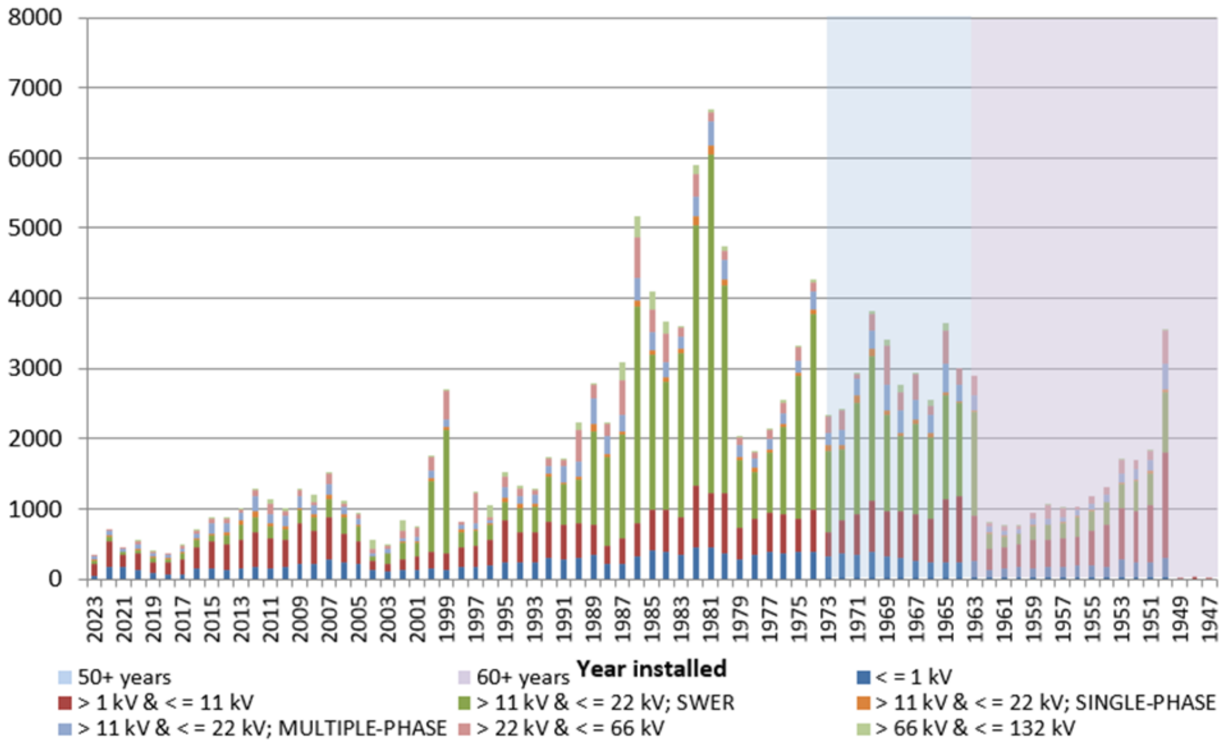

Figure 1: Age Profile Overhead Conductors

3.2 Asset Management Overview

Overhead conductors are an asset of strategic importance to network businesses 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 adversely impacts 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 or Maintenance Acceptability Criteria and in line with best industry benchmark practices.

Additionally, Ergon Energy has been continuously improving the recording of 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 starting to provide the information necessary to support improvements in inspection, maintenance, and asset management practices.

Replacement work practices are optimised to achieve bulk replacement with minimised overall cost and customer impact. Conductors are proactively replaced based on a condition-based risk management process utilising asset performance trends as the key input; with specific criteria to indicate assets if are either at, or near, end of service life.

To meet the regulatory obligations of operating an electrically safe network, we have increased targeted conductor replacement programs to remove high risk aged conductor from the network with particular focus on small diameter HDBC conductor due to poor performance. The volume of aged, small diameter HDBC in high-risk areas replaced per annum will need to be increased significantly to manage this risk. The addition of aging Galvanised Steel (SC/GZ) and Steel Reinforced Aluminium Conductor (ACSR) into these targeted programs is also proposed, prioritised by safety risk and the influence of coastal environments. The targeted program (in order of priority) consists of replacement 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 over 70
- Coastal galvanised steel 3/12 SC/GZ conductor aged over 55
- Coastal ACSR and Aluminium imperial conductor aged over 70.

3.3 Asset Performance

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

Functional Failure Type	Description
Catastrophic (Unassisted failure)	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 requires 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 effectively dictates whether normal planning processes are employed (P2), or more urgent repair works are initiated (P1 and P0).

Figure 2 and Figure 3 display the number of unassisted failures and defects respectively. Ergon Energy continues to progress through an increased step change targeted conductor replacement program which has seen defect volumes reduce. A delayed impact on failures is expected due to the higher volume of overhead networks assets exceeding useful life as shown in the age profile and predictive model.

Leading conductor defects include corrosion and loss of strands resulting in loss of conductor strength. Unassisted failure will eventually occur if these defects are left unaddressed. The number of joints in a span could also cause deterioration as part of normal wear and tear, or during hostile environmental conditions, which could lead to conductor failure. The number of joints increases over the life of the asset.

Modified inspection and condition assessments now record number of joints in a span to provide improved in conductor asset data and management.

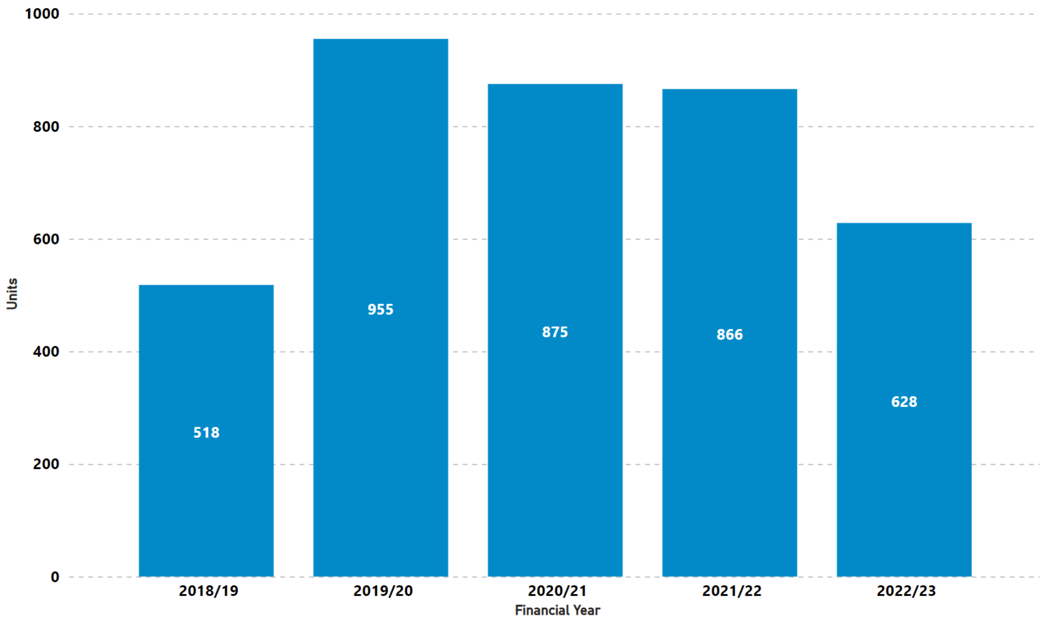

Figure 2: Unassisted OH Conductor Failures

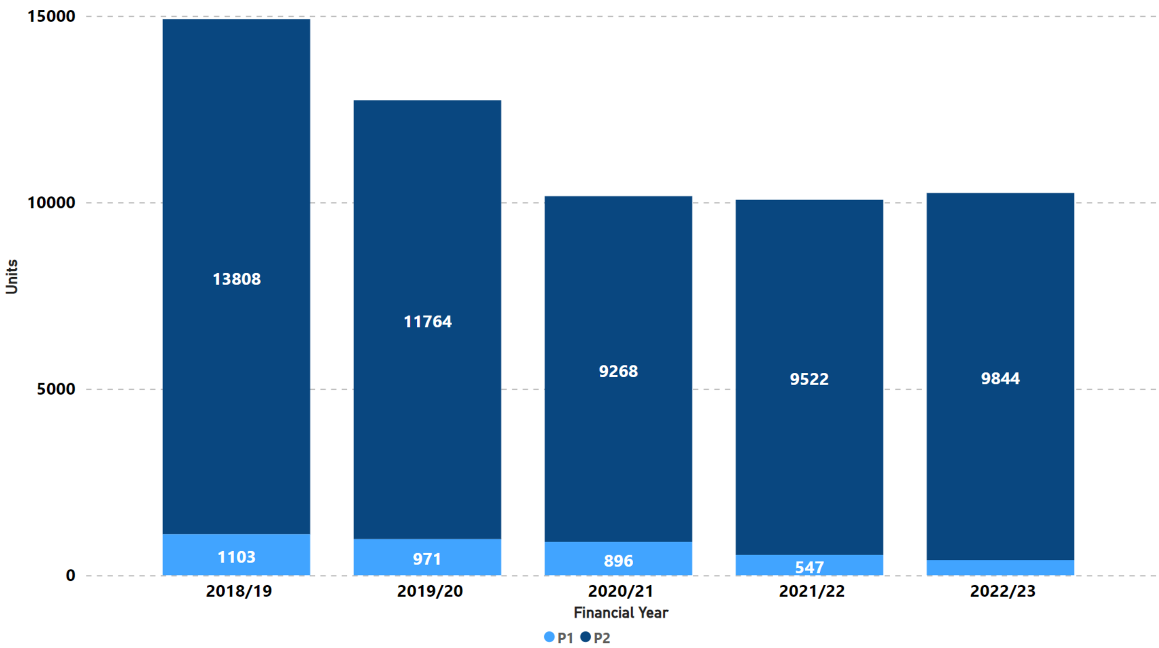

Figure 3: OH Conductor Defects

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 Calculations

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; the 'Export' is not material to conductors.

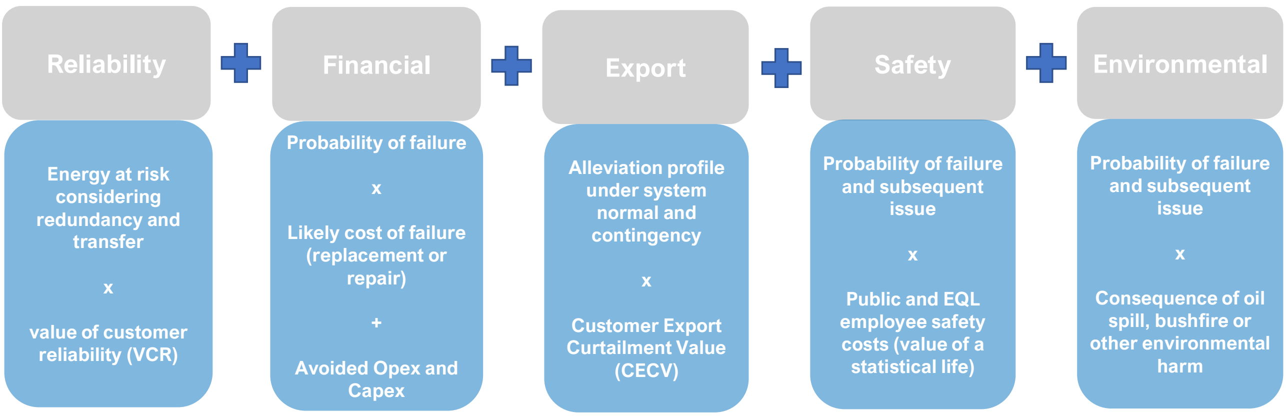

Figure 5: Risk Streams for Assets

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

To determine asset condition, several contributing factors have been considered including appropriate probabilistic impact scales aligning with Condition Based Risk Management (CBRM) and Common Network Asset Indices Methodology (CNAIM) principles. Both measured (number of joints in a span) and observed condition data (wear and tear, corrosion etc) from inspections are incorporated into the Health Index (HI) for all conductors calculating the future probability of failure (PoF) to estimate prudent replacement volume as per Figure 6. Where condition data is limited, the HI is developed utilising asset performance trends according to conductor type. The HI is calculated on a scale of 0 to 10 representing the extent of condition degradation:

- 0 indicating new conductor in excellent condition, very low PoF
- 10 indicating the worst condition, high PoF.

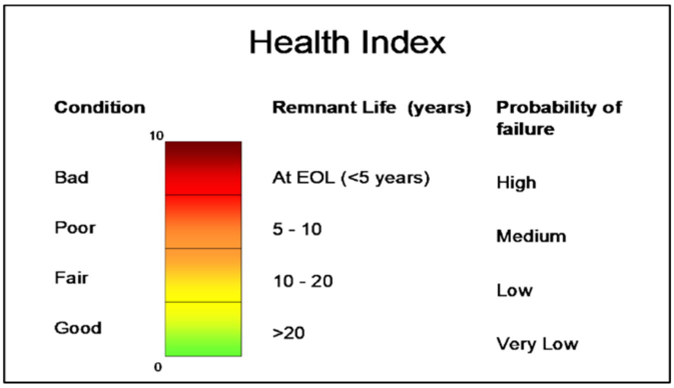

Figure 6: HI and PoF Relationship

The relationship between HI and PoF is not linear in Figure 7; 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. Data analytics show a HI of 7.5 is typically used as the point at which assets are identified as candidates for intervention.

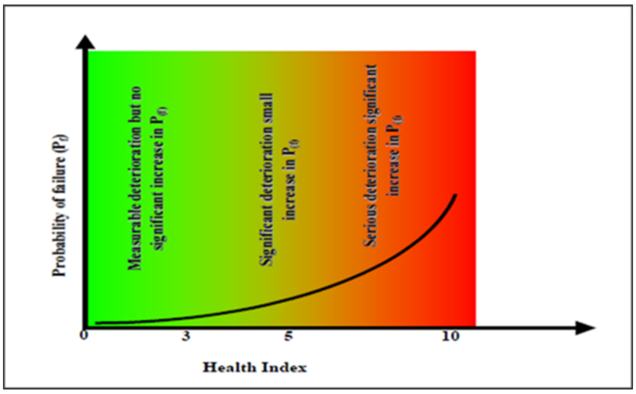

Figure 7: HI and PoF Relationship Graph

FY23 analytics show approximately 6,750 km of conductor identified with a HI of >7.5, requiring intervention in the next few years as per Figure 8. However, interventions are assessed in conjunction with cost benefit analysis identifying various replacement options across HI bands ensuring maximum customer value from asset management decisions.

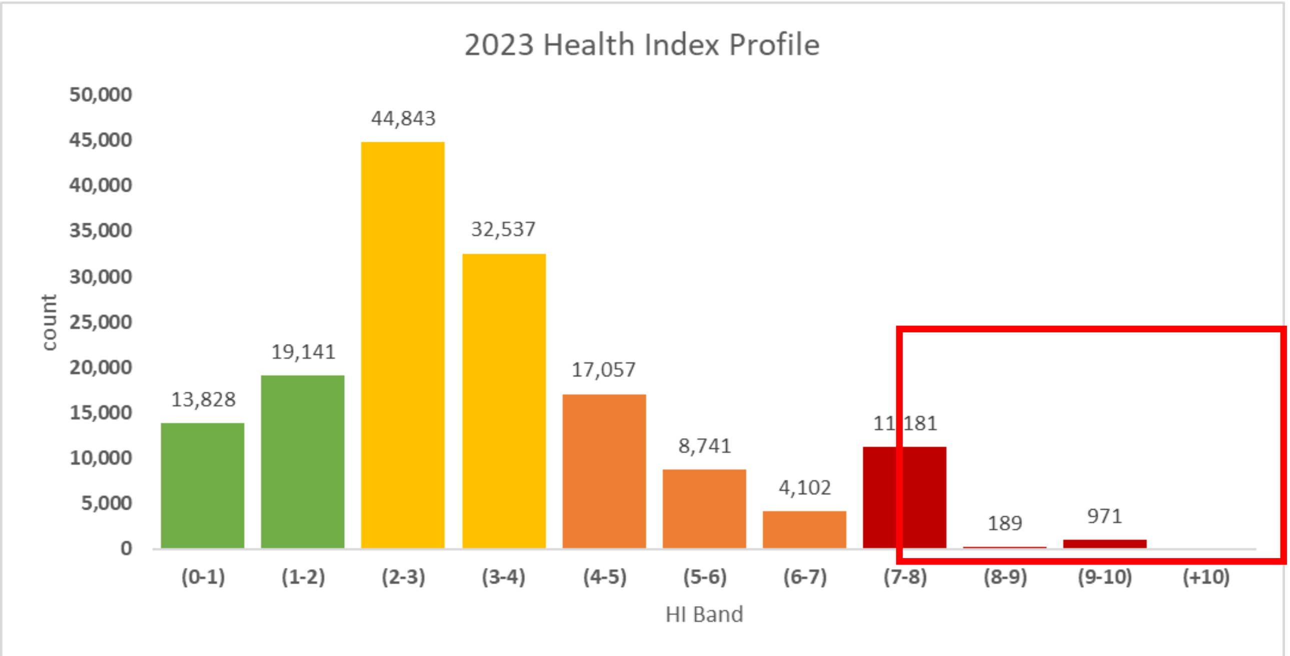

Figure 8: HI Summary OH Conductors 2023

Conductor HI values forecasted to the end of the modelling period (FY43) as per CBRM indicate approximately 40,534km of conductor >7.5 as per Figure 9. To mitigate this state, an average of 2,020km of conductor intervention per year over the next 20 years would be required. This is significantly higher than the existing rate requiring a significant step change in resources and budget which is not considered feasible at this stage.

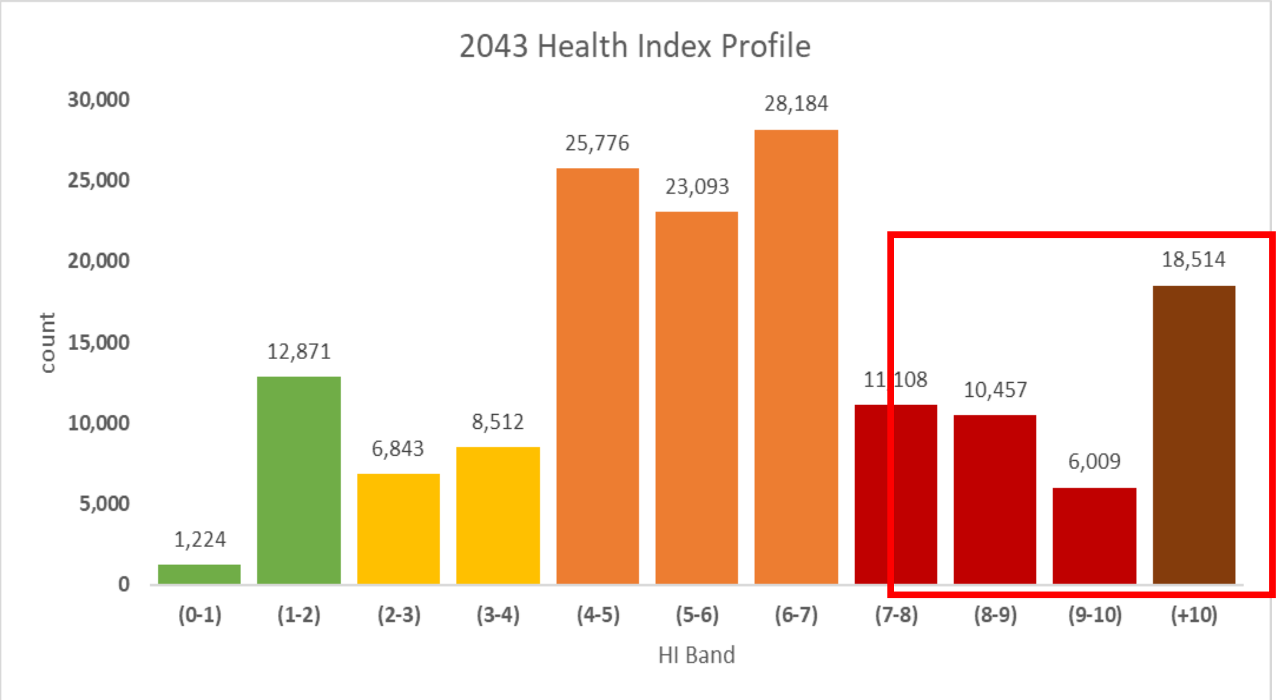

Figure 9: Future HI for OH Conductor EE

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

In identifying the value of our level of intervention over the 2025-30 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 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.

To the extent possible the CoF and LoC are conductor 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 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 and customer kWh loss and duration due to this event is utilised to determine the lost load that would on average be lost following a conductor failure.
- **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 weighted average replacement cost per kilometre for a conductor is $56,500. This is the same whether proactive, defective replacement or replacement following a failure. The cost ranges from $23,000/km for a 11 kV SWER line to $500,000/km for a sub-transmission line conductor.
- **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 the 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 analysing 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:

- **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 km of conductor has been estimated as $11,228.
- **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 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 REPLACEMENT

During OH conductor replacement, condition of the supporting structure (poles) and other equipment affixed to the supporting structure is evaluated to determine whether it is feasible and cost-effective to replace them. These equipment encompasses poles, crossarms, transformers, service lines, and switches.

In the cost-benefit analysis, we consider the replacement of this equipment as an integral part of conductor replacement. Hence, we have included the investments and benefits associated with these consequential replacements into the analysis to ensure that the overall replacement costs and benefits are factored into the modelling.

The consequential asset volume replacement under the proposed OH conductor replacement program over the 2025-30 regulatory control period is shown in Table 2.

Proposed Program (2025-30) Consequential Replacement Volume	2025-26	2026-27	2027-28	2028-29	2029-30	Total
Pole	2,537	2,646	2,719	2,791	2,827	13,522
Pole Top	5,097	5,317	5,461	5,607	5,680	27,162
Services	2,749	2,867	2,945	3,024	3,063	14,647
Pole Transformer	264	275	283	290	294	1,407
Fuse	528	550	566	580	582	2,814
Switch	280	292	300	308	312	1,494

Table 2: Consequential Asset Volume in Reconductor Program – Proposed Program

5.1 Benefit Assumptions

Cost benefit modelling has been employed to account for the costs and benefits of proposed asset replacement in Table 2.

Table 3 outlines an 'advanced' or brought forward view of asset replacement including used service life at the time of replacement.

Consequential Replacement Asset Description	Average failure age in Years as per Weibull Analysis	Estimated Average Age at the time of conductor replacement with conductor age of 55	% Life already Used at conductor replacement time
Poles	58	53	95%
Switches	21	13	62%
Pole Top Structure	41.5	13.5	32.5%
Pole Transformers	33	22	66%
Services	37	18	49%

Table 3: Estimated Used Life of Consequential Assets

Consequential pole top structures are estimated to be replaced with only 32.5% life used; the asset providing least benefit from replacement as 67.5% life is still unused. Similarly, services provide 49 % benefits while transformer and switches provide benefits of 66% and 62% respectively. Poles replaced selectively over 55 years provide maximum consequential benefit of around 95% with minimal remaining life. However, our conservative approach is to assume that all the consequential assets are replaced at 75% of remaining life. In the Post Implementation Review (PIR) of our expenditure over the 2018-19 to 2022-3 period, we allocated 25% of the benefits from these consequential replacements in our assessment. This is likely to understate the benefits that our customers will see from these consequential replacements.

For this business case, the following assumptions have been used in the analysis of NPV of consequential replacements:

- Estimated average replacement age of pole 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.

Replacement of consequential assets has been estimated from three years historical data as per Table 4.

Consequential Asset Replacement Volume Ratio	
Asset Description	**Volume Ratio**
Pole	3.62
Pole Top	7.28
Services	3.93
TD	0.38
Fuse	0.76
Switch	0.40

Table 4: Consequential Replacement Volume Ratio

In the 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 each year during 2025-30 for all options shall be calculated based on ratio of 3.62 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 Statement

In response to concerns of high unassisted conductor failure rates, we initiated a review of our asset management practices in relation to overhead conductor. The review noted that:

- our replacement volume based on a legacy strategy is substantially below the requirement of a prudent operator.
- AER REPEX modelling for the 2015-20 and 2020-25 regulatory control periods predicted a significantly higher volumes of replacements.
- Over the 2015-20 regulatory control period, we continued to carry out significantly smaller volumes of conductor replacements in accordance with old strategy.
- We have substantially increased our volume of replacement over the last three years.
- However, as a result of the historical low volume of replacement, we have accumulated a high proportion of poor performance, high risk, aged conductor assets that will require urgent replacement in the 2025-30 regulatory control period.

To ensure that we have evidence-based information, we have improved the quality of the health profile modelling, accurate recording of failure data, utilisation of the data systems for modelling and monitor the condition data gathering. This improvement has indicated an escalating rate for unassisted conductor failures requiring more targeted replacements.

6.2 Compliance

As an electricity entity, Ergon Energy has a duty to comply with all current legislation, regulations, rules, and codes (Refer Section 1.1 of OH Conductors Asset Management Plan). For example, an electricity entity must comply with the following:

- **Electrical Safety Act 2002 (Qld) s29**
    - An electricity entity must ensure that its works are electrically safe and operated in an electrically safe manner. This includes the requirement that the electricity entity inspects, tests, and maintains the works.
- **Electricity Regulation 2006 (Qld)**
    - An electricity entity must, in accordance with recognised practice in the electricity industry, periodically inspect and maintain its works to ensure the works remain in good working order and condition.
- **Electricity Safety Regulations 2013 (Qld)**
    - General obligations related to safety of works of an electrical entity for this asset class outline specific 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. EQL is also required to notify the Electrical Safety Office in the event of any Serious Electrical Incident (SEI) or Dangerous Electrical Event (DEE).
    - 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.
    - 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).
    - 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 including agreed with AER SAIDI and SAIFI targets.

The desired level of service for conductors in the Energy Queensland network is to minimize the in-service conductor failure numbers to deliver a safety risk outcome which is considered SFAIRP..

6.3 Counterfactual Analysis (Base case – Historical Average)

6.3.1 Summary

The counterfactual option would be to maintain the targeted volume that has been used in the 2020-25 regulatory control period.

6.3.2 Volumes

The estimated volume for the counterfactual option is shown in the Table 5:

Counterfactual Volume (km) **Reconductoring and Consequential Replacement**	**2025-26**	**2026-27**	**2027-28**	**2028-29**	**2029-30**	**Total**
Reconductoring	**550**	**550**	**550**	**550**	**550**	**2,250**
Pole (Consequential)	1,994	1,994	1,994	1,994	1,994	9.970
Pole Top (Consequential)	4,005	4,005	4,005	4,005	4,005	2,025
Services (Consequential)	2,160	2,160	2,160	2,160	2,160	10,800
Pole Transformer (Consequential)	207	207	207	207	207	1,035
Fuse (Consequential)	414	414	414	414	414	2,070
Switch (Consequential)	220	220	220	220	220	1,100

Table 5: Counterfactual Delivery for the Period (2025/26-2029/30)

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 in Section 4.2. Figure 10 provides the results of a quantitative forecast of emerging risk, there would have been risk costs increase driven mainly by the age profile of the existing population, and expected failure rate increases from problematic conductors if the counterfactual replacement volumes assumed to be maintained at current level in the future.

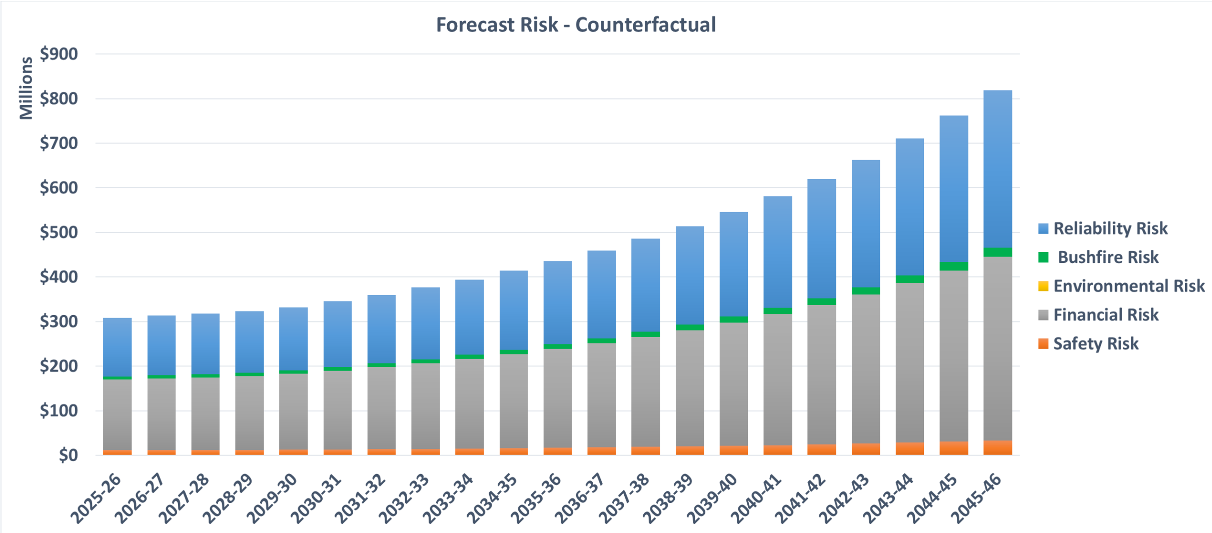

Figure 10: Counterfactual Quantitative Risk Assessment

Figure 11 represents the failure forecast for counterfactual option where the rate continues to accelerate further if the replacement volume is below where Ergon Energy needs to be and suggesting that significantly more proactive replacements are required next 20 years to manage the risk.

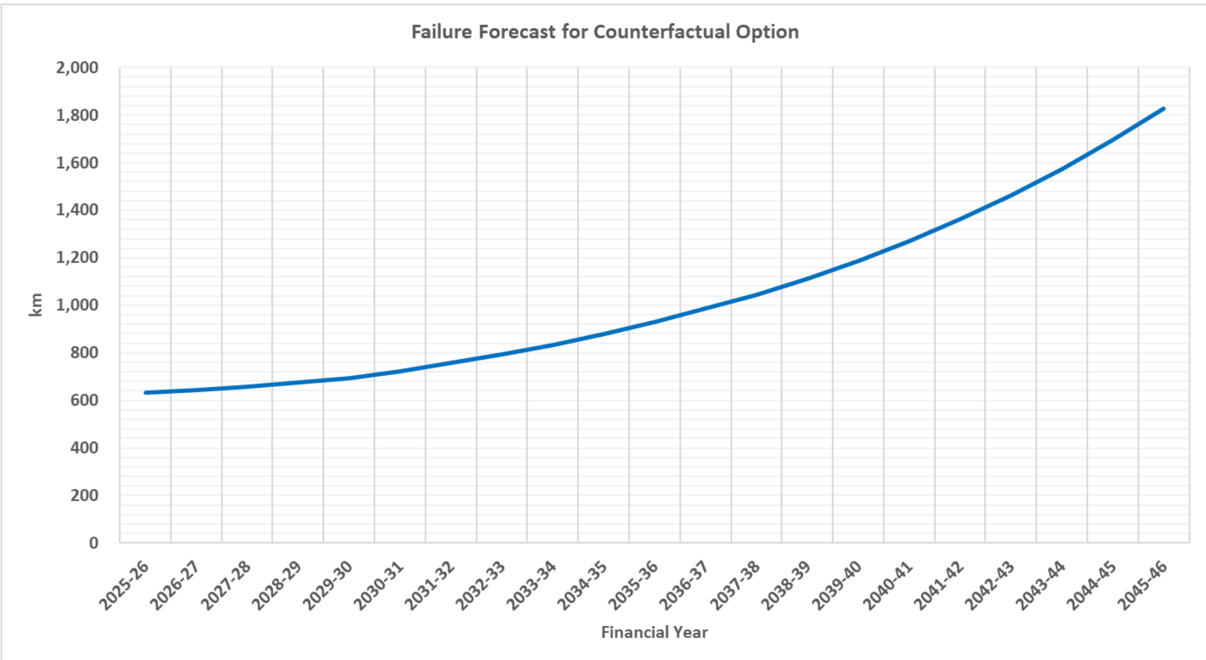

Figure 11: Conductor Failure Forecast - Counterfactual

7 OPTIONS ANALYSIS

In assessing the prudency of our proposed program, we have compared a range of interventions against the counterfactual (historical replacements) to assess the options that will maximise the value to our customers. We have sought to identify a practicable range of technically feasible, alternative options that would satisfy 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 –REPEX Model Cost Scenario

Option 1 includes the replacement of conductor volume based on the AER's REPEX model - Cost Scenario with volumes estimated using the total conductor allowance expenditure from the Cost Scenario between 2025-30, divided by our average actual unit cost.

7.1.1 Volumes Option 1

Option 1 modelled replacement volumes are outlined in Table 6.

Historical Volume (km) Reconductoring and Consequential	2025-26	2026-27	2027-28	2028-29	2029-30	Total (km)
Reconductoring	**601**	**601**	**601**	**601**	**601**	**800**
Pole (Consequential)	2,177	2,177	2,177	2,177	2,177	10,885
Pole Top (Consequential)	4,373	4,373	4,373	4,373	4,373	21,865
Services (Consequential)	2,358	2,358	2,358	2,358	2,358	11,790
Pole Transformer (Consequential)	226	226	226	226	226	1,130
Fuse (Consequential)	452	452	452	452	452	2,260
Switch (Consequential)	241	241	241	241	241	1,205

Table 6: Replacement Volume

7.1.2 Risks/Benefits

Option 1 modelling suggests that the unassisted conductor failures are projected to remain comparable to those in the counterfactual option providing only minor improvements for community and business both in short and in long term. Accordingly, this option is not expected to achieve any transition towards improvement in safety or customer benefits.

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

Option 2 includes replacement of all conductors assessed with HI >7.5. This option requires a significant increase in replacement volumes, leading to considerable reduction in failure risks including safety and reliability risk reductions. However, it requires significant investment in addition to additional resourcing.

7.2.1 Intervention Volumes for Option 2

Option 2 modelled replacement volumes are outlined in Table 7.

Health Index Volume (km) **Reconductoring and Consequential**	**2025-26**	**2026-27**	**2027-28**	**2028-29**	**2029-30**	**Total (km)**
Reconductoring	**2020**	**2020**	**2020**	**2020**	**2020**	**10,100**
Pole (Consequential)	7,322	7,322	7,322	7,322	7,322	36,612
Pole Top (Consequential)	14,709	14,709	14,709	14,709	14,709	73,545
Services (Consequential)	7,932	7,932	7,932	7,932	7,932	39,660
Pole Transformer (Consequential)	759	759	759	759	759	3,795
Fuse (Consequential)	1,518	1,518	1,518	1,518	1,518	7,590
Switch (Consequential)	809	809	809	809	809	4,045

Table 7: Replacement Volume

7.2.2 Risks/Benefits

Option 2 modelling predicts that the occurrence of unassisted conductor failures will be significantly reduced in comparison to the counterfactual option. This transition aims to bring the failure rate within desirable limits ensuring a satisfactory level of reliability and mitigating public safety risks. However, this option demands excessively more resources and investment compared to the counterfactual, outweighing the advantages to customers due to significantly high-cost impacts.

7.3 Option 3 – REPEX Model Lives Scenario

Option 3 volume is based on REPEX model live scenario output, includes prioritised replacement of all the oldest conductors in the network to achieve a DNSP median life of 84 years. This is considered a viable option. Estimated volumes using conductor allowance expenditure in Lives Scenario have been used between 2025-30, divided by average actual unit cost**.**

7.3.1 Volumes Option 3

Option 3 modelled replacement volumes are outlined in Table 8.

AER REPEX Live Scenario Volume (km) Reconductoring and Consequential	2025-26	2026-27	2027-28	2028-29	2029-30	Total (km)
Reconductoring	**802**	**802**	**802**	**802**	**802**	**4,010**
Pole (Consequential)	2,907	2,907	2,907	2,907	2,907	14,535
Pole Top (Consequential)	5,840	5,840	5,840	5,840	5,840	29,200
Services (Consequential)	3,149	3,149	3,149	3,149	3,149	15,745
Pole Transformer (Consequential)	301	301	301	301	301	1,505
Fuse (Consequential)	602	602	602	602	602	3,010
Switch (Consequential)	321	321	321	321	321	1,605

Table 8: Replacement Volume

7.3.2 Risks/Benefits

Option 3 modelling indicates that unassisted conductor failures are expected to be lower compared to the counterfactual option in the long term with a slowing down of failures. This level of performance is likely to reduce the failure rate below the desired level to maximise customer benefits from a reliability and safety perspective. However, it would impact customers and the community moderately from a cost impact perspective.

Additionally, recent failure and defect analysis shows that problematic conductors cannot achieve the same 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 there are over 6000km of problematic conductors in the network. Nevertheless, this option would be effective after elimination of all problematic conductors. This would be mitigated by us still targeting problematic conductor within the same funding envelope as a solely age-based replacement strategy.

7.4 Option 4 – Proposed Program (Preferred Option)

Option 4 involves replacement of targeted conductors, assessed through historical performance and health index model outcome. This option will provide significant benefits to community and customers with moderate additional investment compared to counterfactual.

7.4.1 Cost/Volumes

The costs and volumes that have been modelled in Option 4 are outlined in Table 9 and Table 10.

Proposed Program Volume (km) Reconductoring and Consequential	2025-26	2026-27	2027-28	2028-29	2029-30	Total km
Reconductoring	**700**	**730**	**750**	**770**	**780**	**3,730**
Pole (Consequential)	2,537	2,646	2,719	2,791	2,827	13,521
Pole Top (Consequential)	5,097	5,316	5,461	5,607	5,680	27,161
Services (Consequential)	2,749	2,866	2,945	3,024	3,063	14,647
Pole Transformer (Consequential)	263	274	282	289	293	1,401
Fuse (Consequential)	526	548	564	578	586	2,802
Switch (Consequential)	280	292	300	308	312	1,492

Table 9: Replacement Volume

Counterfactual Direct Expenditure ($m) Reconductoring and Consequential	2025-26	2026-27	2027-28	2028-29	2029-30	Total $m
Reconductoring	**39.8**	**41.5**	**42.7**	**43.8**	**44.4**	**212.2**
Pole (Consequential)	15.8	16.5	17	17.4	17.6	84.3
Pole Top (Consequential)	14.3	14.9	15.4	15.8	16	76.4
Services (Consequential)	3.7	3.8	3.9	4	4.1	19.5
Pole Transformer (Consequential)	7.7	8.1	8.3	8.5	8.6	41.2
Fuse (Consequential)	4.2	5.3	5.5	5.7	5.8	26.6
Switch (Consequential)	2.6	2.8	2.8	2.9	2.9	14.0
Consequential Total	44.1	46.1	47.4	48.6	49.2	235.4

Table 10: Replacement Costs

7.4.2 Risks/Benefits

Option 4 modelling suggests that unassisted conductor failures are projected to be reduced compared to the counterfactual option. This option is the preferred option to transition into improving asset performance without substantial resource and investment impacts.

While Option 4 requires more resources and investment than the counterfactual, the benefits for customers outweigh any potential drawbacks of this extra cost. Additionally, this option will continue improving customer benefits and avoid the need for a significant increase in near-term investments. More importantly, this option provides transition towards improved safety outcomes with avoidance of conductor drops. Our Deliverability Strategy attachment outlines our approach to delivering our forecast program of work.

8 OUTCOME OF OPTION ANALYSIS

8.1 Failure Forecast Analysis

The failure rate forecast for all the main options have been provided in Figure 12.

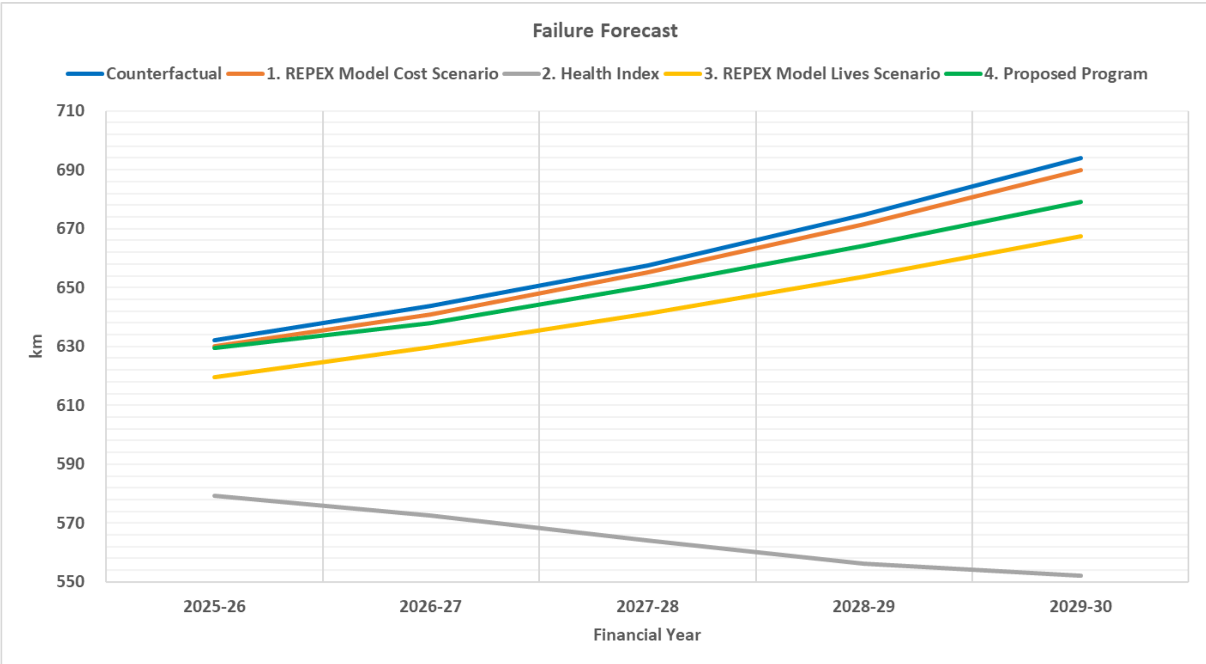

Figure 12: Failures Forecast For All Options

The projected failure forecast shows a relatively small difference between all options (except Option2) in the near term with considerable increase for the counterfactual and Option 1.

Option 2 forecast reductions in failure rate but require a step change in investment and resources with significant cost impact on community and therefore not providing optimising outcome.

Options 3 and 4 (**preferred option**), are the most viable options to control the failure rate gradually and not allowing the failure rate to accelerate. The proposed forecast provides the best outcome for community in terms of customer benefits and investment.

8.2 Economic Analysis

The NPV of cost benefit analysis of the options is summarised in Table 11 with a replacement volume summary in Table 12 which demonstrates the following:

- All options provide a positive NPV and reduce failures compared to the counterfactual demonstrating that any volume greater than the counterfactual providing further benefits for our customers.
- Options 1, 2 and 3 provide a positive NPV, with only option 2 providing a failure rate reduction. However, significant investment is required as replacement volumes are almost threefold higher when compared to the proposed option.

- Option 4 provides a balanced outcome in terms of managing the failure rate and cost impacts to deliver increased customer benefits. We are proposing to proceed with this option.

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	5	0	$0	$0	$0	$0
Option 1	REPEX Model Cost Scenario	4	$10,203,524	-$24,281,004	$41,232,691	-$14,213,447	$7,465,284
Option 2	Health Index	1	$725,930,650	-$806,827,251	$1,614,777,260	-$183,324,327	$101,304,967
Option 3	REPEX Model Lives Scenario	2	$87,663,551	-$144,712,555	$264,890,604	-$71,583,394	$39,068,895
Option 4	Proposed Program	3	$30,539,790	-$64,206,060	$121,603,232	-$56,367,552	$29,510,171

Table 11: NPV modelling outcomes for all options

Replacement (km)						
		2025-26	2026-27	2027-28	2028-29	2029-30
	Counterfactual	550	550	550	550	550
Option 1	REPEX Model Cost Scenario	587	587	587	587	587
Option 2	Health Index	2,020	2,020	2,020	2,020	2,020
Option 3	REPEX Model Lives Scenario	802	802	802	802	802
Option 4	Proposed Program	700	730	750	770	780

Table 12: Volume Summary – All options

Table 13 shows the NPV outcome when we add in the consequential replacement costs and benefits.

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		**5**	$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	**REPEX Model Cost Scenario**	**4**	**$10,203,524**	**-$24,281,004**	**$41,232,691**		**-$14,213,447**	**$7,465,284**
						Pole	-$6,292,187	$3,338,541
						Pole Top	-$2,833,143	$2,939,379
						Services	-$738,600	$436,989
						Pole Top Transformer	-$3,443,015	$327,487
						Switches	-$906,502	$422,887
Option 2	**Health Index**	**1**	**$725,930,650**	**-$806,827,251**	**$1,614,777,260**		**-$183,324,327**	**$101,304,967**
						Pole	-$81,431,514	$48,107,610
						Pole Top	-$36,463,473	$37,745,486
						Services	-$9,496,812	$5,608,555
						Pole Top Transformer	-$44,276,775	$4,419,788
						Switches	-$11,655,753	$5,423,529
Option 3	**REPEX Model Lives Scenario**	**2**	**$87,663,551**	**-$144,712,555**	**$264,890,604**		**-$71,583,394**	**$39,068,895**
						Pole	-$32,091,969	$18,509,651
						Pole Top	-$14,127,314	$14,646,228
						Services	-$3,681,821	$2,177,045
						Pole Top Transformer	-$17,163,543	$1,629,230
						Switches	-$4,518,747	$2,106,741
Option 4	**Proposed Program**	**3**	**$30,539,790**	**-$64,206,060**	**$121,603,232**		**-$56,367,552**	**$29,510,171**
						Pole	-$25,932,654	$13,664,090
						Pole Top	-$10,888,229	$11,312,345
						Services	-$2,589,039	$1,655,193
						Pole Top Transformer	-$13,406,839	$1,253,022
						Switches	-$3,550,791	$1,625,521

Table 13: NPV Analysis including Consequential Impacts – All Options

Figure 13 The relative difference between options remains stable, with all options higher value than the counterfactual, and Option 4 still NPV positive.

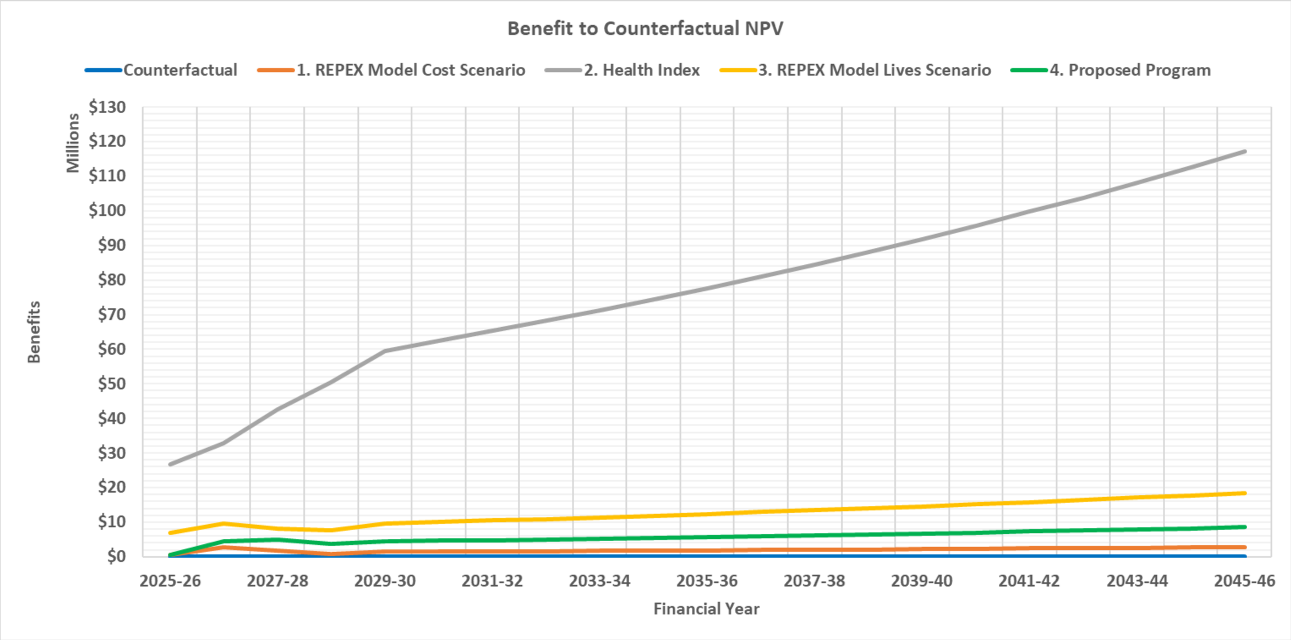

Figure 13: Benefits for All Options

The analysis presented here in Table 14 compares the options to their respective counterfactual alternatives.

Criteria	Option 1 – Repex Model Cost Scenario	Option 2 – Health Index ≥ 7.5	Option 3 – REPEX Model Lives Scenario	Option 4 – Proposed Program (Preferred)
Net NPV	$10m	$726m	$88m	$31m
Investment Risk	Low	Very High	High	Med
Benefits	Med	Very High	High	Med
Delivery Constraint	Med	Very High	High	Med
Detailed analysis – Advantage	• Outcome of AER costs scenario • Aligns with historical volume and ageing population • Not a material investment increase • Prudent option • Minor improvement in the asset performance • Customer benefits of $38m.	• Additional $1.6b Customer Benefit • Removes all defective assets from the network • Significantly improves the asset performance compared to other options.	• Investment requirement is within the top-down constraints • Additional $265m Customer Benefit • Aligns with REPEX Lives scenario volume and investments • Transition towards the improvement in asset performance.	• Additional $122m Customer Benefit • Gradually removes defective assets from the network to improve asset performance. • Matching the AER prediction • Avoid accelerated failures.
Detailed analysis – Disadvantage	• Marginal impact on delivery requirement • Slow transition towards performance improvement.	• Significant increase in investment of $990m • Very High impact on delivery requirement • Not matching the AER model prediction.	• High impact on delivery and budget requirement - $217m • Slow transition towards performance improvement.	• Medium increases in investment of $120m. • Medium impact on delivery requirement.

Table 14: Options Analysis Scorecard

9 SUMMARY

Four feasible options have been assessed and modelled to select the proposed option for the 2025-30 regulatory control period. To ensure that the analysis is robust and comprehensive, we have included the consequential replacements of assets undertaken at the time of conductor replacements.

Modelling confirms that the Option 4 with a total investment of $150m in targeted replacements provides a positive NPV benefit of $31m compared to the counterfactual option.

It is noted that the modelled result for Option 4 shows that conductor failure rates are likely to be maintained at the current level. Hence, it is forecasted that the increased level of remediation programs will be required as a minimum to reduce failure rates in 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 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, Option 4 remains as the most prudent option.

10 RECOMMENDATION

Option 4 (preferred option) has been determined as the most viable. This option has been chosen as it provides the best balance of benefits and risks for the Ergon Energy..

11 APPENDICES

11.1 Appendix 3: Reset Rin Data Reconciliation

	2025/26	2026/27	2027/28	2028/29	2029/30
$,Direct 2022-23	Expdenture	Expdenture	Expdenture	Expdenture	Expdenture
RIN	**$39,840,173**	**$41,547,539**	**$42,685,783**	**$43,824,027**	**$44,393,149**
Defect	5,322,448	5,322,448	5,322,448	5,322,448	5,322,448
Reconductoring	34,517,726	36,225,091	37,363,335	38,501,579	39,070,701
Consequential Replacement	**44,195,421**	**46,088,180**	**47,350,018**	**48,611,857**	**49,242,777**
Conductor Defect					
Pole	2,114,105	2,114,105	2,114,105	2,114,105	2,114,105
Poletop	1,913,983	1,913,983	1,913,983	1,913,983	1,913,983
Services	491,815	491,815	491,815	491,815	491,815
TD	1,027,851	1,027,851	1,027,851	1,027,851	1,027,851
Fuse	709,534	709,534	709,534	709,534	709,534
Switch	352,626	352,626	352,626	352,626	352,626
Reconductor					
Pole	13,710,630	14,388,805	14,840,922	15,293,038	15,519,097
Poletop	12,412,773	13,026,752	13,436,071	13,845,390	14,050,049
Services	3,189,572	3,347,339	3,452,517	3,557,695	3,610,284
TD	6,695,178	7,024,898	7,244,712	7,464,525	7,574,432
Fuse	3,509,932	4,601,549	4,829,157	4,980,896	5,132,635
Switch	2,286,888	2,400,006	2,475,417	2,550,829	2,588,535

Table 15: Reset RIN Reconciliation Table – Expenditure $ in 2022-23

$, direct 2024-25	2025/26	2026/27	2027/28	2028/29	2029/30
RIN	**$45,332,803**	**$47,513,196**	**$49,058,252**	**$50,426,478**	**$51,456,797**
Defect	6,056,236	6,086,678	6,117,024	6,124,318	6,169,333
Reconductoring	39,276,568	41,426,518	42,941,228	44,302,160	45,287,465
Consequential Replacement	**50,288,494**	**52,705,810**	**54,418,801**	**55,935,635**	**57,078,078**
Conductor Defect					
Pole	2,405,570	2,417,662	2,429,716	2,432,613	2,450,493
Poletop	2,177,857	2,188,805	2,199,717	2,202,340	2,218,528
Services	559,620	562,433	565,237	565,911	570,070
TD	1,169,558	1,175,437	1,181,297	1,182,705	1,191,398
Switch	401,241	403,258	405,269	405,752	408,734
Reconductor					
Pole	15,600,868	16,454,840	17,056,491	17,597,061	17,988,429
Poletop	14,124,080	14,897,214	15,441,913	15,931,312	16,285,633
Services	3,629,307	3,827,971	3,967,936	4,093,691	4,184,737
TD	7,618,220	8,033,577	8,326,259	8,589,117	8,779,643
Switch	2,602,174	2,744,614	2,844,967	2,935,132	3,000,411

Table 16: Reset RIN Reconciliation Table – Expenditure $ in 2024-25

	2025/26	2026/27	2027/28	2028/29	2029/30
	Replacement Qty	Replacement Qty	Replacement Qty	Replacement Qty	Replacement Qty
RIN	700	730	750	770	780
Defect	94	94	94	94	94
Reconductoring	607	637	657	677	687

Consequential Replacement					
Conductor Defect					
Pole	339	339	339	339	339
Poletop	681	681	681	681	681
Services	367	367	367	367	367
TD	35	35	35	35	35
Fuse	70	70	70	70	70
Switch	37	37	37	37	37
Reconductor					
Pole	2,199	2,307	2,380	2,452	2,489
Poletop	4,416	4,635	4,781	4,926	4,999
Services	2,382	2,499	2,578	2,656	2,696
TD	229	240	248	255	259
Fuse	458	480	496	510	518
Switch	243	255	263	271	275

Table 17: Reset RIN Reconciliation Table – Volume