Distribution Transformers

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	01/09/2023	Engineer Asset Strategy
Draft V0.2	Finalised draft post Network Investment Strategy review	05/10/2023	Snr Engineer Asset Strategy
V1.0	Finalised	15/11/2023	Manager Asset Strategy

RELATED DOCUMENTS

Document Date	Document Name	Document Type
DEC 2018	EQL SASP AMP Distribution Transformers 21122018 Public Approved	PDF
NOV 2023	Risk Modelling - Weibull – Dist. TX v0.1	Docx & Excel
JUN 2023	RIN 2.2 Compare 2021-22 (Rosetta)	Excel
NOV 2019	Ergon 2018-19 - Category Analysis - RIN Response - Consolidated - 6 November 2019 - PUBLIC D19-174436(v2)	Excel
AUG 2023	Maintenance Activity Frequency (MAF) – Release 2	PDF
JUN 2023	Maintenance Acceptance Criteria (MAC) – Release 11	PDF
OCT 2023	Lines Defect Classification Manual	PDF
JUL 2023	Substation Defect Classification Manual	PDF
OCT 2023	Australian Government, Department of the Prime Minister and Cabinet (Office of Best Practice Regulation) – Best Practice Regulation Guidance Note - Value of a Statistical Life:	PDF
ND	Australian Major Natural Disasters.xlsx (a compendium of various sources)	Excel

1 SUMMARY

Title	Distribution Transformers Ex-Post Review Business Case
DNSP	Ergon Energy Network
Expenditure category	☒ Replacement ☐ Augmentation ☐ Connections ☐ Tools and Equipment ☐ ICT ☐ Property ☐ Fleet
Purpose	The purpose of this Post Implementation Review (PIR) is: • to evaluate the benefits of the change to our increased volume of replacements for Distribution Transformers (DT) specifically pole transformers during the PIR period. • to support the ex post review of Ergon's capital expenditure over the 2018-19 to 2022-23 via a cost benefit analysis.
Identified need	☒ Legislation ☒ Regulatory compliance ☒ Reliability ☐ CECV ☒ Safety ☒ Environment ☒ Financial ☐ Other Ergon Energy is committed to adopting an economic, customer value-based approach when it comes to ensuring the safety and reliability of the network. To demonstrate the advantages of this approach for the community and businesses over the modelling period, they have employed Net Present Value (NPV) modelling. This commitment is in line with our efforts to maximise value for our customers. We noted that since 2018-19, the replacement volume of our distribution transformers was higher than forecasted. This analysis revealed that even though we have declining number of defects since 2018-19, the increase in distribution transformers (predominantly pole transformers) replacement volumes is due to consequential replacements arising from pole replacement. overhead conductor replacement and clearance programs. These consequential replacements are based on a cost-effective replacement strategy to improving asset performance and operation efficiency. This business case covers only the defective distribution transformer and associated fuse replacement volume. Justifications for consequential replacements are detailed in the respective PIRs,
Alternate options	Four different options were considered as per following over the continuation of the counterfactual (AER Final Determination – average 40% of actual defects delivery) replacements: 1. Historical Volumes – average 75% of actual defect 2. Additional targeted replacement –100% of actual defect + 1,303 proactive replacements 3. AER REPEX Model – Live Scenario – average of 49% of actual defect 4. Actual Delivery – 100% of defect.
Expenditure	The expenditure presented in this PIR relates to the actual investment undertaken to replace defective <u>distribution transformers (DT) and associated fuses</u>. A large number of DTs and fuses are consequentially replaced under different programs such as defective

pole replacement, targeted reconductoring, and Clearance to Ground/Structure (CTG/S). Costs and benefits associated with these consequential works are included in their respective PIR.

Year $m nominal/direct	2018-19	2019-20	2020-21	2021-22	2022-23	Total
RIN Dist. Tx	50.4	61.7	51.6	60.0	60.9	284.6
(a) Defect Dist. Tx*	**37.9**	**35.1**	**29.5**	**39.8**	**41.8**	**184.1**
(b) Fuse Consequential due to Defective Dist. Tx*	**10.6**	**12.3**	**14.2**	**13.9**	**13.9**	**64.9**
CTG/CTS Program Dist. Tx Replacement	3.7	5.9	6.4	0.1	0	16.1
Reconductor Program Dist. Tx Replacement	1.1	3.4	5.3	6	8.1	23.9
Pole Defect Program Dist. Tx Replacement	7.8	17.5	10.4	14.1	11	60.8
(a) + (b) PIR Total Investment*	**48.5**	**47.3**	**43.7**	**53.8**	**55.6**	**248.9**
(2022/23 real $)*	**57.2**	**55.3**	**49.4**	**56.4**	**55.6**	**273.8**

*Expenditure considered in this PIR.

Benefits	From our analysis, 'Option 4 – Actual Delivery' is the most cost-effective option. This option has provided the best balance of benefits, deliverability, and risks for the organisation for Ergon Energy This option provides a positive NPV of $80m with customer benefit of $158m over a modelling period of 20 years.

2 PURPOSE AND SCOPE

The purpose of this PIR is to review the increased expenditures and volumes related to Distribution Transformers over the review period (2018-19 to 2022-23). This PIR covers only the defect-based replacements of Distribution Transformers and associated fuses. Consequential replacement investment costs and benefits related with other programs such as pole replacement and reconductoring are included in their respective PIR. This business case also includes the analysis of different options, to ascertain efficiency and prudency through financial NPV modelling.

This document is to be read in conjunction with the Distribution Transformers Asset Management Plan.

3 BACKGROUND

Ergon Energy has recently reviewed its asset management practices with respect to the replacement of Distribution Transformers in response to concerns that Distribution Transformers are being replaced at a higher rate compared to the forecast volumes.

Following a thorough examination of actual performance, it became evident that while the defect rate had been increasing only gradually, the significant increase in DT replacement volume was primarily attributed to the consequential replacements occurring under the pole replacement and overhead reconductoring program. The principal factor driving the higher replacement rates for both poles and conductors was the escalating failure rate of these assets, necessitating an accelerated increase in replacement volumes. This proactive approach was taken to reduce the failure rates to acceptable levels, thereby mitigating public safety and reliability risks.

This business case covers only the defective Distribution Transformer and associated fuse replacement program.

3.1 Asset Population

As per 2018-19 RIN data, Ergon Energy have a total of 102,742 Distribution Transformers as detailed in Figure 1 below. Age profile of Distribution Transformers indicates that 10,020 Distribution Transformers are over 45 years.

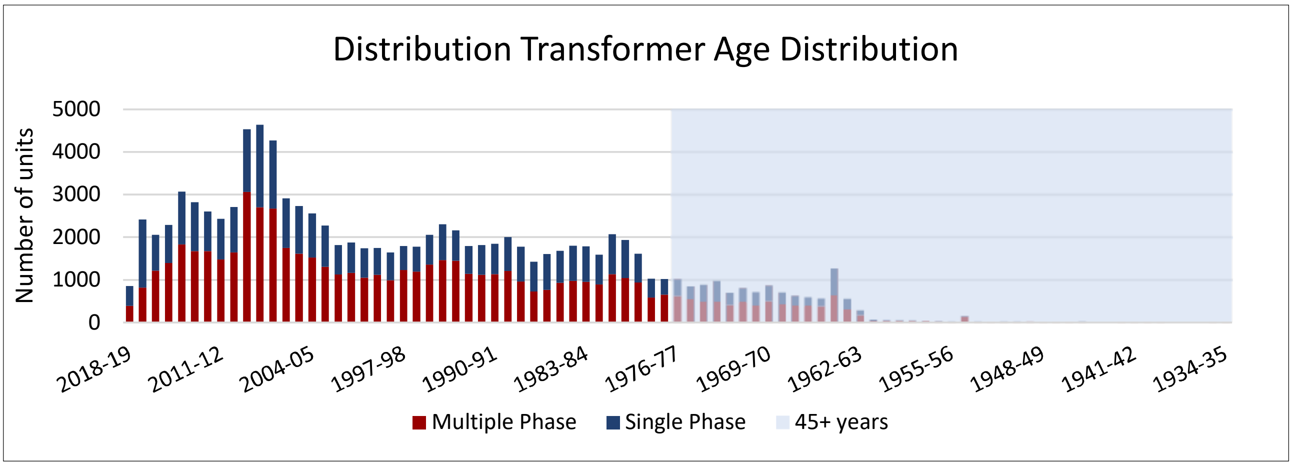

Figure 1: Age Profile - Distribution Transformers

3.2 Asset Management Overview

Distribution Transformers are inspected periodically as required per the Network Schedule of Maintenance Activity Frequency. They are reactively replaced, due to either electrical failure or poor condition (leaking oil, chipped insulators etc) as assessed by ground-based inspection. It is generally considered uneconomical to complete refurbishment of Distribution Transformers, specifically small pole mounted transformers, and they are routinely scrapped once they are removed from service.

End of asset life is determined by reference to the benchmark standards defined in our Defect Classification Manuals. Our Maintenance Acceptance Criteria and Replacement work practices are optimised to achieve bulk replacement to minimise overall replacement cost and customer impacts.

Distribution Transformers may also be replaced based on risk, where criteria indicating assets are either at or near end of life can be identified. Consequential replacement is typically undertaken with other work such as feeder refurbishment programs or bundled into logical groups for efficiency of delivery and cost.

3.3 Asset Performance

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

Functional Failure Type	Description
Catastrophic **(Unassisted Failure)**	Loss of structural integrity of a Distribution Transformer or associated components with transformer, excluding any associated other hardware related to pole or structure. Functional failure of this asset under normal operating conditions not caused by any external intervention such as abnormal weather or human
Degraded (D**efect**)	A Distribution Transformer or associated component asset deemed defective based on physical or observed serviceability criteria and if not rectified within a prescribed timescale (P0/P1/P2) could result in an unassisted failure.

Table 1: Description of Functional Failure

Identified defects are scheduled for repair according to a risk-based priority scheme (P0/P1/P2/C3/no defect). The P0, P1 and P2 defect categories relate to priority of repair, which effectively dictates whether normal planning processes are employed (P2), or more urgent repair works are initiated (P1 and P0). Generally, most defects are categorised as P2 to defer the replacement, unless it is assessed that failure is imminent, or location is too critical in terms of failure consequences.

The number of unassisted failure and defects of our Distribution Transformers over the last 8 years is provided in Figure 2 and Figure 3 below. The failure data indicates a continuous decline for the first three years from a peak of 1,572 failures in 2015-16. Over the last 4 years, the unassisted failure rate has stabilised to around 200 failures per year since.

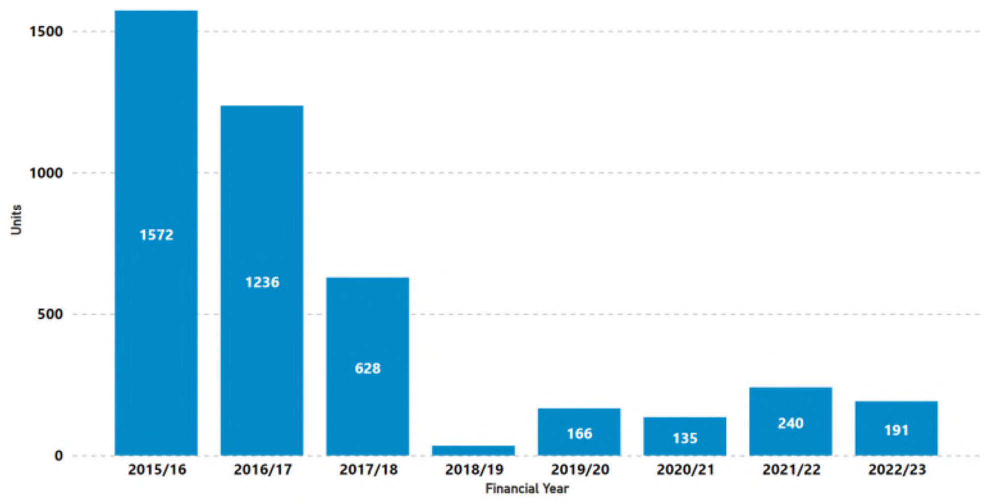

Figure 2: Unassisted Distribution Transformer Failures

The defect data of our distribution data since 2015-16 is shown in Figure 3. Discounting the volatility of data for 2015-16 and 2017-18, the annual defects prior to 2017-18, averaged approximately 900 defects per year. However, since 2019 -20 the number of defects has been declining; in part due to the increased replacement volumes through consequential replacements.

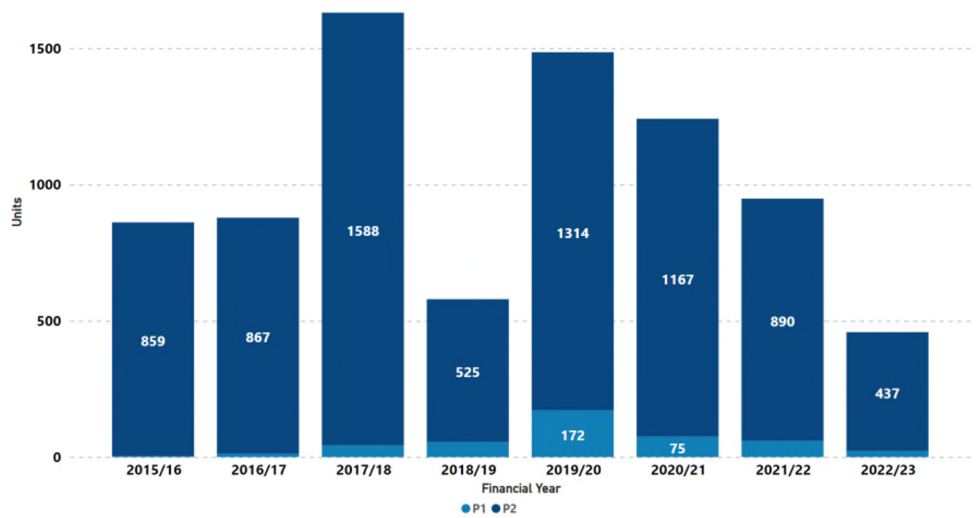

Figure 3: Distribution Transformer Defects

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4 RISK ANALYSIS

Our cost-benefit analysis aims to optimize our risk calculation at the program level, so that we can maximize the benefits to our customers. After conducting a cost-benefit analysis using net present value (NPV) modeling, we will select the preferred replacement option based on the most positive NPV of the volumes considered. In the case of this PIR, the most positive NPV validates that 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 4 - Monetised risk calculation per category.

Figure 4: Monetised Risk Calculation per Category

Ergon Energy broadly considers five value streams for investment justifications regarding replacement of widespread assets as shown in Figure 5. Only four of the value streams in Figure 5 are considered; the ‘Export’ is not material to Distribution Transformers.

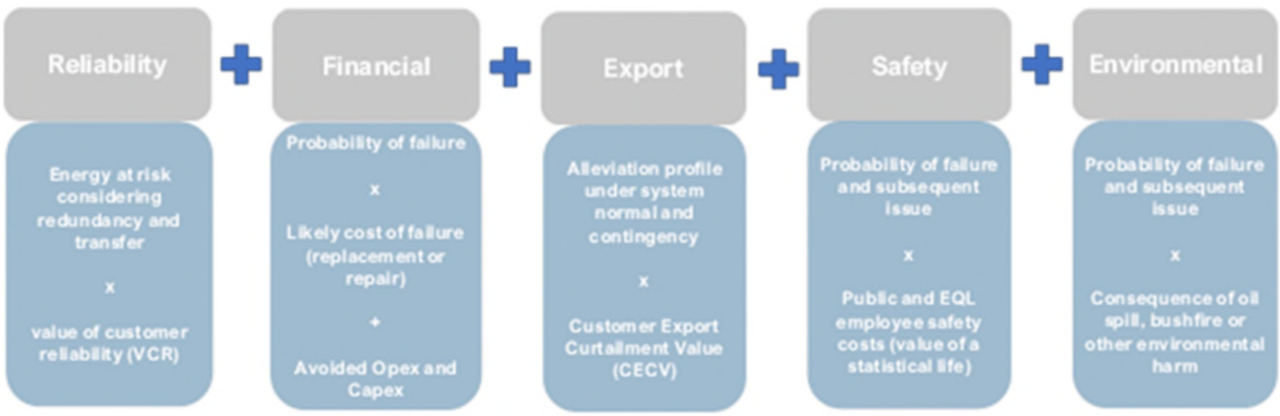

Figure 5: Total Risk Cost Calculation

4.1 Probability of Failure (PoF) – Distribution Transformers

The implementation of an Asset Health Index (AHI) was limited by the availability of condition data. As a result, the Weibull model was used instead due to its flexibility and ability to model skewed data. For Ergon assets such as Low Voltage service cables, Pole Top Structures, Distribution Transformers, and Switches, only failure, defect, and limited observed data were available to estimate Probability of Failure (PoF). To predict the PoF, the Statistical Weibull model has been developed for these assets to assist with the justification of a prudent replacement strategy.

The calculated PoF from the Weibull allows calculation of an individual PoF for each asset age band as shown in Figure 6.

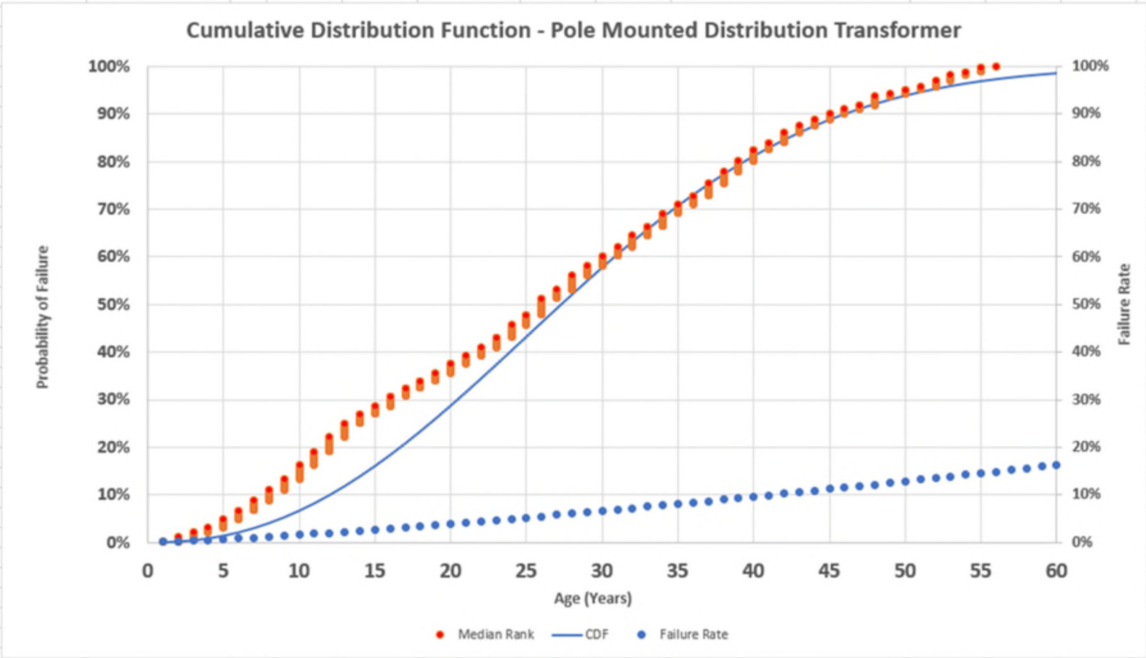

Figure 6: Weibull Cumulative Distribution Function – Pole Mounted Transformers

The resultant curve produced the following characteristics.

Weibull Variables	Value
Beta β	2.2
Eta η	33

Table 2: CDF Weibull Variables

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

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

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

To the extent possible the CoF and LoC are transformer type and size specific. This is particularly the case for the reliability and benefits stream.

4.2.1 Reliability

Reliability represents the unserved energy cost to customers of transformer outages and is based on an assessment of the amount of Load at Risk during failure repair/replacement time. The following assumptions are used in developing the risk cost outcome for a pole failure:

- **Lost load:** Load loss for each transformer is estimated using the transformer type and kVA rating and assumed kilowatt loss is 33% of the maximum rating of the transformer type band. With the large Distribution Transformers (over 600kVA rating), 600kW assumption is used. The restoration time is estimated from subject matter expert based on historical evidence.
- **Value of Customer Reliability Rate:** We have used the Queensland average VCR rate.
- **Probability of Consequence**: all in-service Distribution Transformer 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 pole failure:

- **Transformer replacement:** different unit cost of Distribution Transformer replacement has been taken based on the type and size of the transformer including replacement condition (Planned or emergency). The cost varies between $13,500 (Defective Pole Mounted Distribution Transformer) to $57,300 (Failure replacement – Pole mounted large Distribution Transformer).
- **Probability of Consequence:** all in-service transformer failures result in a need to replace the Transformer under emergency.

4.2.3 Safety

The safety risk for a transformer failure is primarily that a member of the public is in the presence of a fallen transformer debris or shattered porcelain pieces in case of an explosive failure of transformer with/without fire. This could result in a fatality or an injury. For our modelling we have used October 2023 published document from *Australian Government, Department of the Prime Minister and Cabinet (Office of Best Practice Regulation) – Best Practice Regulation Guidance Note - Value of a Statistical Life*:

- **Value of a Statistical Life:** $5.4m
- **Value of an Injury:** $1.3m
- **Disproportionality Factor:** 6 for members of the public
- **Probability of Consequence**: Following an unassisted asset failure, there is a 0.05 chance of causing a fatality and 0.1 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. Historically, the data shows, Distribution Transformer has not been the cause of fatality, therefore the fatality incident due to a conductor asset unassisted failure has been considered for the modelling purpose.

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 transformer causing pole fire or bushfire. 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.

- **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:** The bushfire risk cost per crossarm is used to infer the Distribution Switch's bush fire risk.

5 CONSEQUENTIAL REPLACEMENT

Within the scope of the pole and overhead conductor replacement investments, we always 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 consider the investments and advantages associated with these consequential replacements in our analysis of the PIRs for Poles and Overhead Conductor to ensure that the overall asset expenses are accounted for.

Table 3 outlines the volume of Distribution Transformers replaced because of the pole replacement and reconductoring program during the review period.

Actual Delivery Consequential Transformer Volumes	2018-19	2019-20	2020-21	2021-22	2022-23	Total
With Pole Replacement	266	608	431	473	264	**2,042**
With Reconductoring	38	127	202	249	220	**836**

Table 3: Consequential Asset Volume – Actual Delivery

5.1 Fuse Replacement

Fuses are mainly an expendable protection asset that operates under a fault event. Normally the fuse cartridges are replaced once it operated. Table 4 explains the RIN categorisation of Fuse. In the RIN volume, only switch fuses are counted and the expendable cartridges are excluded.

RIN Fuse Detail	Explanation
Expenditure	Consists of Expenditure from Fuse Cartridges and Switch Fuse
Volume	Volume includes only Switch Fuses (Cartridges excluded)

Table 4: RIN Fuse Expenditure and Volume

Whenever a distribution transformer is replaced, HV and LV fuses are replaced as part of the replacement process. Therefore, the cost of Switch Fuses is included in the NPV of the PIR for distribution transformer as an additional investment to the transformer replacement as shown in Table 5. While there are additional costs associated with fuse replacements, there are no additional benefits. As all the options will have a similar cost impact, fuse replacement costs have been excluded from the NPV analysis.

The expendable cartridges expense will stay with switch business case without the cost benefit analysis as the expense is unavoidable and necessary to replace the burnt fuses after a fault event.

Year	2025-26	2026-27	2027-28	2028-29	2029-30	Total $m
Distribution Transformer Related Fuses ($m)	10.6	12.3	14.2	13.9	13.9	**64.9**

Table 5: Fuse Expenditure included in PIR

6 IDENTIFIED NEED

6.1 Problem statement

This post implementation review covers replacement of defective Distribution Transformers.

Over the review period, we noted an escalating replacement rate for Distribution Transformers. Review of the data has found that the increase is due to:

- a moderate increase of defect rate.
- consequential replacements of pole transformers when defective pole or targeted reconductoring replacements were undertaken.

6.2 Compliance

Ergon Energy's Distribution Transformer assets are subject to several legislative and regulatory obligations:

- National Electricity Rules (NER)
- Electricity Act 1994 (Qld)
- Electrical Safety Act 2002 (Qld)
- Electrical Safety Regulation 2013 (Qld).
- Work Health & Safety Act 2014 (Qld)
- Work Health & Safety Regulation 2011 (Qld)
- Ergon Energy Corporation Limited Distribution Authority No D01/99

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 forecast. The replacement program volume is estimated using final determination pole top structure REPEX forecast divided by our actual unit cost.

6.3.1 Costs/Volume

Under the counterfactual scenario, the volume of DT replaced is based on an AER final determination allowance. Based on this estimation, excluding the consequential volume and respective expenditure, the counter factual volume will be replacing only 40% of defective DTs.

Under the counterfactual scenario, the costs/volumes of Distribution Transformers replaced is provided in Table 6.

Counterfactual Volume/Costs	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Transformer Replacement Cost $m nominal	19.6	28.3	34.1	38.1	40.8	**160.9**
Defective Replacements			40%			**40%**

Table 6: Replacement Cost/Volume - Counterfactual

6.3.2 Risk Quantification

Figure 7 provides the results of a quantitative forecast of emerging risk associated with DT failure. The risk increases substantially as the counterfactual AER allowance able to deliver only 40% of defect and in remaining unattended 60% defects, minimum of 10% is assumed to be converted to unassisted failure.

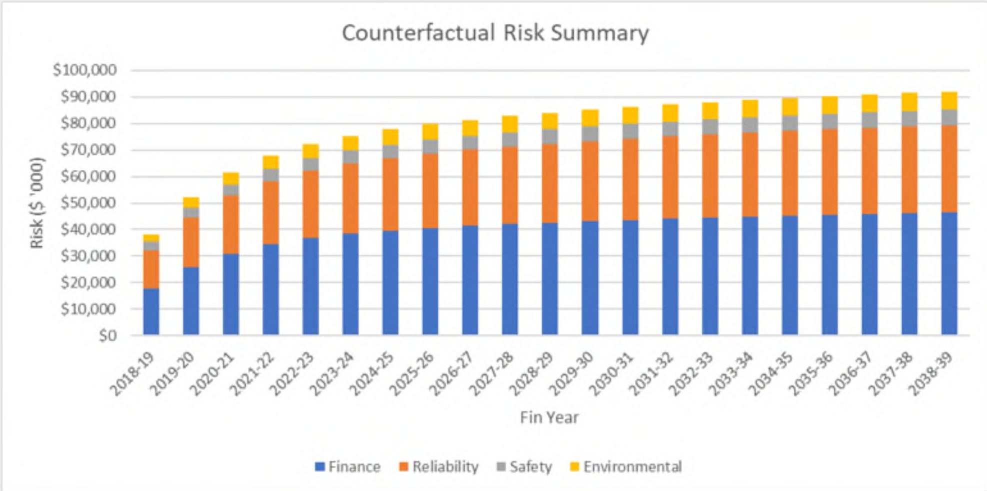

Figure 7: Risk Assessment for Counterfactual Option

Figure 8 represents the failure forecast where the rate continues to rise if the replacement volume needs to remain at counterfactual level.

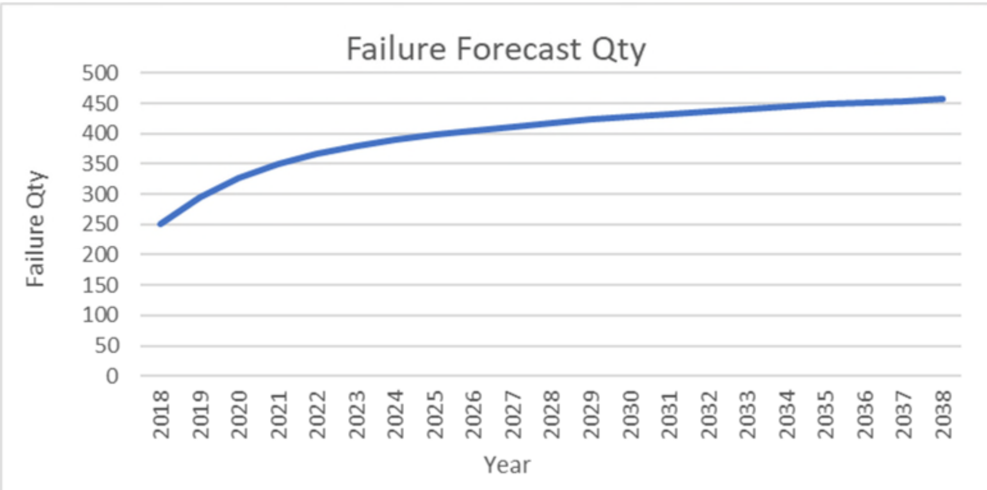

Figure 8: Projected Distribution Transformer Failures

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 range of technically feasible, alternative options that would have satisfied the network requirements in a timely and efficient manner.

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

7.1 Option 1 - Historical Volumes

This option assumes continuation of replacements of defective and failed Distribution Transformer as per historical approach with volumes estimated since last three years replacements prior to review period. This is estimated to be 75% of current defect rate excluding consequential replacement of DTs.

7.1.1 Costs and Volumes

The cost and volume summary under this option has been provided in Table 7.

Historical Replacement Costs/Volumes	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Replacement Costs $m nominal	28.5	34.3	36.6	38	39	176.4
Defective % Replacement			75%			75%

Table 7: Replacement Cost/Volume – Option 1

7.1.2 Risks/Benefits

In this option, our modelling shows the assets performing slightly better than counterfactual but still leaving around 25% of defect unattended which may result in elevated failure rate. 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 low defective transformer replacement volume result in keeping increasingly more defective transformers in active service, causing a ripple effect of investment requirements and poor asset performance.

7.2 Option 2 – Additional Targeted Replacement

In addition to the existing defect rate, this option has an additional targeted replacement where the asset reached the expected life of 45 years.

7.2.1 Costs and Volumes

The cost and volume summary under this option has been provided in Table 8.

Additional Targeted Replacement Costs/Volume	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Replacement Cost $m Nominal	70.0	68.4	68.1	67.9	67.8	342.2
Targeted Volume	1,303	1,303	1,303	1,303	1,303	6,515
Defective % Replacement	100%	100%	100%	100%	100%	100%

Table 8: Replacement Cost/Volume – Option 2

7.2.2 Risks/Benefits

Under this option, our modelling predicts that the occurrence of unassisted Distribution Transformer failures will be notably reduced in comparison to not only the counterfactual option, but all other options as well. However, this option requires more resources and investment compared to all the other options. The significant cost impact on customers outweighs the advantages.

7.3 Option 3 – AER REPEX Model – Live Scenario

As outlined in Table 7 in this option the estimate allowance proposes that an average of 49% of defects are rectified, leaving more than 50% of defects unattended.

7.3.1 Costs and Volumes

The cost and volume summary under this option has been provided in Table 9.

REPEX Model Live Scenario Costs/Volume	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Replacement Cost $m Nominal	21.1	27.9	32.6	36.3	39.3	157.2
Defective % Replacement			49%			49%

Table 9: Replacement Cost/Volume – Option 3

7.3.2 Risks/Benefits

For this option our modelling shows the assets performing slightly better than counterfactual but still leaving around 50% of defect unattended which may result in elevated failure rate. Similar to counterfactual this approach will result in a growing need for substantial investment in the near term due to the escalating rate of asset failures. Continuing with this option will maximise the safety and reliability risk, that will result in increased cost to the customer.

7.4 Option 4 – Actual Delivery

This option is the actual delivery of Ergon Energy DTs within the review period, as explained this business covers only the defect replacement volume and cost.

7.4.1 Costs and Volumes

The cost and volume summary under this option has been provided in Table 8.

Actual Delivery Volume/Costs	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Replacement Cost $m Nominal	37.9	35.1	29.5	39.8	41.8	184.1
Defective % Replacement	100%	100%	100%	100%	100%	

Table 10: Replacement Costs/Volumes – Option 4

7.4.2 Risks/Benefits

Under this option unassisted in-service failures are projected to be lower than the counterfactual, Option 1 and 3. While Option 2 would reduce the unassisted in-service failures, it would require additional resources. The actual delivery option is the most effective option for maintaining the current failure rate and maximizing customer benefits.

In fact, the NPV modelling indicates that by replacing more transformers when identified defective would save the investment in future by a) reducing the in-service failures and b) by preventing accumulation of defective population. Accordingly, it's essential to maintain this level of investment in the future to continue to deliver customer benefits and avoid the need for a significant increase in near-term investments.

8 OUTCOMES OF OPTIONS ANALYSIS

8.1 Distribution Transformer Failure Forecast

The DT failure forecast for all main options is shown in Figure 9. Option 1 and Option 3 similar to counterfactual where portion of defect left unattended leads to elevated failures.

Option 2 indicates transition towards performance improvement with reduction in failures but require significant investment.

Option 4 shows the performance almost being maintained at the current level with moderate investments.

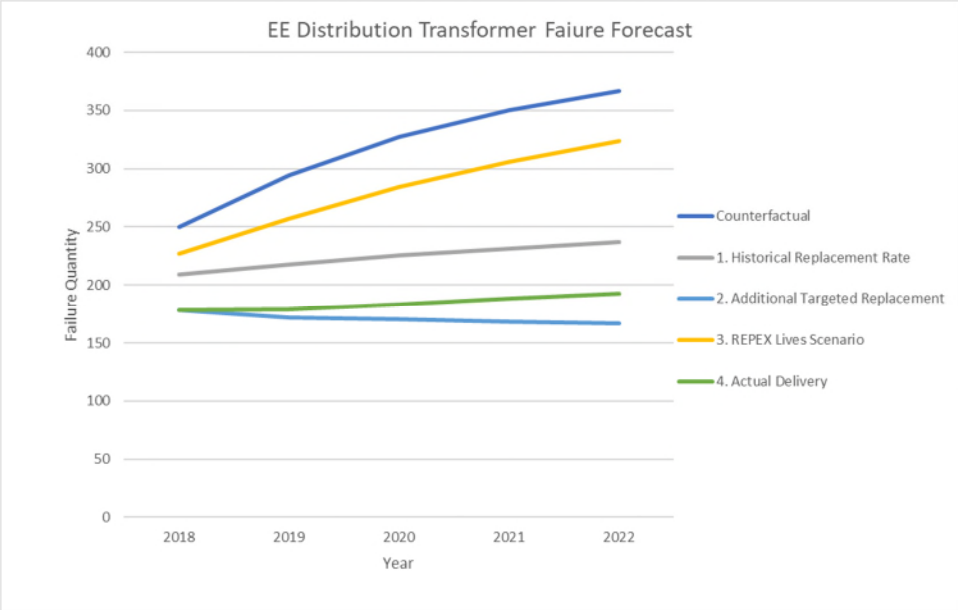

Figure 9: Failure Forecast - Intervention options

8.2 Economic Analysis

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

- All the options represented here shown a positive NPV against counterfactual, this is due to the reason counterfactual being the lowest defect delivery option leaving majority of defect attended.
- Option 4 - Actual Delivery, compared to all options provides the best investment to benefit scenario.

Options	Rank	Net NPV	Intervention CAPEX NPV	Intervention Benefits NPV
Counterfactual	3	$0	$0	$0
1. Historical Replacement Rate	2	$69,032,499	-$48,916,541	$117,949,041
2. Additional Targeted Replacement	5	-$103,524,726	-$347,228,153	$243,703,426
3. REPEX Lives Scenario	4	-$43,934,036	-$15,018,192	-$28,915,844
4. Actual Delivery	1	$80,570,127	-$77,867,219	$158,437,346

Table 11: NPV Modelling Outcomes For All Options

Table 12 below summarises the volume replacements for all options.

Delivery Volumes All Options	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Counterfactual – AER Final Determination	40% Defect Replacement					40%
Option 1 – Historical Volumes	75% Defect Replacement					75%
Option 2- Additional Targeted Replacement	100% Defect Replacement + 1303/year targeted					100% + 6515
Option 3 – AER REPEX Live Scenario	Average 49% Defect Replacement					49%
Option 4 – Actual Delivery	100 % Defect Replacement					100%

Table 12: Option Volumes

Figure 10 illustrates the advantages of all options over their counterfactual confirms option 4 and option 2 being the optimal option for the community.

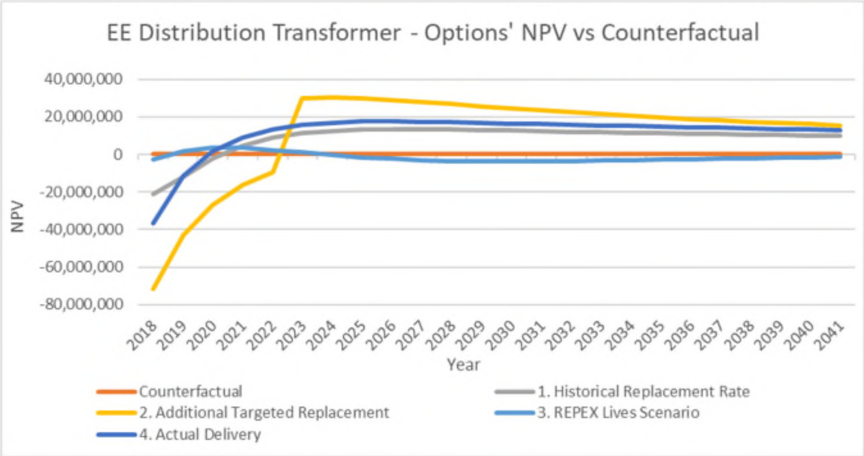

Figure 10: Benefits For All Options

The analysis presented in Table 11 compares the options to their respective counterfactual alternatives.

Criteria	Option 1 – Historical Replacement Rate	Option 2 – Additional Targeted Replacement	Option 3 – AER REPEX Model – Lives Scenario	**Option 4 – Actual Delivery**
Net NPV	$69.0	-$103.5m	-$43.9m	$80.6m
Investment Risk	Low	Very high	Low	High
Benefits	Low	Very High	Low	High
Delivery Constraint	Low	Very High	Low	Med
Detailed analysis – Advantage	• Improved safety and reliability moderately. • Low Investment. • Positive NPV.	• Best option in improving asset performance. • Improved safety and reliability • Positive NPV.	• Matching the counterfactual model. • Low resources and budget requirements.	• Maximise customer benefits compare to investment. • Positive NPV. • Maintain the asset performance and longer-term improvement.
Detailed analysis – Disadvantage	• Leaving high volume defects unattended. • Elevated risk to the community. • Significant increase in near term investment.	• Additional investment of $347.2. • Highest increased resource requirement.	• Leaving high volume defects unattended. • Negative NPV. • Elevated risk to the community • Significant increase in near term investment.	• Moderate resources requirements.

Table 13: Options Analysis Scorecard

9 SUMMARY

We have assessed and modelled four feasible options that we could have undertaken over the review period from 2018-19 to 2022-23.

- The modelling confirms that the additional investment in defective Distribution Transformer replacements of $77.9m provided a positive NPV benefit of $80.6m compared to the counterfactual option of the AER's forecasted volume replacement.
- Detailed quantitative risk analysis for the counterfactual option has shown an escalating trend of expected asset failures and defect which will lead to increasing customer safety and reliability risks. The risk reduction value over the next 20 years of undertaking the Actual Program is $158m.

It is noted that the modelled result for Option 4 shows that Distribution Transformer performance is likely to maintain at current level.

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

Option 4 - Actual delivery is reflective of our commitment to provide maximum customer benefit. It provides an acceptable risk position which balances the achievement of asset management objectives and customer service levels and ensures a sustainable level of investment.