Low Voltage Service

Post Implementation Review

ERGON ENERGY NETWORK
Part of Energy Queensland

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DOCUMENT VERSION

Version Number	Change Detail	Date	Updated by
Draft V0.1	Draft	01/05/2023	Srini Chinnarajan
Draft V0.2	Finalised draft post Network Investment Strategy review	17/10/2023	Monique Bitossi Satendra Goel
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RELATED DOCUMENTS

Document Date	Document Name	Document Type
21/12/2018	EQL SASP AMP Services 21122018 Public Approved	PDF
15/11/2023	Weibull Model Report – Services v0.1	DOCX
NOV 2023	Services Weibull Modelling	Excel
NOV 2023	Services Risk Modelling	Excel
01/06/2023	RIN 2.2 Compare 2021-22 (Rosetta)	Excel
06/11/2019	Ergon 2018-19 - Category Analysis - RIN Response - Consolidated - 6 November 2019 - PUBLIC D19-174436(v2)	Excel
09/08/2023	Maintenance Activity Frequency (MAF) – Release 2	PDF
16/06/2023	Maintenance Acceptance Criteria (MAC) – Release 11	PDF
01/10/2023	Lines Defect Classification Manual	PDF
01/07/2023	Substation Defect Classification Manual	PDF
08/2022	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	Services – Post Implementation Review (PIR)
DNSP	Ergon Energy Network
Expenditure category	☒ Replacement ☐ Augmentation ☐ Connections ☐ Tools and Equipment ☐ ICT ☐ Property ☐ Fleet
Purpose	The purpose of this Post Implementation Review (PIR) is: • to evaluate the benefits of the step change in targeted service replacement that has resulted in increased volume of service replacements implemented during PIR. • to support the PIR review of Ergon's capital expenditure over the 2018-19 to 2022-23 via a cost benefit analysis.
Identified need	☒ Legislation ☒ Regulatory compliance ☒ Reliability ☐ CECV ☒ Safety ☒ Environment ☒ Financial ☐ Other Ergon Energy is committed to adopting an economic, customer value-based approach when it comes to ensuring the safety and reliability of the network. To quantify the advantages of this approach for the community and businesses over the modelling period, they have employed Net Present Value (NPV) modelling. This commitment is in line with our efforts to maximise the value to our customers. The targeted replacement volumes were doubled in the regulatory period 2020-25. NPV modelling has confirmed the benefits of these replacements for community/business over the modelling period. It is also intended to continue with the proposed increased volume of targeted replacement program to manage the in-service failures risks. Within the acceptable limits as per So Far As Is Reasonable Practicable (SFAIRP) approach. Ergon Energy observed that the unassisted failure rate averaging around 1000 services per year was presenting significant risks to public safety and reliability for customers and community. Increased failures could have resulted in a major safety or network incident leading to significant impact on community/company. Upon review Ergon Energy identified: • Significant low replacement volume between 2015-16 and 2018-19 has resulted in significant backlog causing number of defective services increasing substantially. • Number of shocks and tingle incident rising with defective and failed services impacting public safety.

Alternate options	Four different options were considered over the continuation of the counterfactual (AER Final Determination budget allocation – Address 100% defects and no targeted services) replacements. In option 1, 2 and 4, variation applied only for the targeted volume portion as the uniform defect and failed services replacement volume is assumed. 1. Historical Volumes – Targeted 4,250/yr. 2. Additional Proactive Replacement – Targeted 17,000/yr. 3. AER REPEX Live Scenario – Address 87% defects and no targeted 4. Actual Delivery – Targeted 8,500/yr.
Expenditure	This PIR business case relates only to targeted OH services replacements. A large number of services are also replaced with pole replacement under different programs such as overhead reconductoring, defective poles replacements and clearance to ground / structure. However, consequential investment and their respective benefit is included in the respective PIR.
Benefits	The selected option 4. Actual Delivery provides a positive NPV of $27.2m with a total community benefit of $56.7m over a modelling period of 20 years, with optimised outcome in terms of investment and customer benefits. Also, this option forecast failure rate reductions in line with SFAIRP approach.

Year $m, nominal	2018-19	2019-20	2020-21	2021-22	2022-23	Total
RIN Total	10.3	16.9	23.8	23.8	29.0	103.8
- Targeted*	3.1	9.7	13.7	13.2	13.5	53.2
- Defect*	4.7	0.2	3.3	0.3	6.6	15.1
Target + Defect	**7.8**	**9.9**	**17.0**	**13.5**	**20.1**	**68.3**
- Consequential	2.5	7.0	6.8	10.3	8.9	35.5
(2022/23 real $)	**9.2**	**11.6**	**19.2**	**14.1**	**20.1**	**74.2**

** Expenditure considered for this business case.*

2 PURPOSE AND SCOPE

The purpose of this PIR is to review the increased services volumes and expenditures for Ergon Energy services during the regulatory period 2018-19 to 2022-23. The PIR also includes the analysis of different options, to ascertain efficiency and prudency through financial NPV modelling, considered to manage the increasing unassisted services failures that pose an increased risk to public safety and reliability of the network.

This document is to be read in conjunction with the Low Voltage (LV) Service Asset Management Plan.

3 BACKGROUND

Ergon Energy was required to review its asset management practices with respect to services in response to concerns that the unassisted failure rates were tracking too high. Additionally:

- Asset management strategies improvement was required for this class to focus upon improving shock related performance in the Ergon network.
- Energy Queensland has a duty under Section 29 of Queensland Electricity Safety Act to ensure its network operate in a way that is electrically safe. This obligation includes the requirement that Ergon Energy inspects tests and maintains its assets to ensure public safety.

The lower targeted replacements volumes during the period 2010-18 caused a significant backlog of unidentified poor condition services causing an increase in failure rates, triggering a major review of the asset condition assessment process.

Ergon Energy acknowledge that the AER REPEX calculations were providing more realistic forecast outcomes regarding replacement of services and other assets in comparison to Ergon Energy modelling. However, continuing with the lower replacements in line with modelling outcomes has resulted in mounting of poor condition ageing assets now requiring increased volume of replacements to keep the failure rates within acceptable limits in line with SFAIRP approach.

Moreover, over recent years there has been an effort to improve the quality of the failure data, the data gathered by inspectors in the field and the data systems which utilise the services data. The improved failure data captured has indicated an escalating failure rate for services.

Accordingly, Ergon Energy reviewed the current asset inspection and assessment processes and methodologies to ensure that they align with industry best practice, were accurate and reliable.

Within the whole electrical network, overhead services involve the highest safety risk exposure in terms of shock and tingles to residents/public in the houses and commercial venues. Overhead services failure can easily lead to electrical leakage which results in shocks and tingles. This may lead and had led to serious injuries and even multiple fatalities across Australia.

3.1 Asset Population

As per 2018-19 RIN data EE had a total of 402,530 overhead services as shown in Figure 1. Age profile of services reflects that 141,536 services were over 40 years, and 64,073 services were over 50 years in 2018-19. Ergon Energy system is not designed to record the age of the service as historically services not being registered as unique asset. Therefore, Ergon Energy uses service contractual period followed by the nearest pole's pole age to infer the services age.

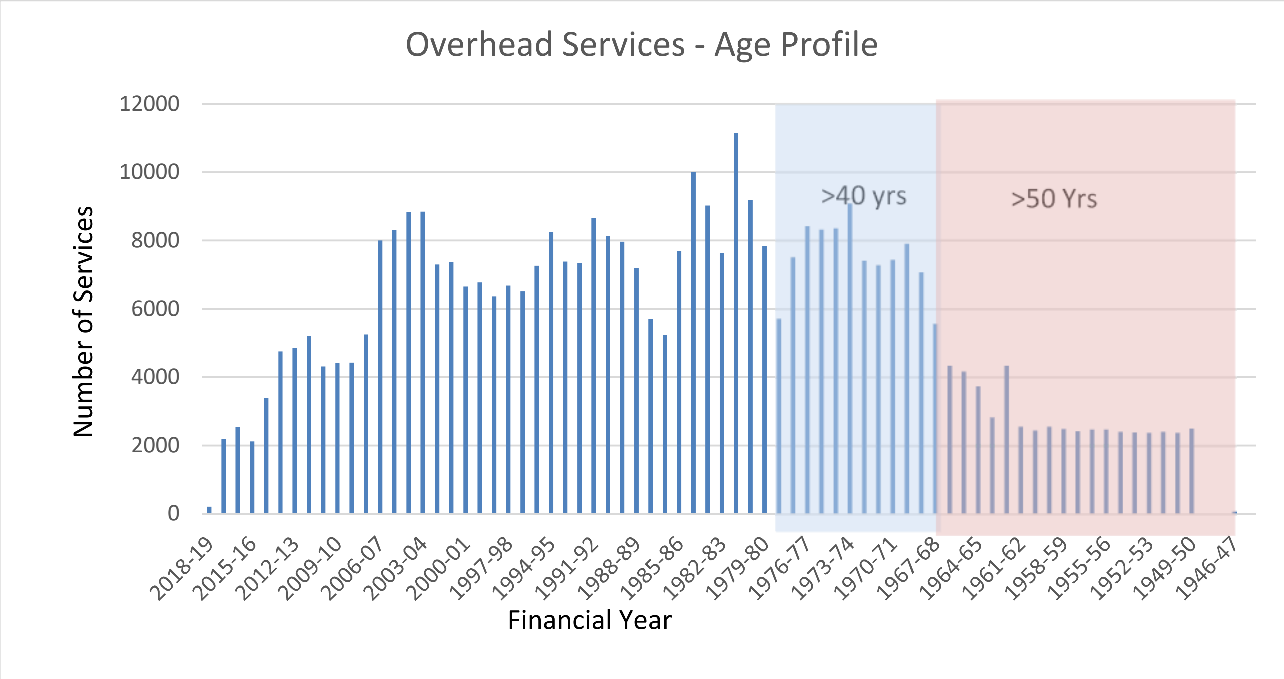

Figure 1: Age Profile Overhead Services EE

3.2 Asset Management Overview

This asset class is managed, consistent with corporate asset management policy, to achieve all legislated obligations and any specifically defined corporate key performance indicators and to support all associated key result areas as reported in the Statement of Corporate Intent (SCI).

Safety risks associated with this asset class is eliminated as per so far as is reasonably practicable (SFAIRP), and if not able to be eliminated, is mitigated SFAIRP. All other risks associated with this asset class are managed to be as low as reasonably practicable (ALARP).

All inspection and maintenance activities are performed consistent with manufacturers' advice, good engineering operating practice, and historical performance, with the intent to achieve the longest practical asset life overall. End of asset life is determined by reference to the benchmark standards defined in the Defect Classification Manuals and or Maintenance Acceptability Criteria.

As listed in Table 1, problematic assets such as very high maintenance or high safety risk assets in the population are considered for early retirement. Replacement work practices are optimised to achieve bulk replacement to minimise overall replacement cost and customer impact.

Asset management strategies with continuous improvement for this class focus upon improving shock related performance in the Ergon network.

Targeted services replacement program makes the biggest component of the forecast. This program is estimated based on a combination of identified problematic services type and design which present a high risk in the event of in-service failure. A large number of services are also replaced when undertaking reconductoring or defective pole replacements programs as an efficient means of work delivery. This consequential investment and benefit have been considered in the respective PIR business cases.

Cable Code	Service Type
B	Bare Open (Open Wire)
N	Neutral Screen PVC)
O	Open wire (PVC)
P	Parallel web (PVC)
T	Twisted multiphase (PVC)
XMT	XLPE Mitti (known issue)

Table 1: Problematic Service Types

3.3 Asset Performance

The two functional failure modes of Services defined in this model are found in Table 2:

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

Table 2: Description of Functional Failure

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

Figure 2 and Figure 3 displays the number of unassisted failures and defects respectively. Figure 2 illustrate consistent failure rate of around 1,000 services with some variations year to year.

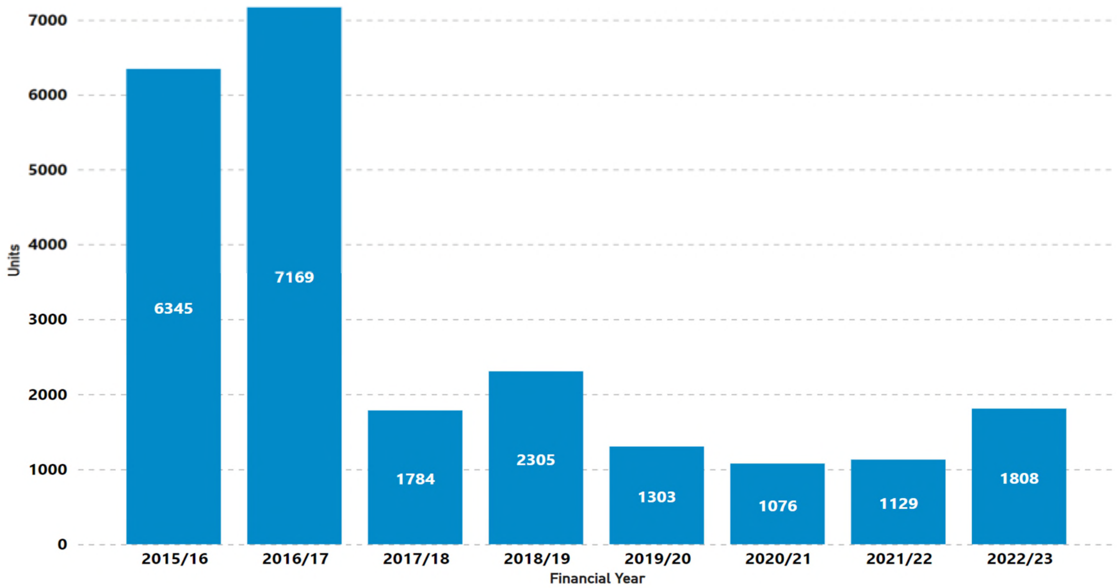

Figure 2: Services unassisted failure

Figure 3 shows that the number of defects were significant during the first two years with step up increases in next two years peaking in 2018-19, triggering the increased replacement volume program. After rigorous replacements the defects volume has gradually and continuously declined, however it is still at considerably high level.

The main cause of defects being insulation, ageing and degradations in associated components causing loss of conductivity and strength in the services, which if left unaddressed eventually cause an unassisted failure of the services. Also, there have been a few known issues with different types of services used during the last 50 to 60 years, requiring replacements proactively to improve the asset performance.

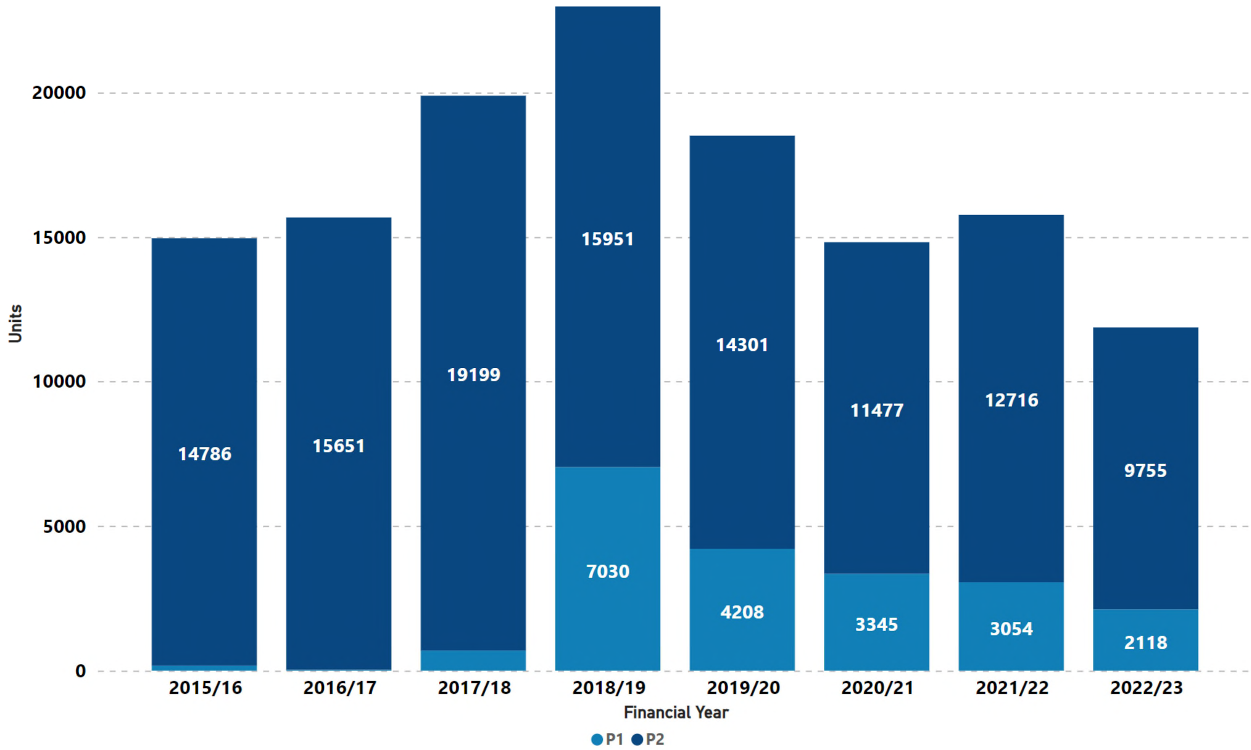

Figure 3: Services defect

Additionally, Figure 4 shows the number of shocks and tingles reported that are directly attributable to overhead services. Ergon Energy is committed to keep the business limit to 0.023% equates to 183 shocks per annum based on customer volume, at the current rate Ergon energy is just managing under this limit.

In order to reach the business target of 0.01% by 2032, Ergon Energy needs as the minimum to maintain the targeted replacement volume at the current rate and look for opportunities to increase the replacement volume based on asset and shock performance trend.

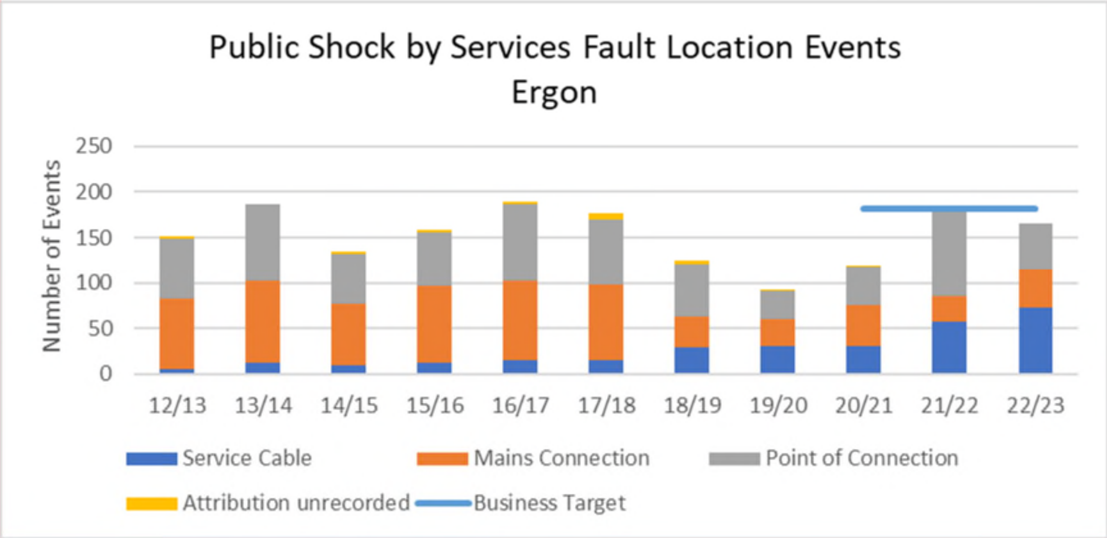

Figure 4: Shock and Tingle Incidents - EE

4 RISK ANALYSIS

In evaluating the risks associated with our services assets, we model each service with age band.

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. As such, following the cost benefit analysis through NPV modelling, the most positive NPV of the volumes considered will form the basis for selecting the preferred option about replacement. In the case of this PIR, the most positive NPV validates the volume of replacement undertaken over the review period is a prudent approach.

The monetised risk is simply calculated as per the calculation in Figure 5:

Figure 5: Monetised Risk Calculations

Each consequence category follows the same calculations in Figure 5 to obtain the total monetised risk is as per below in Figure 6. Ergon Energy broadly considers five value streams for investment justifications regarding replacement of widespread assets. In Figure 6, only four of the value streams are considered; the ‘Export’ is not material to services.

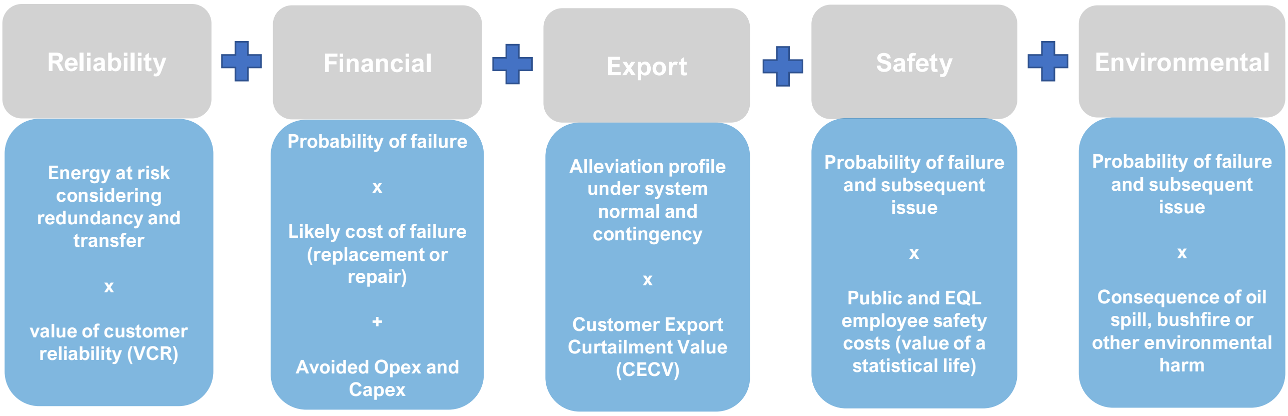

Figure 6: Total Risk Cost Calculation

4.1 Probability of Failure

Due to the limited condition data available for the implementation of an Asset Health Index (AHI), the Weibull distribution model was utilised instead due to its flexibility and ability to model skewed data. The Statistical model Weibull Distribution has been developed for assets having only observed inspection and not having measured data to predict the PoF such as Low Voltage service cables, Pole Top Structures (Crossarm), distribution transformers and distribution switches to assist with the replacement management of ageing assets.

The Weibull distribution is one of the most widely used lifetime distributions in reliability engineering. It is a versatile distribution that can take on the characteristics of other types of distributions, based on the value of the shape parameter, β and the scale parameter, η. The function used to determine the probability of failure from a particular asset's time of failure is the Cumulative Distribution Function (CDF).

Shape parameter eta defines the average period when 63.2% of asset population is expected to fail. The other parameter represents the failure rate behaviour, if beta is less than 1, then the failure rate decreases with time; if beta is greater than 1, then the failure rate increases with time. When beta is equal to 1, the failure rate is constant. The resultant Weibull curve shown in Figure 7 below for the services has produced beta β as 3.7 and the η as 37.

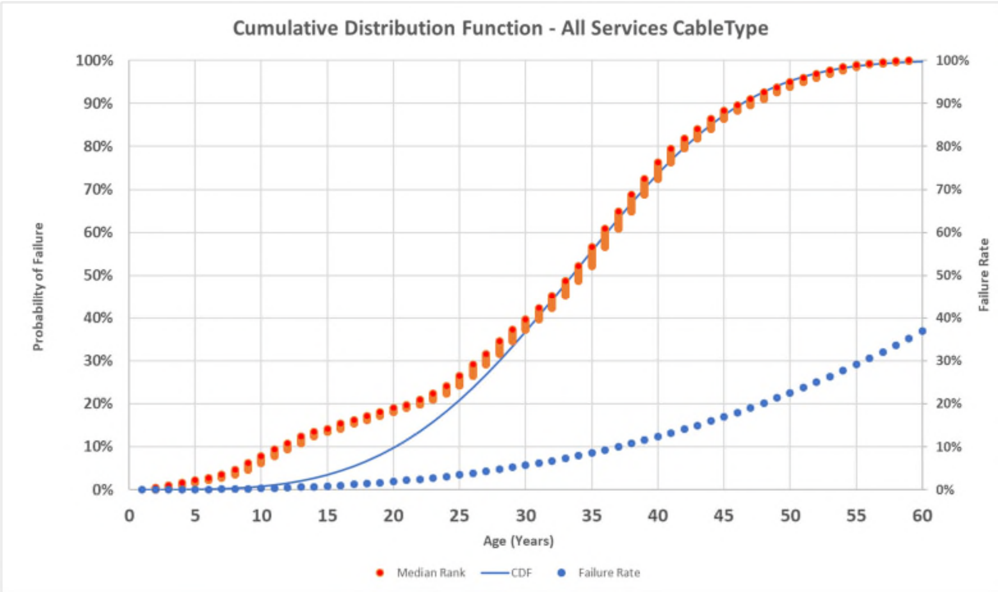

Figure 7: Cumulative Distribution Function – All Service Cable Type

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

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

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

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

- **Lost load:** As per the AER Frontier Economics 2021, the average consumption for a household based on 3-person family is 1 kW. This load on each service in our network is utilised to determine the kW that would on average be lost following a service failure.
- **Restoration timeframe:** the average loss of supply has been estimated for a period of average five hours for service failures and two hours for service defect replacement.
- **Value of Customer Reliability Rate:** We have used the Queensland average VCR rate for not only different residential loads.
- **Probability of Consequence**: all in-service service 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 service:

- Service replacement:
  - Average failure replacement cost is $1,106.
  - Average defect replacement cost is $539.
  - Average targeted replacement cost is $750.
- **Probability of Consequence:** all in-service service failures result in a need to replace the service under emergency.

4.2.3 Safety

The safety risk for a service failure is primarily that a member of the public is in a premises with a failed service line. This could result in a fatality or injury. For our modelling we have used August 2022 published document from *Australian Government, Department of the Prime Minister and Cabinet (Office of Best Practice Regulation) – Best Practice Regulation Guidance Note - Value of a Statistical Life*:

- Value of a Statistical Life: $5.4m
- Value of an Injury: $1.3m
- Value of a shock or tingle: $500
- Disproportionality Factor: 6 for members of the public
- **Probability of Consequence**: Following an unassisted service failure, there is a 0.0043% chance of causing a fatality and 0.1% chance of a serious injury based on historical data evidence. In the last 10 years there has been one fatality incident associated with service line failure.

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 service causing a downed line and fire. For our modelling we have used:

- **Value of Bushfire:** $22.3m – which includes average damage to housing and fatalities following a bushfire being started. In Queensland *as per Australian major natural Disasters.xlsx (a compendium of various sources)*, there were 122 homes lost and 309 buildings lost during bushfires between 1990 and present (2021) across 12 significant fire records. Homes were estimated an average cost of $400,000 while the buildings were estimated at an average cost of $80k.

- **Probability of Consequence:** In consideration with the chances of the fire caused by services failure, EQL uses the four years average fire data to infer the frequency of different level of fire incident, fire caused by services with no material damage, spread wider, with small damage and with serious damage. EQL did not record any bushfire caused by services with serious damage in the past. Due to the location of the services is close to occupied premises, the chances of having serious damage bush fire is very low. Once in 20 years assumption is used in this model.

5 CONSEQUENTIAL REPLACEMENT

Within the scope of the pole and overhead conductor replacement investments, we assess the condition of the equipment attached to the assets and determine the feasibility and cost-effectiveness of replacing them. This equipment includes pole top structures, transformers, service lines, and switches. Consequently, when evaluating the benefits of this approach for our customers, we take into account the investments and advantages associated with these consequential replacements in our analysis of the respective PIR Poles and PIR Overhead Conductor business cases to ensure that the overall asset expenses are accounted for. Table 3 outlines the volume of Low Voltage services replaced as a result of the pole replacement and reconductoring program during the specified reporting period.

Actual Delivery Consequential Services Volume	2018-19	2019-20	2020-21	2021-22	2022-23	Total
With Pole Replacements	2,427	4,861	2,904	3,181	4,366	17,740
With Reconductoring	388	885	2,012	3,151	1,848	8,283

Table 3: Consequential Asset Volume – Actual Delivery

6 IDENTIFIED NEED

6.1 Problem Statement

Ergon Energy required a review of its asset management practices with respect to services in response to concerns that the unassisted services failure and public shocks rate was tracking high. Over recent years there has been an effort to improve the quality of the failure data, the data gathered by pole inspectors in the field and the data systems which utilise the data. The improved failure data captured has indicated an escalating failure rate for unassisted services failures.

6.2 Compliance

Corporate performance outcomes for this asset are effectively rolled up into Asset Safety & Performance group objectives, principally:

- KRA – Customer Index
- KRA – Optimise investments to deliver affordable and sustainable asset solutions for our customers and communities.

Corporate Policies relating to establishing the desired level of service are detailed in the reference documents of Appendix 1.

Public shocks are monitored monthly, with shocks related to neutral integrity being the most significant factor (60-70%). Public shocks are considered notifiable events, required to be reported to the Electrical Safety Office.

In line with EQL's regulatory duty of care, there is an imperative to maintain the incidence of services related shocks SFAIRP. Regulatory performance outcomes for this asset include compliance with all legislative and regulatory standards, including the Electrical Safety Act 2002 (Qld), the Electrical Safety Regulation 2013 (Qld) (ESR), and the Electrical Safety Codes of Practice.

The Electrical Safety Act 2002 (Qld) s29 imposes a specific duty of care for EQL, which is a prescribed Electrical Entity under that Act:

- An electricity entity has a duty to ensure that its works:
    - are electrically safe.
    - are operated in a way that is electrically safe.
- Without limiting subsection (1), the duty includes the requirement that the electricity entity inspect, test and maintain the works.

The ESR details some requirements for overhead service lines. These include various general obligations related to the safety of works of an electrical entity and a number of specific obligations, notably:

- ESR Schedule 2 - Exclusion zones for overhead electric lines
- ESR Schedule 5 - Clearance of low voltage overhead service lines
- ESR s76(4) - "The electricity entity must at periodic reasonable intervals inspect and maintain the insulation of the clamp or apparatus"

- ESR s215 - “An electricity entity must ensure the integrity of the insulation of the relevant part of the electrical entity’s works is inspected and maintained … inspection and maintenance must be performed as periodic reasonable intervals”
- ESR s215 - “An electricity entity must ensure the integrity of insulation for the clamp or other apparatus at the point where consumer mains are connected to the electricity entity’s overhead service line is inspected and maintained … inspection and maintenance must be performed at periodic reasonable intervals.”

It is clear from the legislated requirements above that there is an intention to ensure inspection is undertaken “at periodic reasonable intervals”. Its nature and interval are defined by engineering judgement, taking into account overall safety and performance obligations.

6.3 Counterfactual (Base Case Scenario) – AER Final Determination

To provide a comparison of the potential alternatives to our actual delivery for our cost benefit analysis, we have set the counterfactual to AER final determination final budgets/on volumes for replacement program estimated using final determination services allowance divided by actual unit cost.

6.3.1 Costs/Volumes

The services replacement volumes and costs that have been modelled under this approach are outlined in Table 4 which shows addressing 100% of defects/failed services and no targeted replacement.

Counterfactual Volume/Costs	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Services Cost $m nominal	4.7	4.8	4.9	5.0	5.1	**24.4**
Defect %	100%	100%	100%	100%	100%	
Defective Replacement Quantity	6,313	6,456	6,593	6,723	6,846	**32,931**

Table 4: Replacement Cost/Volume – Counterfactual

6.3.2 Risks Quantification

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

Figure 8 provides the results of a quantitative forecast of emerging risk associated with Ergon’s services asset population failure due to condition related failure modes. This counterfactual risk is based on current failure rates now and forecasted based on Weibull modelled failure rates with replacement of only 77% defective services result in elevated failures and defect volumes.

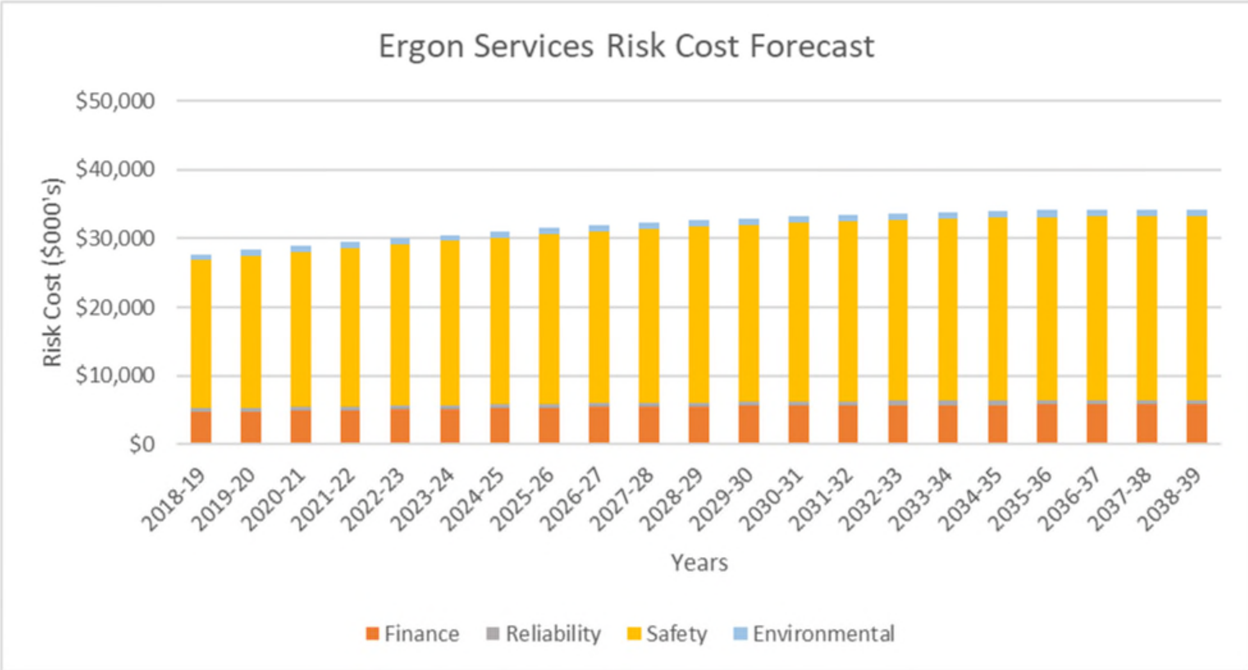

Figure 8: Counterfactual quantitative risk assessment

Figure 9 shows the failure forecast for services over the next 20 years.

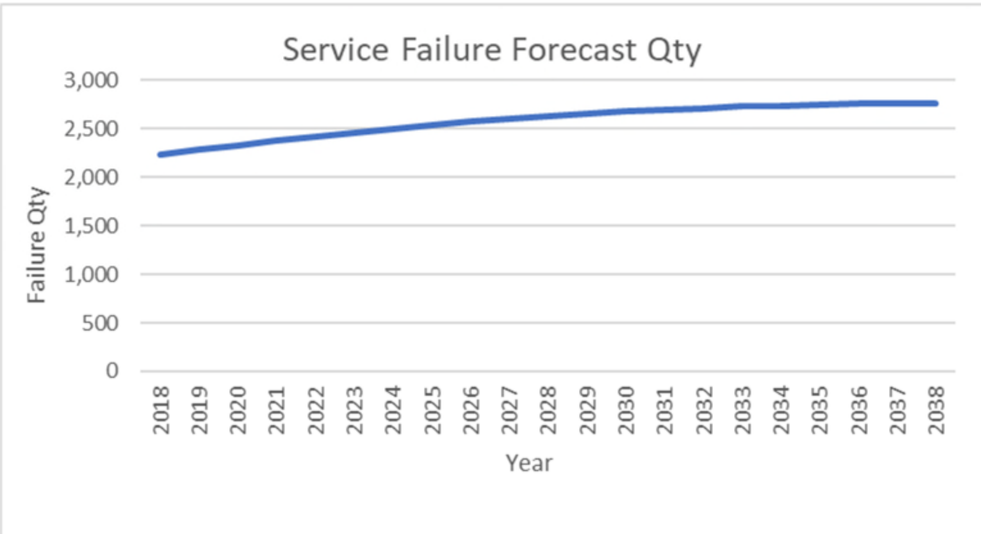

Figure 9: Ergon counterfactual - services failure forecast

Significant risk costs arise in the counterfactual, safety risk is the main driver and followed by financial risk associated with services failures. The cost of these risks further increases marginally though, over the 10-year period shown, driven mainly by the age profile of the existing population, and expected failure rate increases even though assuming that counterfactual replacement program will remain continue during the forecast period. Additionally, Queensland Energy and Job Plan (QEJP) include installation of smart meters by 2030 targeting transition towards ‘replacement on defect’ approach for this asset class as neutral break shall be detected by the smart meters to eliminate the shock risks from the broken neutrals, the biggest risk associated with this asset class.

7 OPTIONS ANALYSIS

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

7.1 Option 1 – Historical Replacement Rate

This option involves continuing the defective replacement numbers based on the 2015-16 and 2017-18 average and continue with same targeted replacement volume.

Ergon Energy Networks programmed 4,250 targeted services replacement per year on top of the defect and failure replacement during the maintenance programs. The resultant replacement cost and volume for the PIR period is shown in Table 56 below:

7.1.1 Costs and Volumes

The volumes and costs that have been modelled as part of Option 1 are outlined in Table 5.

Historical Replacement Volume/Costs	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Additional Targeted Services Cost $m nominal	7.9	7.9	7.9	7.9	7.8	**39.3**
Additional Targeted Volumes	4,250	4,250	4,250	4,250	4,250	**21,250**
Defective Replacement Cost $m	4.7	4.7	4.7	4.7	4.7	**23.4**
Defective Replacement Quantity	6,313	6,322	6,323	6,315	6,299	**31,572**

Table 5: Replacement Cost/Volume – Option 1

7.1.2 Risks/Benefits

In this option, our modelling shows that the unassisted service failures are projected to reduce considerably in comparison to those in the counterfactual option but not compared to current levels with only minor reductions in near future and rising back again offsetting initial advantage. Accordingly, this level of performance does not reduce our failure rate in long term to reduce safety risk or maximise customer benefits. Furthermore, opting for this approach will result in a growing need for substantial investment in the near term due to the escalating rate of asset failures. This is primarily because leaving a large number of defective and old/obsolete services in the network leads to significant investment requirements and poor asset performance.

7.2 Option 2 – Additional Targeted Replacement

This option includes defect and failure replacement with 17,000 targeted services replacement – double the volume of the actual targeted delivery. This option provides the best NPV performance, but the feasibility will be limited by current resources and there is also a significant cost impact on customers.

7.2.1 Costs/Volumes

The volumes and costs that have been modelled as part of Option 2 are outlined in Table 6.

Additional Targeted Replacement Volume/Costs	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Services Cost $m nominal	17.4	17.1	16.8	16.5	16.2	**84.1**
Additional Targeted Volumes	17,000	17,000	17,000	17,000	17,000	**85,000**
Defective Replacement Cost $m nominal	4.7	4.4	4.1	3.8	3.4	**20.3**
Defective Replacement Quantity	6,313	5,910	5,496	5,072	4,637	**27,429**

Table 6: Replacement Cost/Volume – Option 2

7.2.2 Risks/Benefits

Under this approach, our modelling predicts that the occurrence of unassisted services failures will be notably reduced in comparison to not only with the counterfactual option but compare to current level of failures as well. Accordingly, this transition aims to bring the failure rate down SFAIRP ensuring a satisfactory level of public safety risks. While this option provides significant advantages to customers it is not without substantial cost impacts.

7.3 Option 3 – AER REPEX Model Lives Scenario

This option volume is based on the REPEX model lives scenario output and includes limited defect and failure replacement and no targeted services replacement. This option provides the worst NPV performance and the highest risk cost with only 66% of defects replaced.

7.3.1 Cost/Volumes

The volumes and costs that have been modelled as part of Option 3 are outlined in Table 7.

Repex Model Live Scenario Volume **Repex Model Live Scenario Expenditure**	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**Total**
Services Cost $m nominal	4.4	4.9	5.0	5.1	5.2	**24.6**
Volumes based on % defect Replacement	87%	87%	87%	87%	87%	
Defective Replacement Quantity	5,795	6,517	6,717	6,857	6,982	**32,867**

Table 7: Replacement Cost/Volume – Option 3

7.3.2 Risks/Benefits

Under this option, our modelling indicates that unassisted service failures are expected to be more compared to the counterfactual option. Choosing this approach will necessitate a significant increase in near-term and long -term investments due to the rising rate of asset failures and will be detrimental to Ergon Energy commitments of reduce the number of shocks.

7.4 Option 4 – Actual Delivery

This option includes corrective replacement of all the services identified as defective or failed services and 8,500 targeted service replacement.

7.4.1 Cost/Volumes

The volumes and costs that have been modelled as part of Option 3 are outlined in Table 8

Actual Delivery Volume Actual Delivery Expenditure	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Services Cost $m nominal	7.6	11.1	11.0	10.9	10.7	**51.2**
Additional Targeted Volumes	3,960	8,500	8,500	8,500	8,500	**37,960**
Defective Replacement Cost $m	4.7	4.6	4.5	4.4	4.2	**22.3**
Defective Replacement Quantity	6,313	6,184	6,047	5,900	5,742	**30,186**

Table 8: Replacement Cost/Volume – Option 4

7.4.2 Risks/Benefits

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

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

8 OUTCOMES OF OPTIONS ANALYSIS

8.1 Service Failure Forecast

The low voltage services failure rate forecast for main options shown in the Figure 10 below.

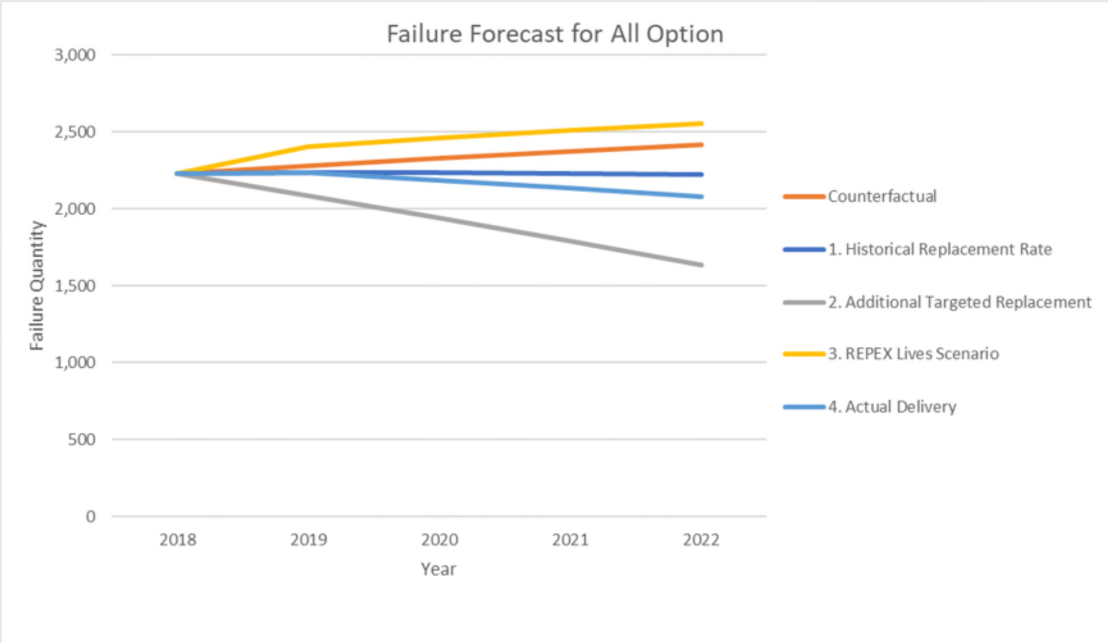

Figure 10: Failure Forecast - Intervention options

The projected failure forecast shows a significant improvement in asset performance for the options involve targeted replacement strategy.

8.2 Economic Analysis

The NPV of cost benefit analysis of the options is summarised in Table 9 which demonstrates the following:

- Option 4 - Actual Delivery, compared to the counterfactual is NPV positive, indicating the benefits to customers of the program that we have undertaken.
- Option 1 and Option 2 also provide a positive NPV however Option 4 results in the optimised customer benefit and customer costs.
- An increased volume of replacements over Option 2 would have delivered even higher value, however this would have had a major impact the resource and service cost to the customer.

Options	Rank	Net NPV	Intervention CAPEX NPV	Intervention Benefits NPV
Counterfactual	4	$0	$0	$0
1. Historical Replacement Rate	3	$13,520,471	-$14,593,767	$28,114,238
2. Additional Targeted Replacement	1	$54,210,125	-$59,353,242	$113,563,367
3. REPEX Lives Scenario	5	-$16,275,272	$77,510	-$16,352,782
4. Actual Delivery	2	$27,226,051	-$29,510,353	$56,736,404

Table 9: NPV Modelling and Consequential Benefits

Table 10 summarises the volume replacements for all options.

Options	Targeted	Defect
Counterfactual	0	100%
1. Historical Replacement Rate	4,250	100%
2. Additional Targeted Replacement	17,000	100%
3. REPEX Lives Scenario	0	87%
4. Actual Delivery	8,500	100%

Table 10: Option Volumes

Finally, Figure 11 compares the net NPV progression and gains over the modelling period compared to counterfactual option. This indicates significant NPV gains for option 1 with NPV increasing thrice at the rate of additional investment. However, this option doesn't reduce the failure rate as desirable in SFAIRP approach. Further increase in investment with option 2 still achieves higher NPV gains but at a slower incremental rate. Option 4 achieves the highest gains and reaches towards most optimum solution in terms of investment and net NPV gains. Considering that this is the option which is highly likely to achieve network standard compliances with reductions in the public safety risk this was/is prudent to choose this option.

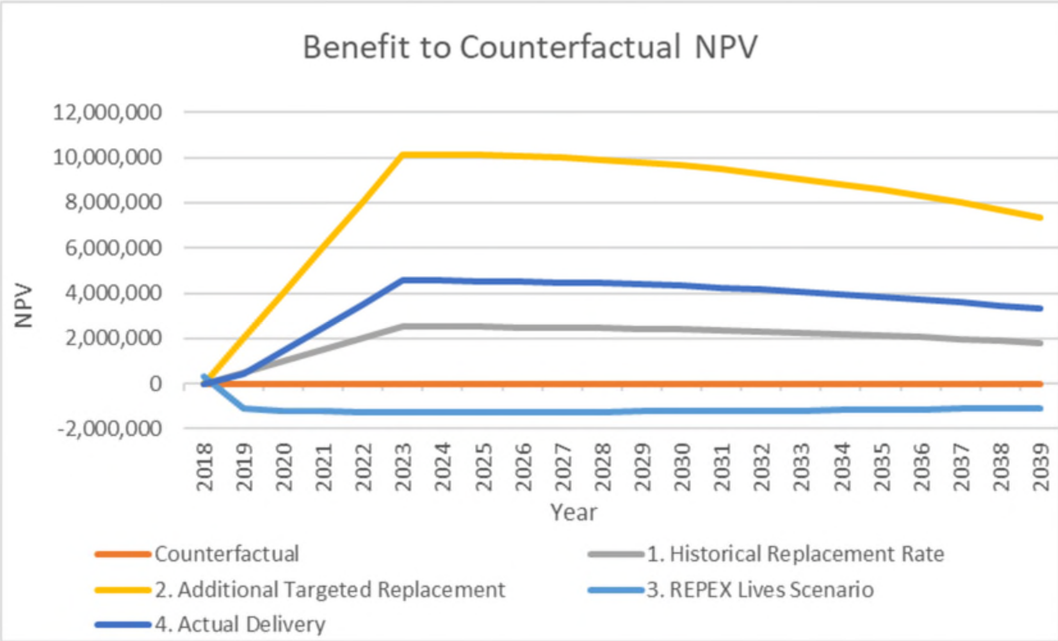

Figure 11: Benefit to Counterfactual NPV

The cost and benefits for all options have been shown in the Table 11, showing a significant customer benefit should Ergon Energy commence proactive service replacement, while on the other hand demonstrating the negative effects of no proactive replacement in the AER Determination and REPEX Live options.

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

Criteria	Option 1 - Historical Replacement rate	Option 2 - Additional Targeted Replacement	Option 3 - AER Repex Model Life Scenario	**Option 4 - Actual Delivery**
Net NPV	$13.5m	$54.2m	-$16.3m	$27.2m
Investment Risk	Low	High	Low	Medium
Benefits	Medium	Very High	Low	High
Delivery Constraint	Low	High	Low	High
Detailed analysis – Advantage	• Additional $28.1m Customer Benefit compares to counterfactual. • Positive NPV • Medium volume proactive replacement to increase asset safety in a balance way. • Removes problematic assets from the network. • Low impact on delivery requirement	• Remove all failed asset. • Reduce failure rate significantly in both short term and long term. • Highest Positive NPV • Highest customer benefits of $113.6m	• Initial capital expenditure reduction • No impact on delivery requirement • No proactive replacement to increase asset safety • Highest failure rate rises in future	• Additional $56.7m Customer Benefit compares to counterfactual. • Positive NPV • High volume proactive replacement to increase asset safety in an aggressive way. • Removes problematic assets from the network. • High impact on delivery requirement • Future proof investment
Detailed analysis – Disadvantage	• Additional investment of $14.6m. • Double the resource requirement. Doesn't reduce failure rate as desirable or in SFAIRP approach	• High investment risk option with cost impact on customers • High delivery impact	• Negative NPV • Public shock and failure rate rise is likely impacting public/customer safety	• Additional investment of $29.5m. • Delivery constraint

Table 11: Options Analysis Scorecard

9 SUMMARY

The increasing risk of services failure associated with no targeted replacement as time progressed was unacceptable, reflecting the growing ageing services population with end of service life including problematic assets left in-service in the network. The historical replacement option 1 of 4,250 proactive replacement reduces the risk marginally and the additional targeted replacement option 2 offers the best NPV cost and benefit but suffer from the feasibility of delivery and significant investment cost impacting community. The most approachable option in this analysis is the Actual Delivery- the option number 4, which provide positive NPV with reasonable community benefits at optimised cost and therefore is the preferred option.

9.1 Sensitivity

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
- WACC
- Probability of Failure (PoF)

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

10 CONCLUSION

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

We have envisaged that an increased in proactive replacements is required in the future. As shown in Option 2, increasing proactive replacements will deliver further positive NPV and will address the service before failure to avoid shocks and tingles to Ergon Energy customers.