Overhead Conductor Replacements

Business Case

19 January 2024

energex

Part of Energy Queensland

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DOCUMENT VERSION

Version Number	Change Detail	Date	Updated by
Draft v0.1	Initial release	06/03/2023	Asset Strategy Engineer
Draft v0.2	Draft	13/05/2023	Senior Asset Strategy Engineer
V1.0	Approved	20/11/2023	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	Energex 2022-23 - Category Analysis - RIN Response - Consolidated - 24 November 2023 – PUBLIC (16063386.1)	Excel
OCT 2023	Lines Defect Classification Manual	PDF
JUN 2023	Maintenance Acceptance Criteria (MAC) – Release 11	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 national disasters.xlsx (a compendium of various sources)	Excel

1 SUMMARY

Title	Overhead Conductor Replacements
DNSP	Energex
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 Energex forecast capital expenditure over the regulatory control period via a cost benefit analysis.
Identified need	☒ Legislation ☒ Regulatory compliance ☒ Reliability ☐ CECV ☒ Safety ☒ Environment ☒ Financial ☐ Other Energex is committed to adopting an economic, customer value-based approach when it comes to ensuring the safety and reliability of the network. To substantiate the advantages of this approach for the community and businesses over the modelling period, we have employed Net Present Value (NPV) modelling. This commitment is in line with our efforts to maximise the benefits to our customers. Investment in the replacement of conductors is required to manage legislation and regulatory compliance, and reliability, financial, safety, environmental risks and consequences that may arise due to the failure of a conductor. When defective conductors are left unattended it may result in conductors falling to the ground leading to dangerous electrical events (DEE). This presents significant safety risks to the public, especially considering that the majority of the Energex network is situated in densely populated areas. Moreover, it reduces the reliability of service for customers and the community. Over the past few regulatory periods, Energex has proactively targeted and removed known problematic and aged small copper conductors from the network. This initiative has resulted in improved asset performance and customer safety. However, recent trends in asset performance indicate a shift from the older small copper conductors with LV Aerial Bundled Cable, bare steel, and HV Covered conductors now dominating the defect and failure statistics. Considering more than 4,000 km of these type of problematic conductors still within the network, continuation of the current targeted replacement volumes, as a minimum, is essential during Reset RIN period 2025-30, as proposed under the counterfactual option.

<table>
<tr><td>Alternate options</td><td>Four different options were considered as per following over the continuation of the counterfactual (historical three-year average – 300 km/year) replacements:

REPEX Model – Cost Scenario – Average 307 km/year
REPEX Model Live Scenario – Average 363 km/year
Counterfactual – 50% -Average 150 km/year
Based on Health Index of ≥ 7.5 – Average 400 km/year.
</td></tr>
<tr><td>Expenditure</td><td>This business case is for targeted OH conductor replacement and associated consequential asset replacements, such as poles, pole-top structures (crossarms) and low voltage services as shown below.
<table>
<tr><th>Year
$m, direct 2022-23</th><th>2025-26</th><th>2026-27</th><th>2027-28</th><th>2028-29</th><th>2029-30</th><th>Total</th></tr>
<tr><td>Targeted Replacement</td><td>16.4</td><td>16.4</td><td>16.4</td><td>16.4</td><td>16.4</td><td>82.0</td></tr>
<tr><td>Defect</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Conductor Reset RIN Total*</td><td>16.4</td><td>16.4</td><td>16.4</td><td>16.4</td><td>16.4</td><td>82.0</td></tr>
<tr><td>Pole</td><td>6.8</td><td>6.8</td><td>6.8</td><td>6.8</td><td>6.8</td><td>34.0</td></tr>
<tr><td>Pole-top</td><td>9.5</td><td>9.5</td><td>9.5</td><td>9.5</td><td>9.5</td><td>47.5</td></tr>
<tr><td>Services</td><td>3.5</td><td>3.5</td><td>3.5</td><td>3.5</td><td>3.5</td><td>17.5</td></tr>
<tr><td>Distribution Transformers</td><td>11.4</td><td>11.4</td><td>11.4</td><td>11.4</td><td>11.4</td><td>57.0</td></tr>
<tr><td>Distribution Switches</td><td>10.2</td><td>10.2</td><td>10.2</td><td>10.2</td><td>10.2</td><td>51.0</td></tr>
<tr><td>Consequential Total*</td><td>41.5</td><td>41.5</td><td>41.5</td><td>41.5</td><td>41.5</td><td>207.5</td></tr>
<tr><td>Overall REPEX Investment (this business case)*</td><td>57.9</td><td>57.9</td><td>57.9</td><td>57.9</td><td>57.9</td><td>289.5</td></tr>
</table>
* Expenditure considered for this business case.</td></tr>
<tr><td>Benefits</td><td>After a thorough evaluation of all available options, it has been determined that our <u>Counterfactual</u> – Proposed program of 300km per year' is the optimal solution. This option has been chosen over other options, as it provides the best balance of benefits, deliverability, and risks for the organization.</td></tr>
</table>

2 PURPOSE AND SCOPE

The purpose of this business case is to evaluate the benefits of the proposed volume of targeted conductor's replacements during the regulatory period 2025-30 and assess alternative options. A financial NPV model was developed to evaluate and compare alternative options to ensure prudent expenditure.

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 for Conductor 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 utilise 2022-23 dollars and exclude overheads.

3 BACKGROUND

Overhead conductors are an asset of strategic importance to Energex 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 Energex business objectives related to safety, customers, and compliance. Energex maintains a diverse population of bare and insulated overhead conductor types and sizes due to legacy organisations, the length of the asset's operational life, changes in period supply contracts, and advancements in conductor technology. 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 age, range and variability of conductor materials, and the diverse environmental and operational conditions.

Steel Core Galvanized (SC/GZ) conductor exhibits poor performance in coastal and polluted environments. To address this failure mode, Energex has modified its design standards to install aluminium clad steel (SC/AC) conductor on new steel lines installed in proximity to coastal areas to replace the old failing conductors. Steel conductor has been targeted for removal in Energex urban locations due to thermal limitations under high fault currents.

The overhead conductor targeted replacement program being proposed has been determined using historical data of failures and defects. This is due to any increase in 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 the proactive replacement rate, forward planning is essential, as replacing assets on an ad-hoc basis 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.

3.1 Asset Population

Energex maintains a population of approximately 35,100 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 less than or equal to 11kV.

These conductors are expected to have a service life ranging from 50 years to 70 years based on type, size, and voltage. By 2025, around 8,306 km, 1,696 km and 1,218 km of OH conductors will be 50, 60 and 70 years old respectively.

Energex 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 an accurate 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.

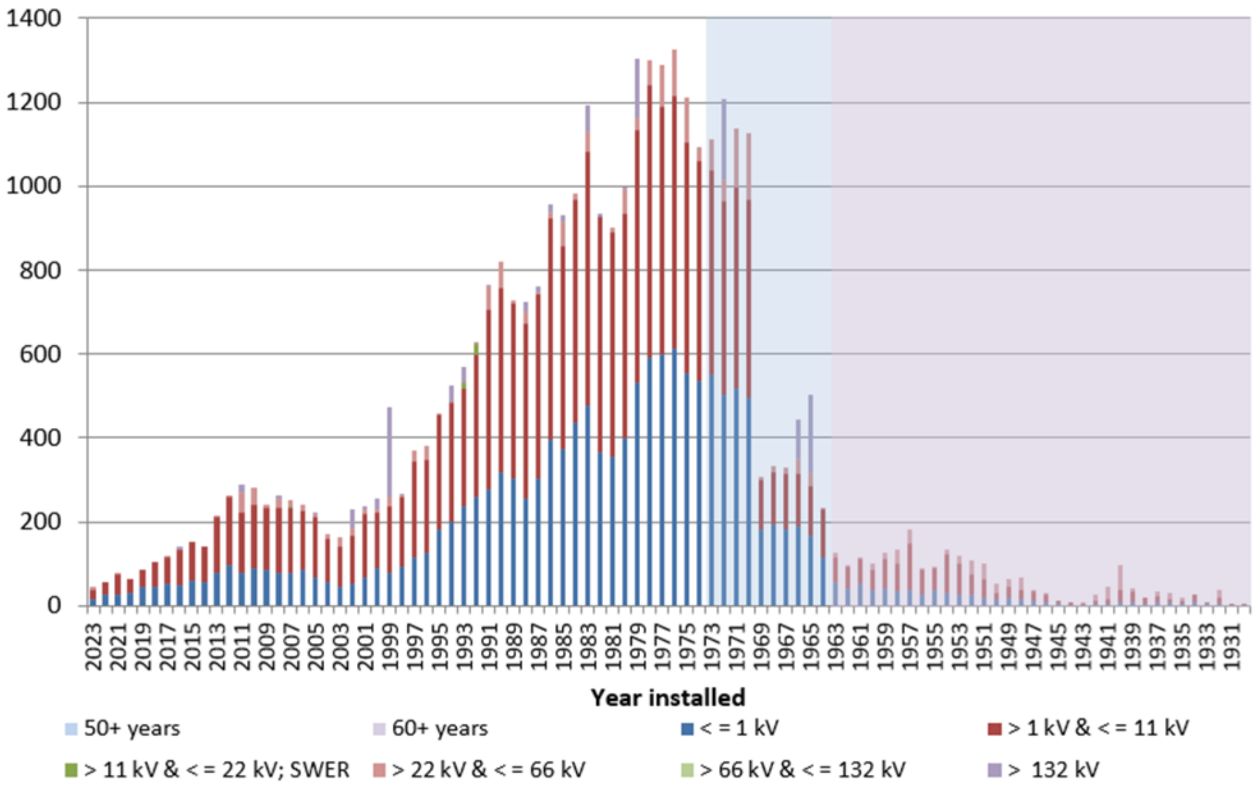

Figure 1: Age profile Overhead Conductors

3.2 Asset Management Overview

Overhead conductors are an asset of strategic importance to Energex 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 Energex 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 Acceptance Criteria in line with best industry benchmark practices.

Additionally, Energex continuously improves the record 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 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; specific criteria indicate assets are either at, or near, end of service life.

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. This excludes 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. The recent failure and defect analytics have identified LV Aerial Bundled Cable, bare steel, and HV Covered conductors started to decline in their performance is an indication of a need for an intervention strategy. More detailed information is included in Asset Management Plan for Conductor.

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 also cause deterioration as part of normal wear and tear, or during hostile environmental conditions, and lead to conductor failure. The number of joints typically increases over the life of the asset, which in combination with condition deterioration leads to a higher probably of in-service failure.

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

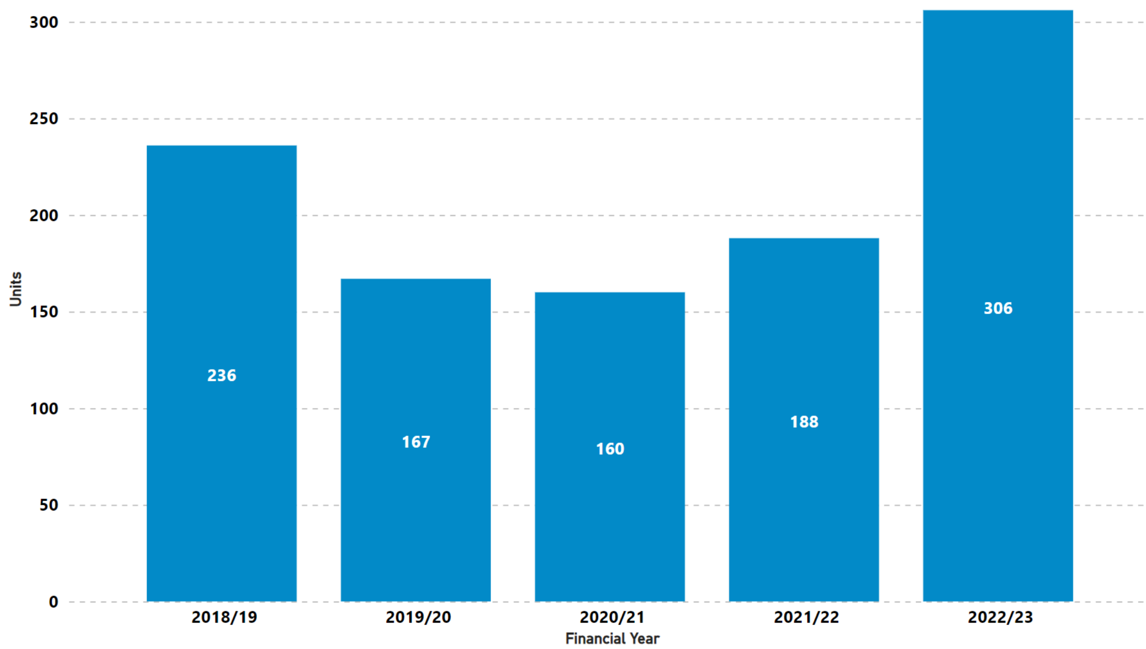

Figure 2: Unassisted OH Conductor Failures

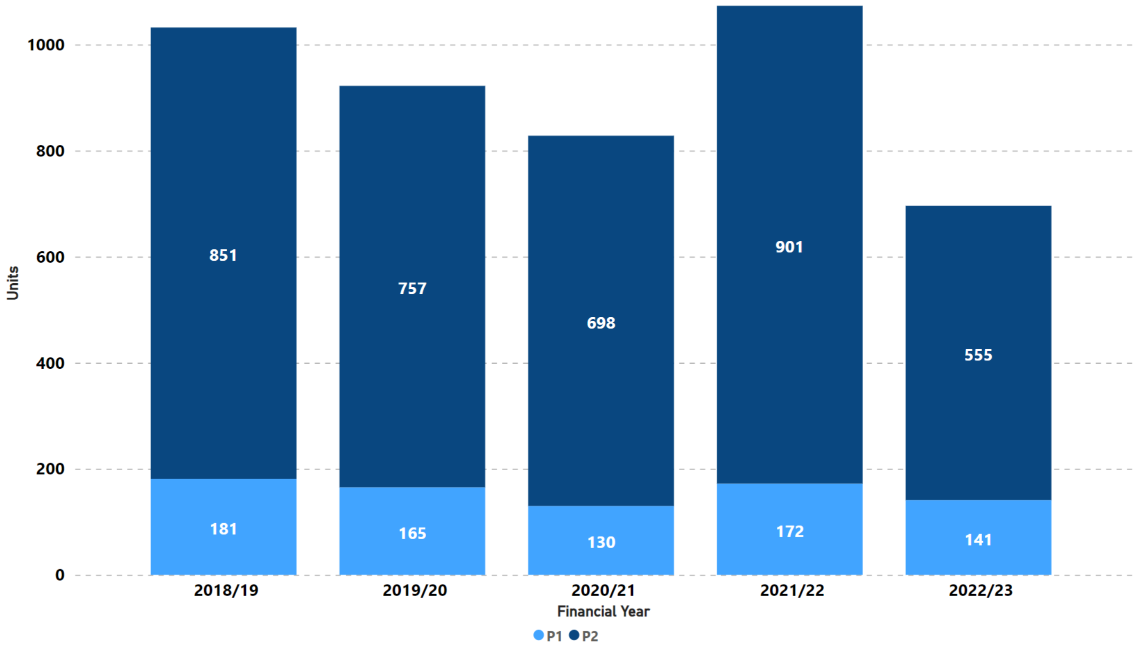

Figure 3: OH Conductor Defects

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

Energex 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.

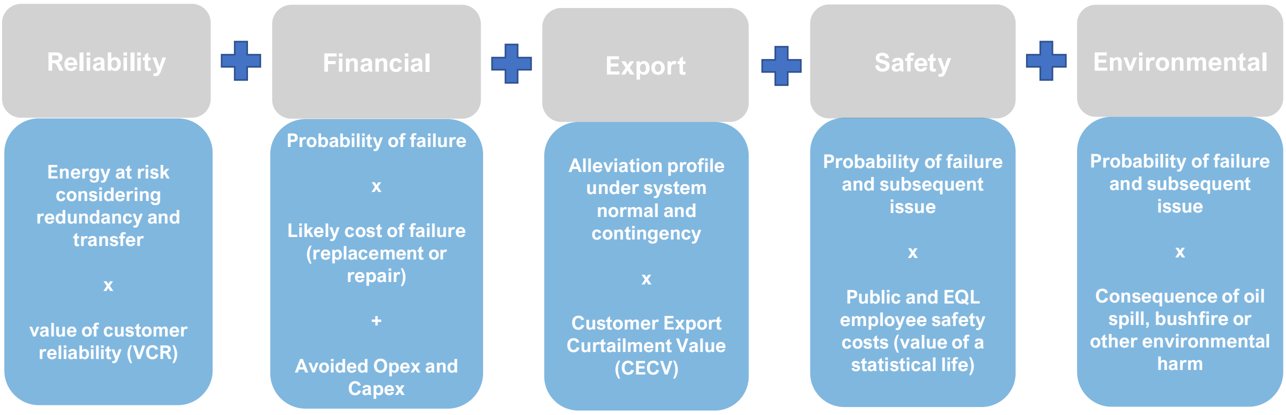

Figure 5: Risk Streams for Assets

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, location) 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.

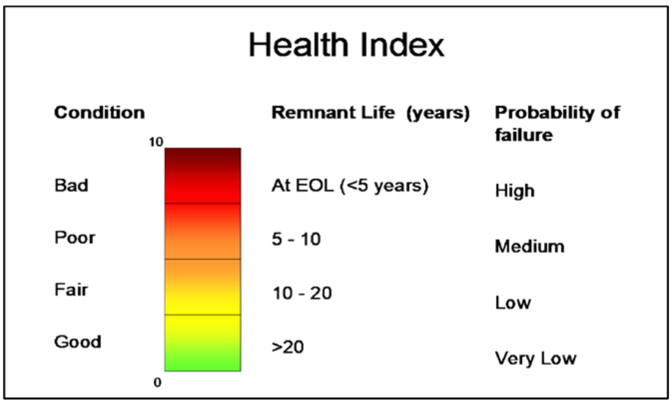

Figure 6: HI and PoF Relationship

The relationship between HI and PoF is not linear as per 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.

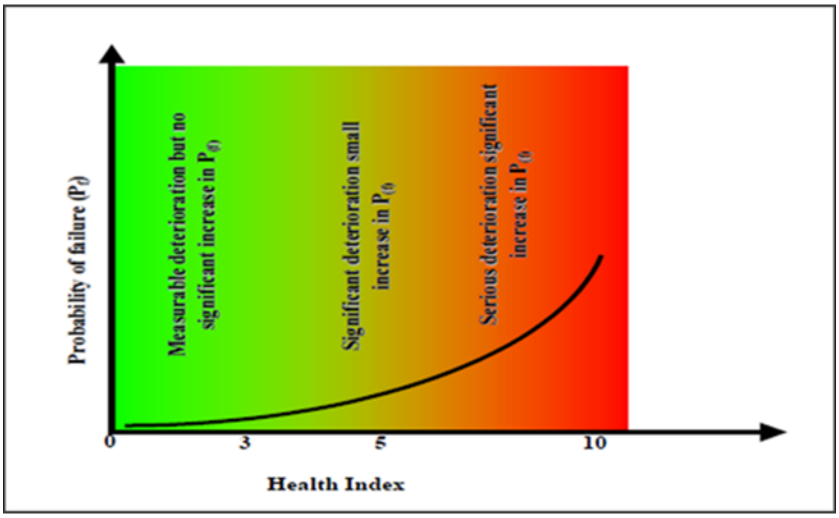

Figure 7: HI and PoF Relationship Graph

2023 analytics in Figure 8 show approximately 1,131 km of conductor identified with a HI of >7.5, requiring intervention in next few years. 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.

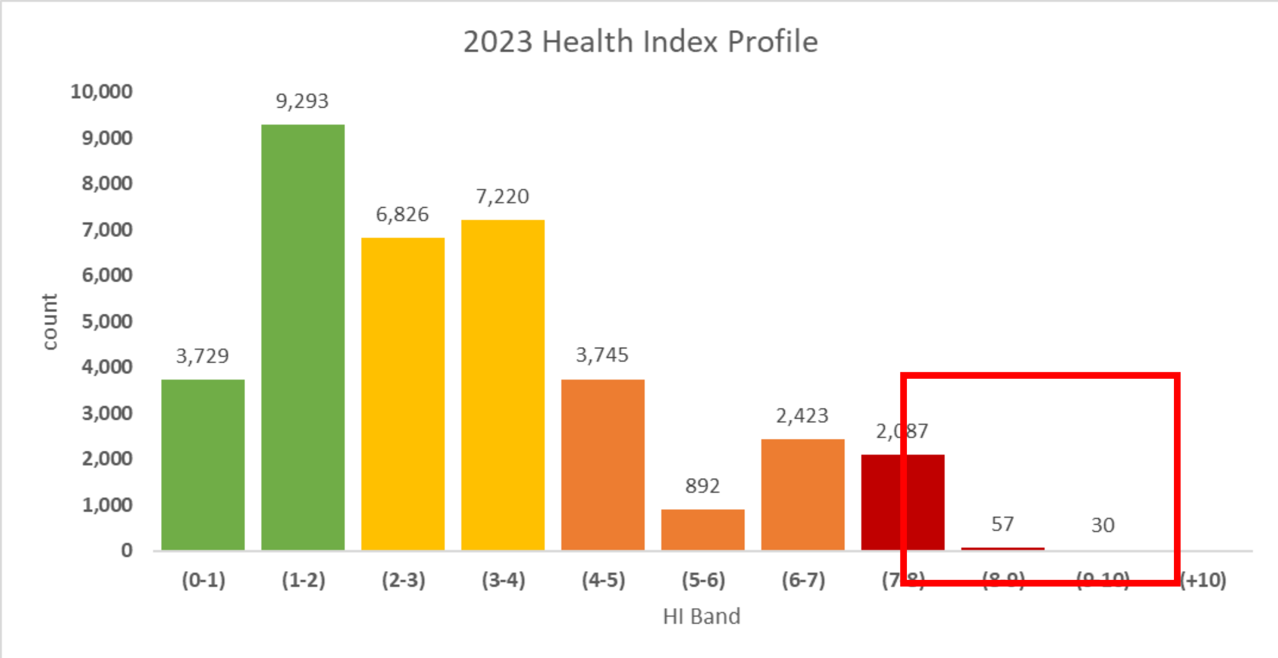

Figure 8: HI Summary OH Conductors 2023

Conductor HI values forecast to the end of the modelling period (2043) as per CBRM indicate approximately 7,940km of conductor >7.5 as per Figure 9. To mitigate this state, an average of 400km of conductor intervention per year over the next 20 years would be required. This is significantly higher than the existing rate, with no intervention planned beyond the end of the current program. A significant step change in resources would be required which is not considered feasible at this stage.

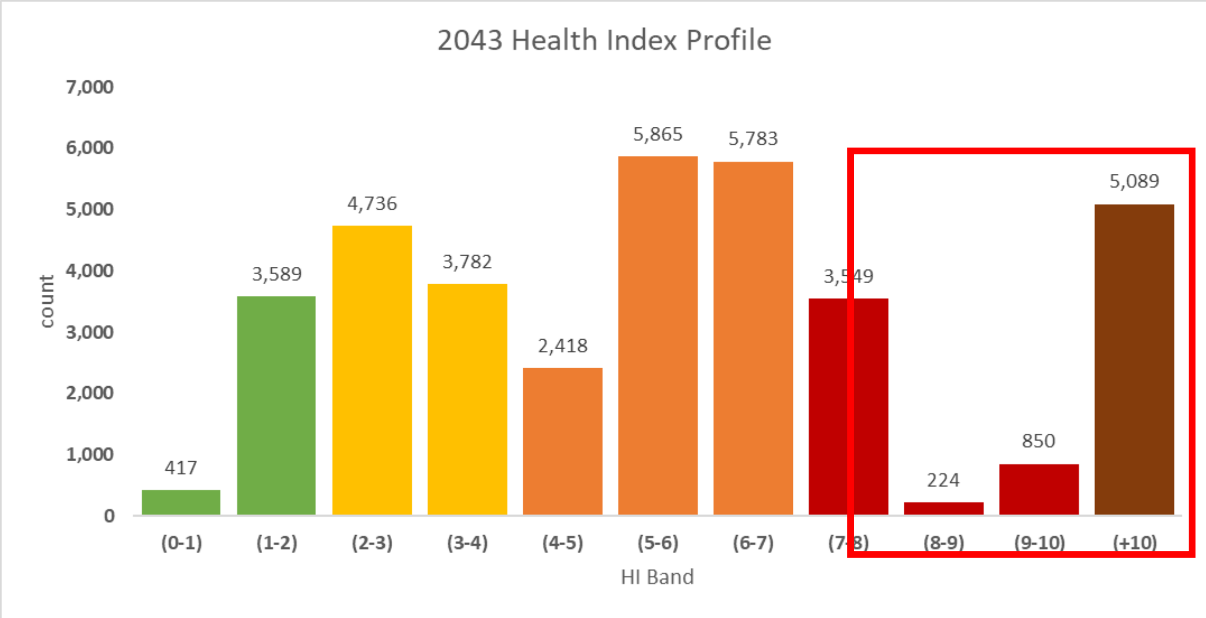

Figure 9: Future HI for OH Conductor EE

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, Energex has utilized a combination of historical performances and researched results. Energex 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 2 to 9 hours 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:** Energex has assumed that the weighted average replacement cost per kilometre for a conductor is $54,682. This is the same whether proactive, defective replacement or replacement following a failure. The cost ranges from $19,122/km for a 11kV SWER line to $715,500/km for a sub-transmission line conductors.
- **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 4 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 5 incidents where unassisted conductor 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 a historical full two years data when there were 18 fires recorded due to electrical asset failures in Energex. In those two years there were 12 pole failures, 285 cross-arm failures and 402 conductor failures that had potential to cause fire ignition, giving a probability of 0.026 (18/699). 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, the condition of the supporting structure (poles) and other equipment affixed to the supporting structure are evaluated to determine whether it is feasible and cost-effective to replace them. This equipment includes poles, crossarms, transformers, service lines, and switches. Overall cost-benefit evaluation is an integral consideration for OH conductor replacement in conjunction with assessing the advantages of this approach for customers. The consequential asset volume replacement under the proposed OH conductor replacement program for regulatory period 2025-30 is shown in Table 2.

Proposed Program (2025-30) Consequential Replacement Volume	2025-26	2026-27	2027-28	2028-29	2029-30	Total
Pole	979	979	979	979	979	**4,895**
Pole Top	4,379	4,379	4,379	4,379	4,379	21,895
Services	4,483	4,483	4,483	4,483	4,483	**22,415**
Pole Transformer	405	405	405	405	405	**2,025**
Switch	1,183	1,183	1,183	1,183	1,183	**5,915**

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 consequential asset replacements shown in Table 2.

Table 3 outlines an 'advanced' or bring forward view of asset replacement including used service life at the time of replacement. It is notable that only the poles with minimum age of 55 years are considered for replacement.

Consequential Replacement Asset Description	Average failure age in Years as per Weibull Analysis	Estimated Average Age at the time of conductor replacement	% Life already Used at conductor replacement time
Poles	58	55	95%
Switches	21	13	62%
Pole Top Structure	41.5	13.5	33%
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. On that basis, we allocate 25% of the benefits as a conservative approach for these consequential assets. This is likely to guarantee the minimum levels of benefits that our customers will see from these consequential replacements.

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 last year historical data as per Table 4.

Consequential Asset Replacement Volume Ratio	
Asset Description	**Volume Ratio**
Pole	3.26
Pole Top	14.6
Services	14.94
TD	1.35
Switch	3.94

Table 4: Consequential Replacement Volume Ratio

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 each year during 2025-30 for all options shall be calculated based on ratio of 3.26 poles per km of reconductoring.

6 IDENTIFIED NEED

The identified need for this investment is driven by a positive cost/benefit analysis based on Value of Customer Reliability, Financial, Safety and Environmental benefits.

6.1 Problem Statement

Energex frequently reviews its asset management practices with respect to all assets including overhead conductor. The counterfactual targeted strategy has aided in managing our asset performance. Since the introduction of our targeted replacement strategy, Energex has replaced all the known population of small copper conductors. Recent performance analytics has identified that LV Aerial Bundled Cable, bare steel, and HV Covered conductors have started to deteriorate and requires an intervention strategy. In-depth details of our performance analysis are detailed in our Asset Management Plan for Conductor.

Accordingly, over recent years, an effort to improve the quality of the health profile modelling, failure data, utilisation of the data systems for modelling, condition data gathering, and recording is continuing. This initiative aims to target the worst condition conductor to reduce conductor failures, thereby minimising incidents of conductors falling to the ground and improving safety and reliability for the public and the community.

6.2 Compliance

As an electricity entity, Energex 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.
  - Energex 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 Energex network is to minimize the in-service conductor failure numbers which deliver a safety risk outcome which is considered SFAIRP, and as a minimum, maintains current performance standards.

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 past regulatory period 2020-25.

6.3.2 Costs/Volumes

The estimated costs and volumes for the counterfactual option is shown in the Table 5 and Table 6.

Reconductoring and Consequential Replacement Volume (km)	2025-26	2026-27	2027-28	2028-29	2029-30	Total
Reconductoring	**300**	**300**	**300**	**300**	**300**	**1,500**
Pole (Consequential)	979	979	979	979	979	**4,895**
Pole Top (Consequential)	4,379	4,379	4,379	4,379	4,379	**21,895**
Services (Consequential)	4,483	4,483	4,483	4,483	4,483	**22,415**
Pole Transformer (Consequential)	405	405	405	405	405	**2,020**
Switch (Consequential)	1,183	1,183	1,183	1,183	1,183	**5,915**

Table 5: Counterfactual Delivery Volumes – 2025-30

Reconductoring and Consequential Expenditure ($m)	2025-26	2026-27	2027-28	2028-29	2029-30	Total $m
Reconductoring	**16.4**	**16.4**	**16.4**	**16.4**	**16.4**	**82.0**
Pole (Consequential)	6.8	6.8	6.8	6.8	6.8	**34.0**
Pole Top (Consequential)	9.5	9.5	9.5	9.5	9.5	**47.5**
Services (Consequential)	3.5	3.5	3.5	3.5	3.5	**17.5**
Pole Transformer (Consequential)	11.4	11.4	11.4	11.4	11.4	**57.0**
Switch (Consequential)	10.2	10.2	10.2	10.2	10.2	**51.0**
Consequential Total	**41.5**	**41.5**	**41.5**	**41.5**	**41.5**	**207.5**

Table 6: Counterfactual Expenditure – 2025-30

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.

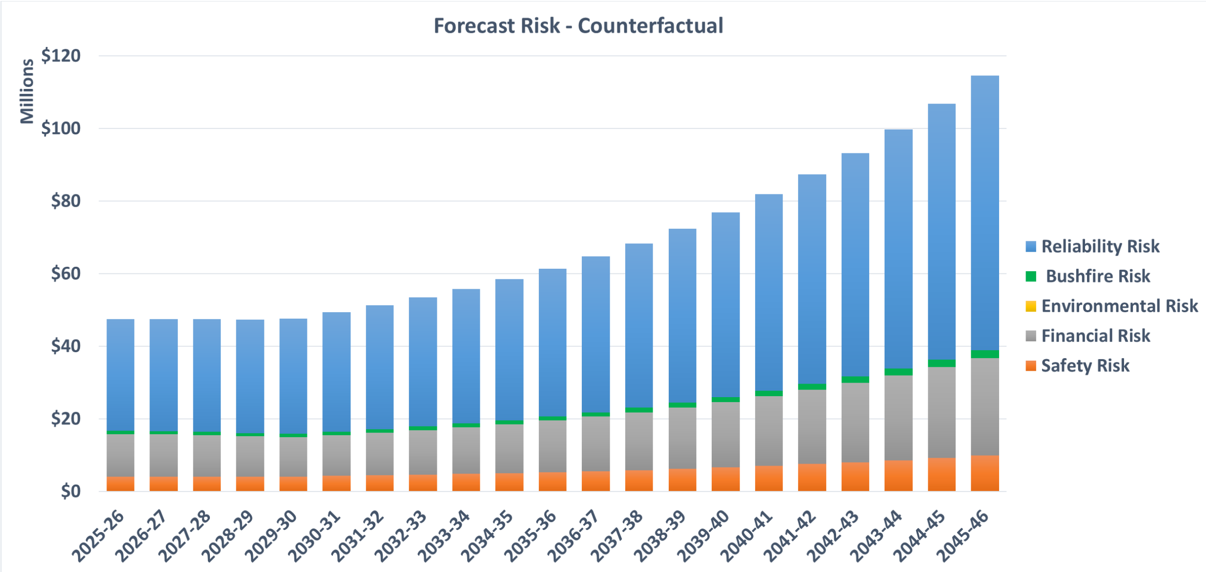

Figure 10: Counterfactual quantitative risk assessment

Figure 11 represents the failure forecast for counterfactual option where the rate is maintained at current level and increases gradually (297 to 308) if the replacement volume is maintained at counterfactual levels.

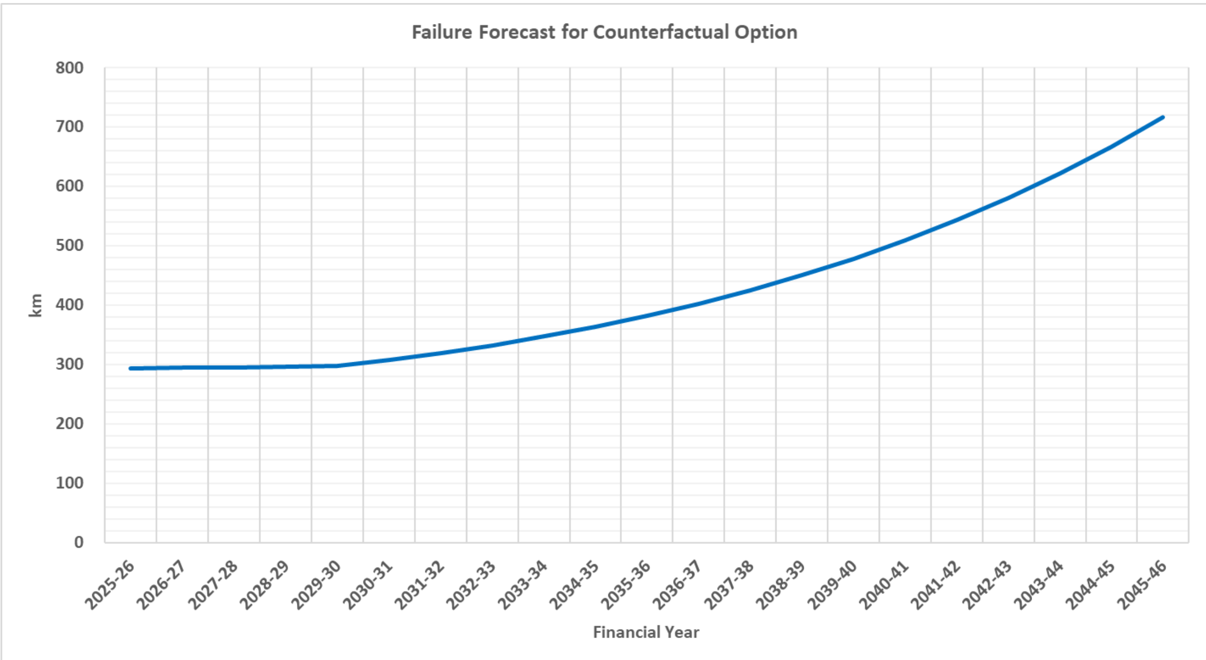

Figure 11 Conductor failure forecast - Counterfactual

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.

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 conductor allowance expenditure from Cost Scenario between 2025-30 divided by average actual unit cost.

7.1.1 Intervention Volume

Option 1 modelled replacement volumes are outlined in Table 7.

Historical Volume (km) Reconductoring and Consequential	2025-26	2026-27	2027-28	2028-29	2029-30	Total (km)
Reconductoring	**307**	**307**	**307**	**307**	**307**	**1,535**
Pole (Consequential)	1,002	1,002	1,002	1,002	1,002	**5,010**
Pole Top (Consequential)	4,482	4,482	4,482	4,482	4,482	**22,410**
Services (Consequential)	4,588	4,588	4,588	4,588	4,588	**22,940**
Pole Transformer (Consequential)	414	414	414	414	414	**2,070**
Switch (Consequential)	1,210	1,210	1,210	1,210	1,210	**6,050**

Table 7: Replacement Volume

7.1.2 Risks/Benefits

Option 1 modelling suggests that the unassisted conductor failures are projected to remain similar to those in the counterfactual option providing only marginally less failures and better outcomes for community and business both in short and in long term. In fact, this option is very close to counterfactual option and could be considered if increased failures are observed in future.

7.2 Option 2 – REPEX Model Lives Scenario

Option 2, based on the AER's REPEX model Lives Scenario output, includes prioritised replacement of all the oldest conductors in the network to achieve a DNSP median life of 84 years. Estimated volumes using the overall conductor allowance expenditure output from the 2025-30 Lives Scenario have been used, divided by our average actual unit cost.

7.2.1 Intervention Volumes for Option 2

Option 2 modelled replacement volumes are outlined in Table 8.

Health Index Volume (km) Reconductoring and Consequential	2025-26	2026-27	2027-28	2028-29	2029-30	Total (km)
Reconductoring	**363**	**363**	**363**	**363**	**363**	**1,815**
Pole (Consequential)	1,185	1,185	1,185	1,185	1,185	**5,925**
Pole Top (Consequential)	5,296	5,296	5,296	5,296	5,296	**26,480**
Services (Consequential)	5,422	5,422	5,422	5,422	5,422	**27,110**
Pole Transformer (Consequential)	490	490	490	490	490	**2,450**
Switch (Consequential)	1,430	1,430	1,430	1,430	1,430	**7,150**

Table 8: Replacement Volume

7.2.2 Risks/Benefits

Option 2 modelling indicates that unassisted conductor failures would be lower compared to the counterfactual option in the long term. This level of performance is likely to reduce the failure rate above the desired level and maximise customer benefits from a reliability and safety perspective. However, it would impact customers and the community 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 proportionate lowering of unassisted conductor failures in the short term given there are over 4,000km of problematic conductors in the network. However, this option would be effective after the elimination of all problematic conductors.

7.3 Option 3 –Counterfactual – 50% REPEX Model Lives Scenario

Option 3 volume is based on 50% of counterfactual option to evaluate the risks/benefits associated with a reduced volume.

7.3.1 Intervention Volumes

Option 3 modelled replacement volumes are outlined in Table 9.

AER REPEX Live Scenario Volume (km) Reconductoring and Consequential	2025-26	2026-27	2027-28	2028-29	2029-30	Total (km)
Reconductoring	**150**	**150**	**150**	**150**	**150**	**750**
Pole (Consequential)	490	490	490	490	490	**2,450**
Pole Top (Consequential)	2,190	2,190	2,190	2,190	2,190	**10,950**
Services (Consequential)	2,242	2,242	2,242	2,242	2,242	**11,210**
Pole Transformer (Consequential)	203	203	203	203	203	**1,015**
Switch (Consequential)	591	591	591	591	591	**2,955**

Table 9: Replacement Volume

7.3.2 Risks/Benefits

Option 3 modelling indicates that unassisted conductor failures are expected to increase significantly compared to the counterfactual option in the short and long term both. This option provides the worst outcome in terms of failures and customer benefits.

7.4 Option 4 –Health Index Based Replacement (HI>7.5)

Option 4 includes replacement of all conductors assessed with HI >7.5. This is deemed a viable option. It suggests a significant increase in replacement volumes leading to considerable reduction in failure risks including safety and reliability risk reductions. However, it requires marginally additional investment and resourcing comparatively.

7.4.1 Intervention Volumes

Option 4 modelled replacement volumes are outlined in Table 10.

AER REPEX Live Scenario Volume (km) Reconductoring and Consequential	2025-26	2026-27	2027-28	2028-29	2029-30	Total (km)
Reconductoring	**400**	**400**	**400**	**400**	**400**	**2,000**
Pole (Consequential)	1,306	1,306	1,306	1,306	1,306	**6,530**
Pole Top (Consequential)	5,839	5,839	5,839	5,839	5,839	**29,195**
Services (Consequential)	5,977	5,977	5,977	5,977	5,977	**29,885**
Pole Transformer (Consequential)	540	540	540	540	540	**2,700**
Switch (Consequential)	1,577	1,577	1,577	1,577	1,577	**7,885**

Table 10**: Replacement Volumes**

7.4.1 Risks/Benefits

Our modelling predicts that the occurrence of unassisted conductor failures will be significantly reduced in comparison to the counterfactual option. This transition estimates to minimise the failure rate ensuring a better level of reliability and mitigating public safety risks in high public density areas with elimination of worst performing conductors. However, this option demands significantly more resources and investment compared to the counterfactual, outweighing the advantages to customers due to moderate cost impacts.

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.

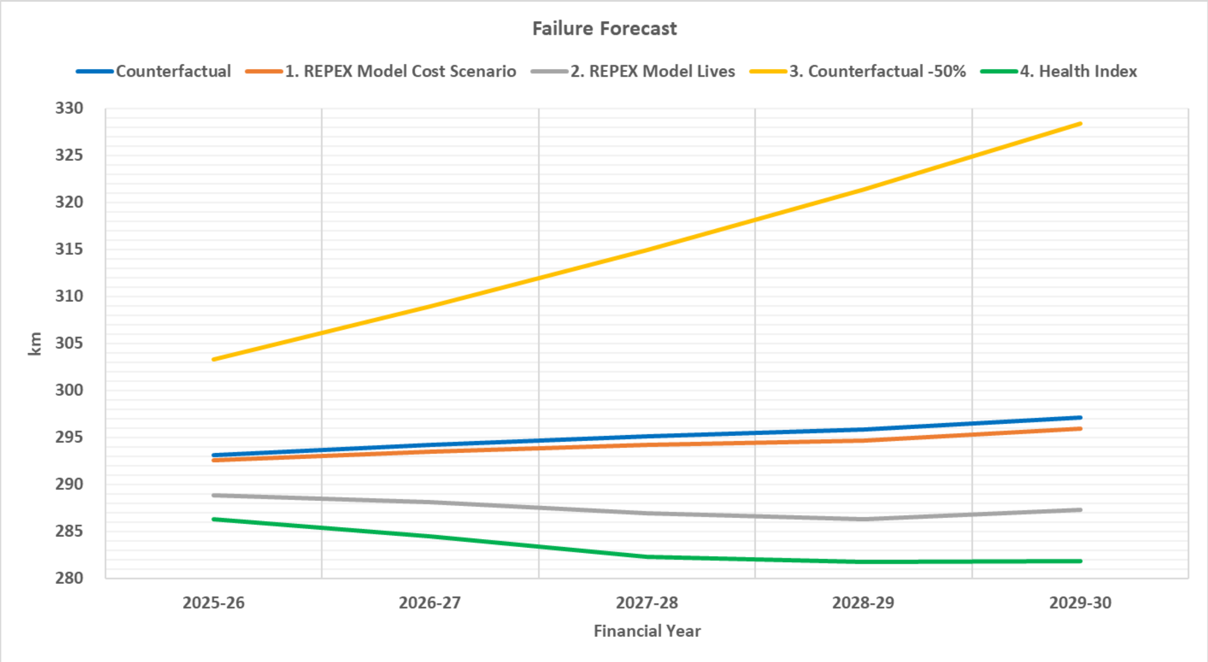

Figure 12: Failures Forecast for all options

The projected failure forecast shows a wide difference among the options in near years, with considerable decrease in failures for Options 2 and 4. However, both these options require additional investment and resource compared to counterfactual.

Option 1 is very close to the counterfactual option. Option 3 provide the worst outcome in terms of failures and customer benefits, indicating that any volume less than the counterfactual would deliver a negative NPV and reduced customer benefit.

The counterfactual (preferred option) is the option that maximises value for our customers and maintains our existing asset performance.

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:

- Any volume greater than the counterfactual is providing a positive customer benefit for the additional investment.
- Even though Options 1, 2 and 4 provide a negative NPV, these options provide notable failure rate reduction. However, significant investment and resource is required compared to counterfactual option.
- While option 3 provides a positive NPV, it results in a significantly higher risk during the period.

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	2	0	$0	$0	$0	$0
Option 1	REPEX Model Cost Scenario	3	-$11,446,904	-$12,036,163	$5,128,313	-$6,280,732	$1,741,678
Option 2	REPEX Model Lives	4	-$47,760,796	-$54,693,115	$42,142,758	-$54,256,222	$19,045,783
Option 3	Counterfactual -50%	1	$182,559,771	$214,178,528	-$122,950,137	$129,431,614	-$38,100,234
Option 4	Health Index	5	-$58,565,364	-$62,473,034	$64,625,693	-$86,456,932	$25,738,910

Table 11: NPV modelling outcomes for all options

Replacement (km)						
		2025-26	2026-27	2027-28	2028-29	2029-30
	Counterfactual	300	300	300	300	300
Option 1	1. REPEX Model Cost Scenario	307	307	307	307	307
Option 2	2. REPEX Model Lives	363	363	363	363	363
Option 3	3. Counterfactual -50%	150	150	150	150	150
Option 4	4. Health Index	400	400	400	400	400

Table 12: Volume Summary – All options

With all the options apart from Option 3 providing positive NPV and benefits to customers, adding the consequential benefits and investment to the NPV analysis indicates increasing numbers proportionately without impacting the current option analysis and the preferred option decision. The NPV table with consequential Capex (CCPEX) investment and benefits has been provided in Table 13.

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		2	$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	3	-$11,446,904	-$12,036,163	$5,128,313		-$6,280,732	$1,741,678
						Pole	-$1,031,763	$432,917
						Pole Top	-$429,916	$602,916
						Services	-$238,289	$67,147
						Pole Top Transformer	-$3,258,952	$65,967
						Switches	-$1,321,812	$572,732
Option 2	REPEX Model Lives	4	-$47,760,796	-$54,693,115	$42,142,758		-$54,256,222	$19,045,783
						Pole	-$7,170,616	$3,006,238
						Pole Top	-$3,859,707	$5,408,226
						Services	-$2,138,345	$601,986
						Pole Top Transformer	-$29,245,025	$586,947
						Switches	-$11,842,528	$9,442,387
Option 3	Counterfactual -50%	1	$182,559,771	$214,178,528	-$122,950,137		$129,431,614	-$38,100,234
						Pole	$16,984,533	-$7,104,179
						Pole Top	$9,199,631	-$12,931,528
						Services	$5,105,386	-$1,441,918
						Pole Top Transformer	$69,824,079	-$1,436,495
						Switches	$28,317,985	-$15,186,113
Option 4	Health Index	5	-$58,565,364	-$62,473,034	$64,625,693		-$86,456,932	$25,738,910
						Pole	-$11,471,395	$4,956,915
						Pole Top	-$6,146,015	$8,606,791
						Services	-$3,403,950	$957,629
						Pole Top Transformer	-$46,554,215	$927,742
						Switches	-$18,881,358	$10,289,833

Table 13: NPV Analysis including Consequential Impacts – All Options

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 4.

While Option 3 has a higher NPV, the **Counterfactual Option**, with 300km per annum replacement volume, achieves a proportionate outcome. This option is also the most achievable from a deliverability point of view and is what we are proposing to continue with into the next regulatory period.

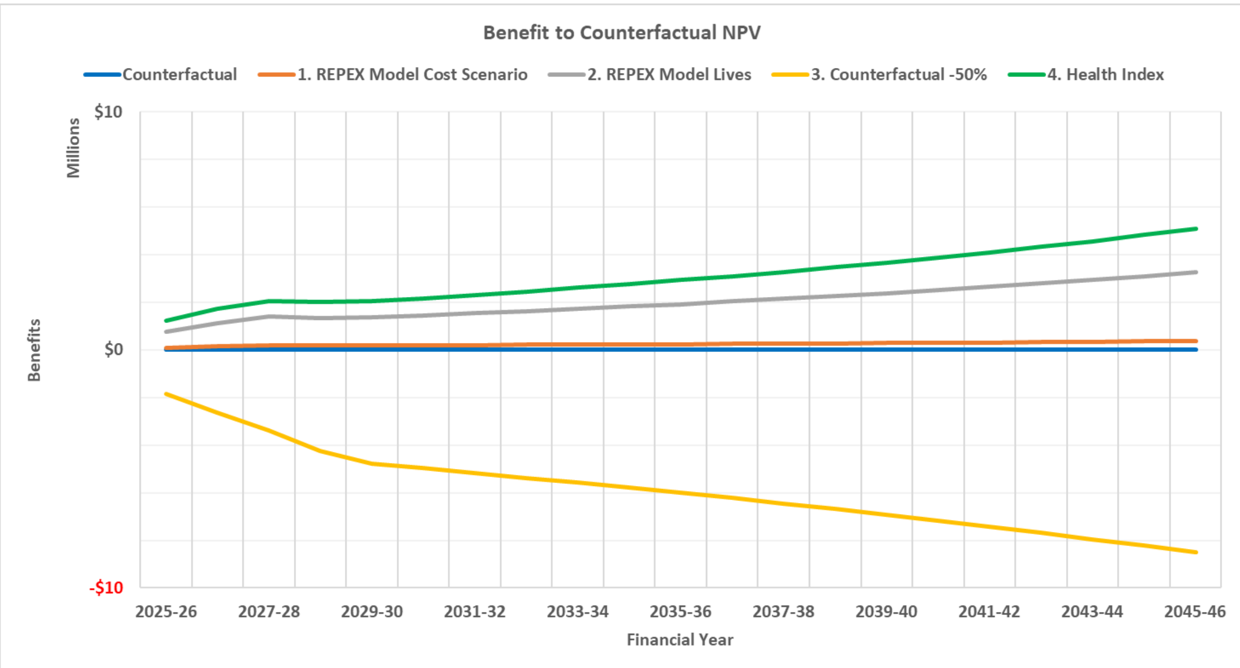

Figure 13: Benefits for All Options

The analysis presented here in Table 14 compares the options to their respective counterfactual (**<u>Preferred Option</u>**) alternatives.

Criteria	Option 1 – Repex Model Cost Scenario	Option 2 – REPEX Model Lives Scenario	Option 3 – Counterfactual (– 50%) Scenario	Option 4 – Health Index Based replacement (HI ≥ 7.5)
Net NPV	-$11m	-$48m	$183m	-$59m
Investment Risk	Med	High	Low	High
Benefits	Med	High	Very Low	Very High
Delivery Constraint	Med	High	Low	High
Detailed analysis – Advantage	• Aligns with counterfactual. • Maintains the current performance. • Additional Customer benefits of $7m • Positive NPV.	• Additional $61m Customer Benefit • Achieve the expected life of our asset based on Repex Lives model • Gradual Transition towards the improvement in asset performance • Positive NPV.	• Do minimum option • Reduced investment of $344m • Positive NPV.	• Additional $90m Customer Benefit • Removes poor performing assets proactively from the network. • Significantly improves the asset performance compared to other options • Positive NPV.
Detailed analysis – Disadvantage	• Slow transition towards performance improvement • Negative NPV.	• Slow transition towards performance improvement • Negative NPV.	• Poor or worst asset performance with increase of risks and failure rate • Future investment requirement. • Leaving larger volume of defective asset in service.	• Significant increase in investment. • High impact on delivery requirement • Negative NPV.

Table 14: Options Analysis Scorecard

9 SUMMARY

Four feasible options have been assessed and modelled to select the proposed option for the AER regulatory period 2025-30. 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 total investment of $338m in targeted replacements of 300 km conductor per annum under the **Counterfactual** proposal provides a comparable NPV outcome to a higher volume of replacement, as outlined in Option 1. We have proposed to continue with the Counterfactual into the next regulatory control period. The modelled result for counterfactual option shows that conductor failure rates are likely to be maintained the current level.

9.1 Sensitivity Analysis

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

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

In most of the sensitivity analysis outcomes the 'Preferred Option' has claimed its prudency and effectiveness over other options and therefore is recommended to be approved.

10 RECOMMENDATION

After thorough evaluation of all available options, **Counterfactual** has been determined as the most viable. This option has been chosen as it provides the best balance of benefits and risks for the organisation, with a focus on optimising existing processes and enhancing efficiencies where possible.

11 APPENDICES

11.1 Appendix 1: Reset RIN DATA RECONCILIATION

	2025/26	2026/27	2027/28	2028/29	2029/30
	Expdenture	Expdenture	Expdenture	Expdenture	Expdenture
RIN	$16,404,472	$16,404,472	$16,404,472	$16,404,472	$16,404,472
Conductor Replacement					
Defect	0	0	0	0	0
Reconductoring	16,404,472	16,404,472	16,404,472	16,404,472	16,404,472
Conductor Consequential Replacement					
Consequential Pole Replacement	6,842,026	6,842,026	6,842,026	6,842,026	6,842,026
Consequential Poletop Replacement	9,491,360	9,491,360	9,491,360	9,491,360	9,491,360
Consequential Services Replacement	3,549,466	3,549,466	3,549,466	3,549,466	3,549,466
Consequential TD Replacement	11,431,347	11,431,347	11,431,347	11,431,347	11,431,347
Consequential Switch Replacement	10,209,822	10,209,822	10,209,822	10,209,822	10,209,822
Consequential Replacement	**41,524,020**	**41,524,020**	**41,524,020**	**41,524,020**	**41,524,020**
BC Total	**57,928,492**	**57,928,492**	**57,928,492**	**57,928,492**	**57,928,492**

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

$, direct 2024-25	2025/26	2026/27	2027/28	2028/29	2029/30
	Expenditure	Expenditure	Expenditure	Expenditure	Expenditure
Conductor Replacement					
Defect	0	0	0	0	0
Reconductoring	18,652,181	18,714,962	18,766,985	18,802,002	18,926,704
Conductor Consequential Replacement					
Consequential Pole Replacement	7,779,507	7,805,692	7,827,390	7,841,995	7,894,006
Consequential Poletop Replacement	10,791,847	10,828,171	10,858,271	10,878,531	10,950,682
Consequential Services Replacement	4,035,807	4,049,391	4,060,647	4,068,224	4,095,206
Consequential TD Replacement	12,997,648	13,041,396	13,077,649	13,102,050	13,188,947
Consequential Switch Replacement	11,608,751	11,647,825	11,680,203	11,701,997	11,779,609
Consequential Replacement	**47,213,560**	**47,372,476**	**47,504,161**	**47,592,796**	**47,908,450**
BC Total	**65,865,740**	**66,087,437**	**66,271,146**	**66,394,798**	**66,835,154**

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	300.000	300.000	300.000	300.000	300.000
Conductor Replacement					
Defect	0.000	0.000	0.000	0.000	0.000
Reconductoring	300.000	300.000	300.000	300.000	300.000
Conductor Consequential Replacement					
Consequential Pole Replacement	979	979	979	979	979
Consequential Poletop Replacement	4,379	4,379	4,379	4,379	4,379
Consequential Services Replacement	4,483	4,483	4,483	4,483	4,483
Consequential TD Replacement	405	405	405	405	405
Consequential Switch Replacement	1,183	1,183	1,183	1,183	1,183

Table 177: Reset RIN reconciliation table - Volumes