Switches

Post Implementation Review

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	30/10/2023	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 Switches 21122018 Public Approved	PDF
NOV 2023	Risk Modelling - Weibull – Switches 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	Switches – 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 change to our increased volume of Switches replacements undertaken over the review period between 2018-19 and 2022-23. • to support the ex-post review of Ergon's capital expenditure over the review period through 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 the value for our customers. Ergon Energy observed that the replacement volume was tracking higher than expected and number of defects and failures were increasing at alarming rate. The improved replacement data captured has confirmed the escalating replacement rate for Switches. This analysis reveals that even though we have considerable increase in defects, predominantly the step change in Switches is being replaced because of the pole replacement and overhead conductor programs, aimed at improving asset performance and operation efficiency result in cost effective replacement strategy. Although the defect and failure rates has decreased after 2018-19, the increase in replacements within these programs has consequently led to an increase in the volume of Switch replacements. The justification for the increase is detailed on their respective PIR business cases, this business case covers only the defective Switch replacement volume. We have noted that since 2018-19, the replacement volume of Switches was higher than forecasted. Our analysis revealed that even though we have declining number of defects since 2019-20, the increase Switches replacement volumes is due to consequential replacements arising from pole replacement and overhead conductor programs. These consequential replacements are based on a cost-effective replacement strategy to improving asset performance and operation efficiency. This PIR covers only the defective Switches

	replacement volume. Justifications for consequential replacements are detailed in the respective PIRs.
Alternate options	Four alternative options were evaluated and compared to the counterfactual (the AER final determination – 21% of actual defect): 1. Historical Replacement rate – 57% of actual defect rate 2. Additional Targeted replacement – In addition to actual defect add on targeted replacement. 3. AER REPEX Live Scenario– 44% of actual defect 4. Actual Delivery – 100% of actual defect

Expenditure

This business case relates only to defective Switches including fuse replacement outside of substations. Many Switches and fuses are also consequentially replaced under different programs such as overhead reconductoring, defective poles replacements, Distribution Transformer replacement and clearance to ground / structure. This PIR relates only to defective Switch replacement outside of substations. Consequential costs and benefits of other asset programs are included in their respective PIRs.

Year $m, direct Nominal	2018-19	2019-20	2020-21	2021-22	2022-23	Total
RIN Total	32.1	42.4	50.8	47.4	57.0	229.7
(a) Switch Defect*	**8.6**	**7.9**	**8.4**	**7.1**	**12.1**	**44.0**
(b) Fuses Defect *	**5.4**	**7.8**	**10.6**	**10.2**	**18.2**	**52.2**
- Switch Consequential Pole Program	3.7	3.2	3.0	2.7	1.8	14.4
- Switch Consequential Conductor program	0.45	2.0	3.4	5.2	4.2	15.2
- Fuses Distribution Tx Consequential	**10.6**	**12.3**	**14.2**	**13.9**	**13.9**	**64.9**
- Fuses CTG/CTS Program	0.8	1.9	3.7	0.3	0	6.7
- Fuses Reconductor Program	0.3	1.3	2.4	2.7	3.1	9.8

	- Fuses Pole Replacement Program	2.1	6.1	5.1	5.2	3.7	22.2
	(a) + (b) PIR Total (Nominal $)*	**14.0**	**15.7**	**19**	**17.3**	**30.3**	**96.2**
	(2022/23 real $)	**16.5**	**18.4**	**21.5**	**18.1**	**30.3**	**104.7**
	**** Expenditure considered for this PIR.***						
Benefits	From our analysis, 'Option 4 – Actual delivery' is the most cost-effective option. This option provided the best balance of benefits, deliverability, and risks for the organisation.						

2 PURPOSE AND SCOPE

The scope of this Post Implementation Review (PIR) is to review the increased expenditures and volumes for Ergon Energy Switches including fuses over the review period. The PIR also includes the analysis of different options, to ascertain prudency through NPV modelling.

In this PIR the Fuse Cartridges are excluded from the cost benefit analysis as the cartridges are an expendable item and has to be replaced after each operation. The Switches categories included in the PIR are Air Break Switch (ABS) that includes isolator, load break Switch, load transfer Switch and disconnectors, Gas Break Switch (GBS) that include Sectionaliser and Ring Main Unit (RMU), based on the Switch category explained in RIN. In this PIR the fuse category is excluded in the cost benefit analysis as the fuses are an expendable item and are not efficient to refurbish or repair.

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

3 BACKGROUND

We reviewed its asset management practices with respect to the replacement of Switches in response to concerns that Switches are being replaced at a higher rate than forecast volumes. Additionally, the failure and defect rate prior to 2018-19 were rising significantly presenting increasing risk for safety and reliability to trigger the review of management practices.

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 asset data.

Following a thorough examination of actual performance, it became evident that while the increasing failure and defect rate was driving the increased volume in 2018-19, the significant spike in Switch 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.

For a more detailed analysis of the root causes behind the rising failure rates, associated risks, and replacement volumes, please refer to our PIRs for Poles Overhead Conductor. This PIR covers only the defective Switch replacement program.

3.1 Asset Population

As per 2018-19 RIN data, Ergon Energy had a total of 96,041 Switches detailed in Figure 1. Age profile of Switches reflects that 10,545 Switches are over 45 years.

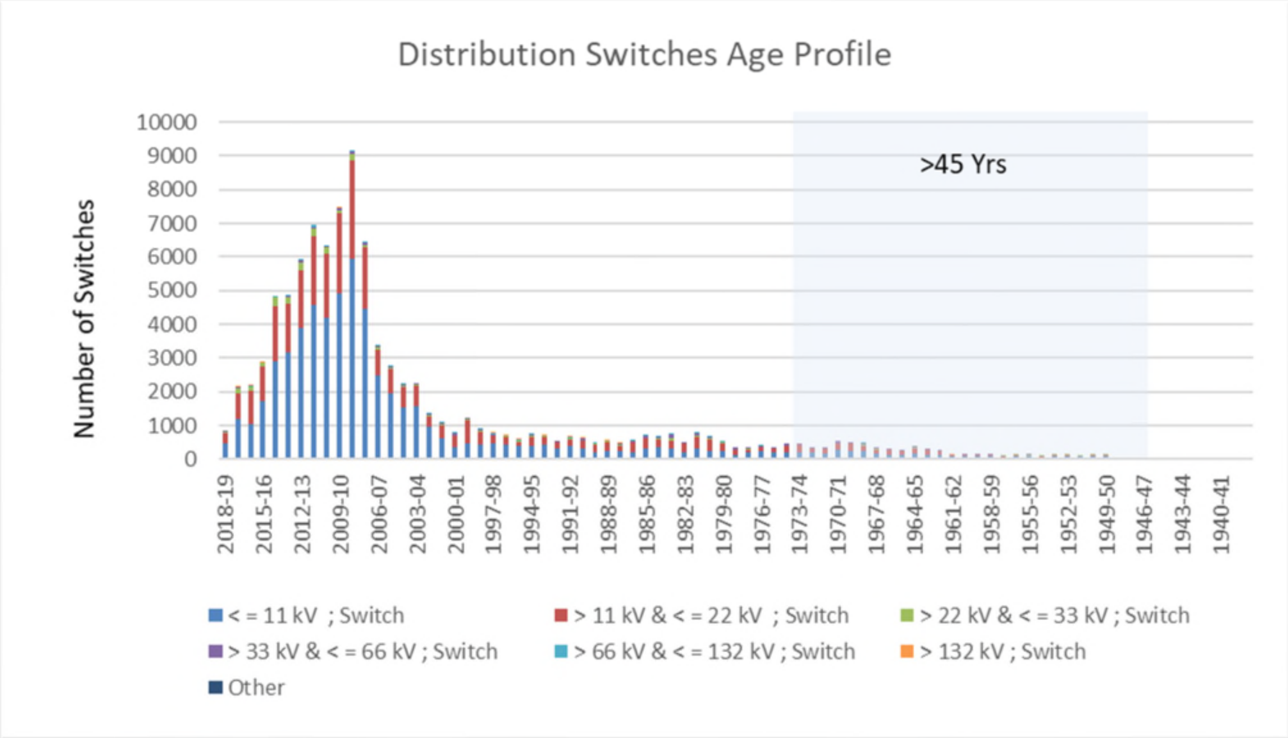

Figure 1: Age Profile – Switches ERG

3.2 Asset Management Overview

Switches are inspected periodically as required by the Network Schedule of the Maintenance Activity Frequency (MAF) and require very little maintenance except for removal of vegetation and animal detritus. They are reactively replaced, due to either electrical failure or poor condition as assessed by ground-based inspection. It is generally considered uneconomical to refurbish Switches, and they are routinely scrapped once removed.

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

Consequential replacement is typically undertaken with other work such as overhead reconductor programs or bundled into logical groups for efficiency of delivery cost and resource.

3.3 Asset Performance

Two functional failure modes of Switches have been defined in this model are found in the table below:

Functional Failure Type	Description
Catastrophic **(Unassisted)**	Loss of structural or conductivity integrity of any component associated with the Switch, excluding any associated pole top hardware or other pole mounted plant, such that the external or internal condition of Switch/component required immediate intervention. Functional failure of a Switch asset under normal operating conditions not caused by any external intervention such as abnormal weather or human
Degraded **(Defects)**	A Switch asset deemed defective based on observed physical and serviceability criteria and if not rectified within a prescribed timescale (P0/P1/P2) could result in failure.

Table 1: Description of Functional Failure

Figure 2 and Figure 3 displays the number of unassisted and defect failures respectively. The main cause of defects being the corrosion of metallic enclosures, operational issues, insulation ageing and degradations of associated components, which if left unaddressed eventually cause an unassisted failure of the Switch.

The failure and defect data between 2015/16 and 2017/18 are not reliable and due to error in interpreting and recording of failures. From 2018/19 onwards, we have improved the quality data gathered by inspectors in the field and our data systems. The recent 3 years trend shows a steady state of failure and defect rates; which reflect the impact of consequential replacement strategy has provided to our asset performance.

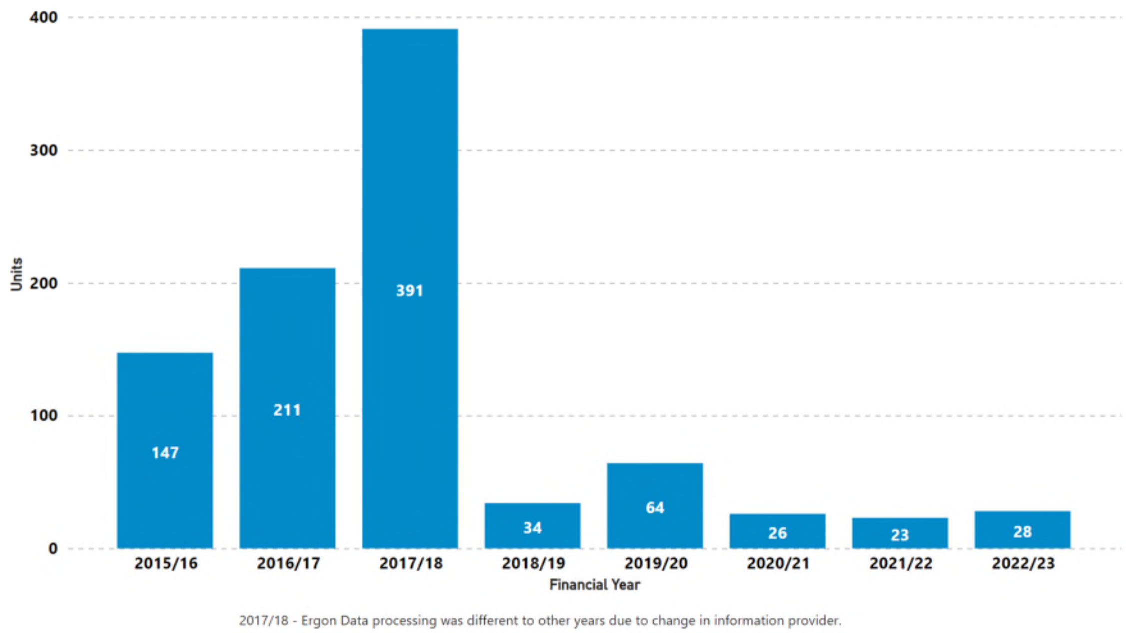

Figure 2: Unassisted Switch Failures

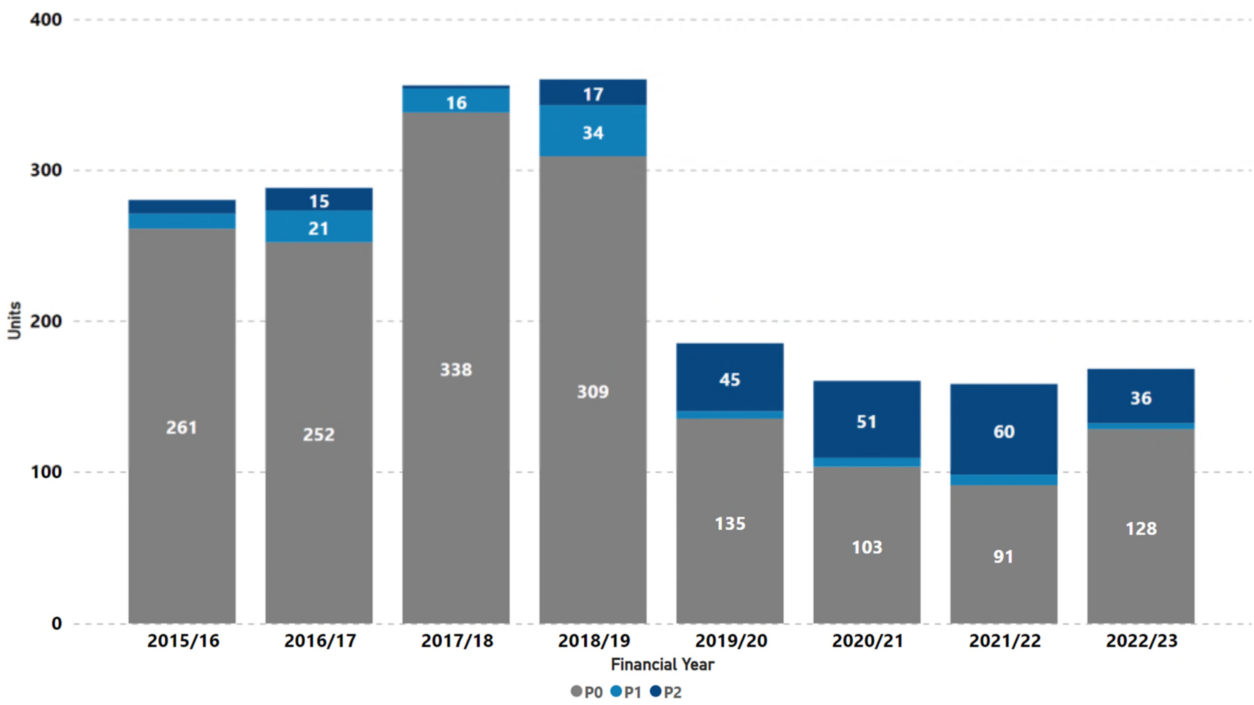

Figure 3: Switch Defects

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. These are shown in Figure 5. For services, only four of the value streams are considered. As the 'Export' impact is not material therefore is not considered in this calculation.

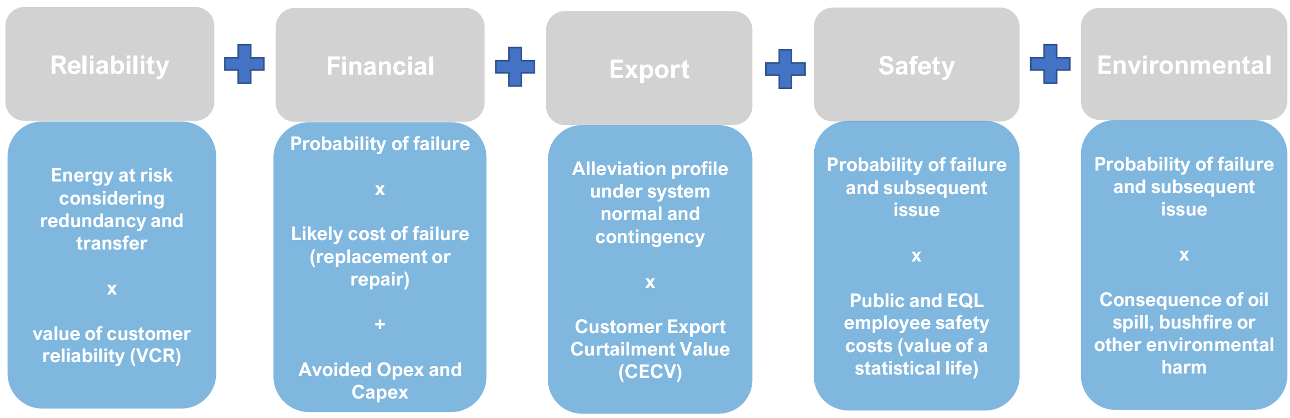

Figure 5: Risk Steams for Assets

4.1 Probability of Failure (PoF) – Weibull Analysis

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.

The Weibull characteristics for Switches is estimated using the actual failure information from 2018-19 data. The categories included in the business case are ABS that includes isolator, load bread Switch, load transfer Switch and disconnectors, GBS that include Sectionaliser and RMU, based on the Switch category explained in RIN.

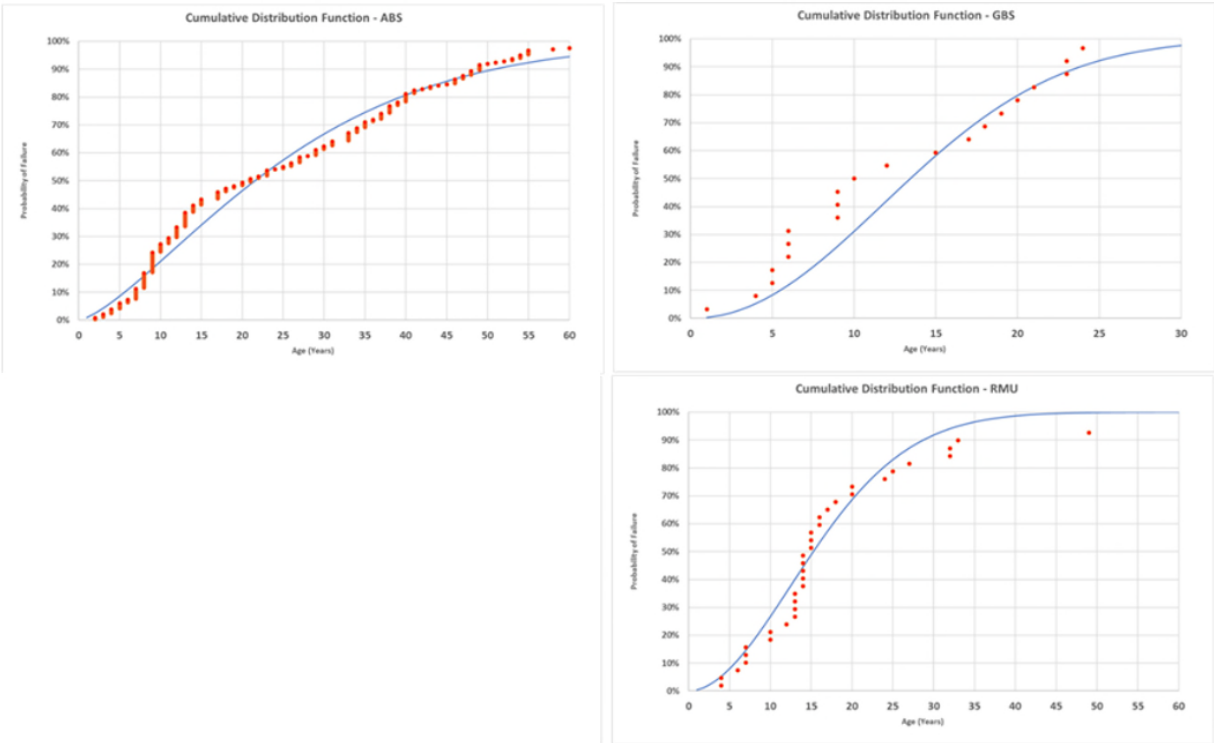

Figure 6: Weibull Cumulative Function – Switches

The resultant curve produced the following characteristics, as the estimated Weibull characteristics is lower than expected life of these assets.

	Weibull Variables	Value
ABS	**Beta β**	1.4
	Eta η	28
	Weibull Variables	Value
GBS	**Beta β**	1.6
	Eta η	22
	Weibull Variables	Value
RMU	**Beta β**	1.9
	Eta η	18.5

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

The key consequence of Switch 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 estimated CoF and LoC applied for each Switch age band.

4.2.1 Reliability

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

- **Lost load:** Each Switch age band is modelled individually, with the relationship developed between the Switch and the feeder that it is installed at. The historical average load on each 11kV feeder in our network is utilised to determine the kW lost following a Switch failure as larger population of Switches are in 11kV network. We have utilised one third of the historic average load on 11kV feeder, which represents the most likely outcome, as the data regarding the exact electrical location of the Switch in a feeder is not available.
- **Value of Customer Reliability Rate:** We have used the Queensland average VCR rate.
- **Probability of Consequence**: Majority of the in-service Switch failures results 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:

- **Switch replacement:** different unit cost of Switch replacement has been taken based on the subject matter expert estimation for different Switch types typically around $5K to $40K.
- **Switch Defect Rectification:** As Switches are not economical to refurbish or repair, the defect rectification cost is assumed to be similar to replacement cost.
- **Probability of Consequence:** all in-service Switch failures result in a need to replace the Switch under emergency.

4.2.3 Safety

The safety risk for a Switch failure is primarily that a member of the public is in the presence of a catastrophic event. 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
- **Disproportionality Factor:** 6 for members of the public
- **Probability of Consequence**: Following an unassisted asset failure in Ergon Energy, there is a once in 20 years chance of causing a fatality and once in 10 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. Historically, the data shows, Switch 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 Switch causing downed conductor 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.
- **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 bush fire risk cost per crossarm is used to infer the distribution Switches bush fire risk.

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 to determine the feasibility and cost-effectiveness of replacing them at the same time. 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 costs and benefits are accounted for. Table 2 outlines the volume of Switches replaced as a result of the pole replacement and reconductoring program during the specified reporting period.

Actual Delivery Consequential Switches Volume	2018-19	2019-20	2020-21	2021-22	2022-23	Total
With Pole Replacements	395	309	310	296	371	**1,681**
With Reconductoring	93	87	157	314	244	**895**

Table 2: Consequential Asset Volumes – Actual Delivery

5.1 Fuse Replacement

Fuses are mainly an expendable protection asset operates under a fault event. Normally the fuse cartridges are replaced once it operated. Table 3 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 3: 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 investment from Switch Fuses required are included in distribution transformer PIR as an additional investment to the transformer replacement. Some of these costs are ultimately included in replacement of poles or overhead conductors which have consequential transformer replacements.

The expendable cartridges expense will stay with Switch business case and has not been included in cost benefit analysis as the expense is unavoidable and necessary to replace the burnt fuses after a fault event as per Table 4.

Year	2025-26	2026-27	2027-28	2028-29	2029-30	Total $m
Defective Switch Fuse and Cartridges ($m)	5.4	7.8	10.6	10.2	18.2	**52.2**
Distribution Transformer Related Fuses ($m)#	13.8	21.5	25.4	22.2	20.6	103.7

Table 4: Business case Fuse Expenditure

- Expenditure included in Distribution transformer, poles and overhead transformers PIRs

6 IDENTIFIED NEED

6.1 Problem Statement

Ergon Energy reviewed its asset management practices with respect to Switches in response to concerns that the replacement rate was tracking too high. Over recent years there has been an effort to improve the quality of the replacement data, the data gathered in the field and the data systems which utilise the Switch data. The improved replacement data captured has indicated an escalating replacement rate for Switches.

Review of the data has found that predominantly Switches were frequently replaced consequentially when the pole and conductor was being replaced in addition to moderate increase of defect rate. This business case cover only the defect replacement volume prudency.

6.2 Compliance

Ergon Energy's Switch assets are subject to several legislative and regulatory standards:

- 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 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 REPEX forecast for Switches. The volume is estimated using final determination Switches REPEX forecast divided by our actual unit cost.

6.3.1 Costs/Volume

Under the counterfactual scenario, the volume of Switches 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 21% of defective switches.

The estimated expenditure of the counterfactual option is shown in Table 3.

Year	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Defect %	21%					
Exp ($M Nominal)	3.0	4.7	6.1	7.3	8.3	29.4

Table 5: Counterfactual Estimation for the PIR period

6.3.2 Risk Quantification

Figure 7 provides the results of a quantitative forecast of emerging risk associated with Switch failure. The risk increases substantially as the counterfactual AER allowance able to deliver only 21% of defect and in remaining unattended 80% defects, minimum of 10% is assumed to be converted to unassisted failure.

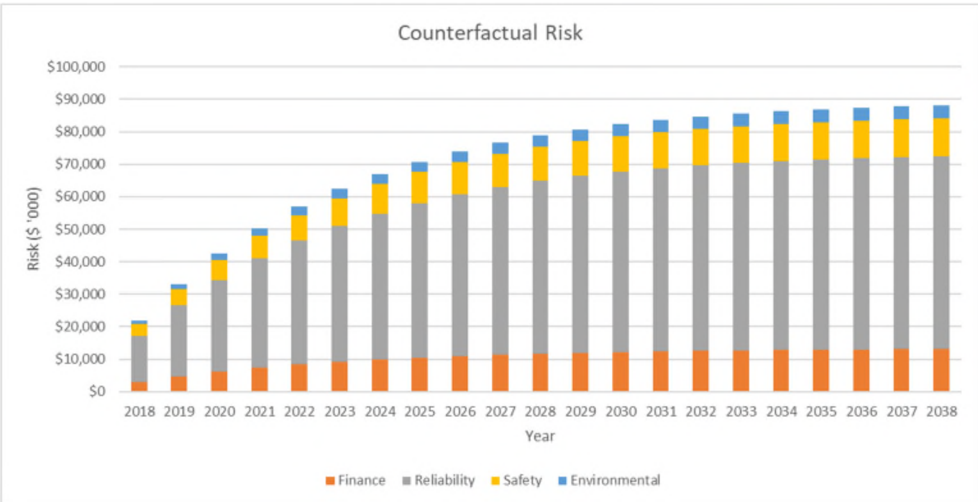

Figure 7: Counterfactual Quantitative Risk Assessment Forecast

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

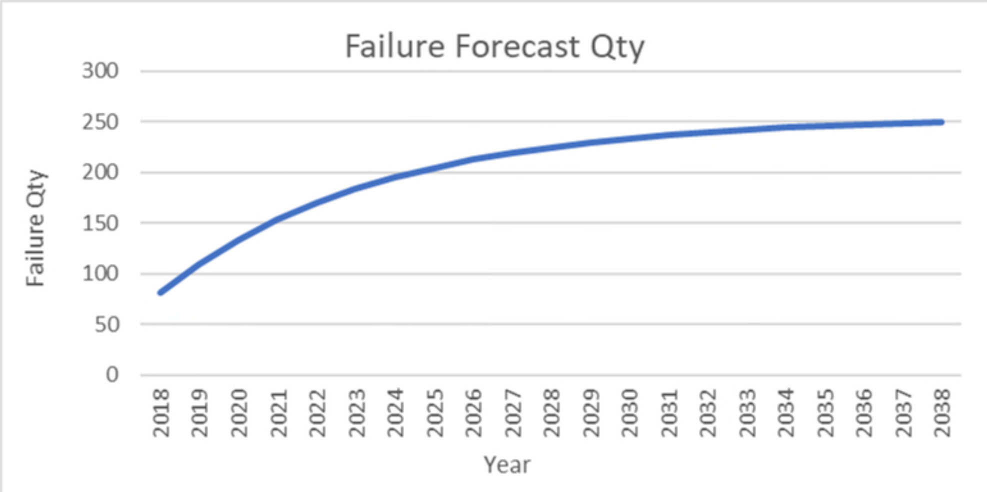

Figure 8: Failure Forecast - Counterfactual Option

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.

7.1 Option 1 – Historical Replacement Rate

This option assumes continuation of replacements of defective and failed Switches as per historical approach with volumes estimated on the basis of last three years replacements prior to review period as outlined in Table 4, this is estimated to be 57% of current defect rate excluding consequential replacement Switches.

7.1.1 Costs and Volumes

Year	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Defect %			57%			
Exp ($M Nominal)	5.5	7.6	8.7	9.3	9.6	**40.7**

Table 6: Costs/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 40% 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 leaving a large number of defective will cause a ripple effect of investment requirements and poor asset performance

Continuing with this option will maximise the safety and reliability risk, that will result in increased cost to the customer.

7.2 Option 2 – Additional Targeted

In addition to the existing defect rate, this option assumed an additional targeted replacement of assets above the expected life of 45 years as outlined in Table 5.

7.2.1 Costs and Volumes

Year	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Defect %			100%			
Targeted Volume	104	104	104	104	104	
Exp ($M Nominal)	10.1	10.2	10.4	10.6	10.8	52.2

Table 7: Costs/Volumes – Option 2

7.2.2 Risks/Benefits

Under this approach, our modelling predicts that the occurrence of Switch failures will be notably reduced in comparison to not only with the counterfactual option but compare to current level of replacement. While this option provides advantages to customers, but it is not without cost and resource impacts.

7.3 Option 3 – AER REPEX Model – Lives Scenario

As outlined in Table 6, in this option the estimate allowance proposes that an average of 44% of defects are rectified, leaving approximately than 56% of defects unattended.

7.3.1 Costs and Volumes

Year	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Defect %			44%			
Exp ($M Nominal)	4.9	7.0	8.2	8.9	9.4	38.4

Table 8: Costs/Volumes – Option 3

7.3.2 Risks/Benefits

As this option is similar to Option 1 historical replacement rate, in this option also, 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 Option 1 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 Switches within the PIR period, as explained this business covers only the defect replacement volume and cost and is outlined in Table 7.

7.4.1 Costs and Volumes

Year	2018-19	2019-20	2020-21	2021-22	2022-23	Total
Defect %			100%			
Exp ($M Nominal)	8.6	7.9	8.4	7.1	12.1	44.0

Table 9: Costs/Volumes – Option 4

7.4.2 Risks/Benefits

In this option, our modelling shows that unassisted service failures are projected to be maintained and moderate improvement compared to the counterfactual option and also compare to current levels. 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. 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 OPTION ANALYSIS

8.1 Switch Failure Forecast

The Switch failure forecast for all main options is shown in Figure 9, as stated, similar to counterfactual where a portion of defects left unattended lead to elevated failure. Option 4 - Actual Delivery shows the performance almost being maintained at the current level.

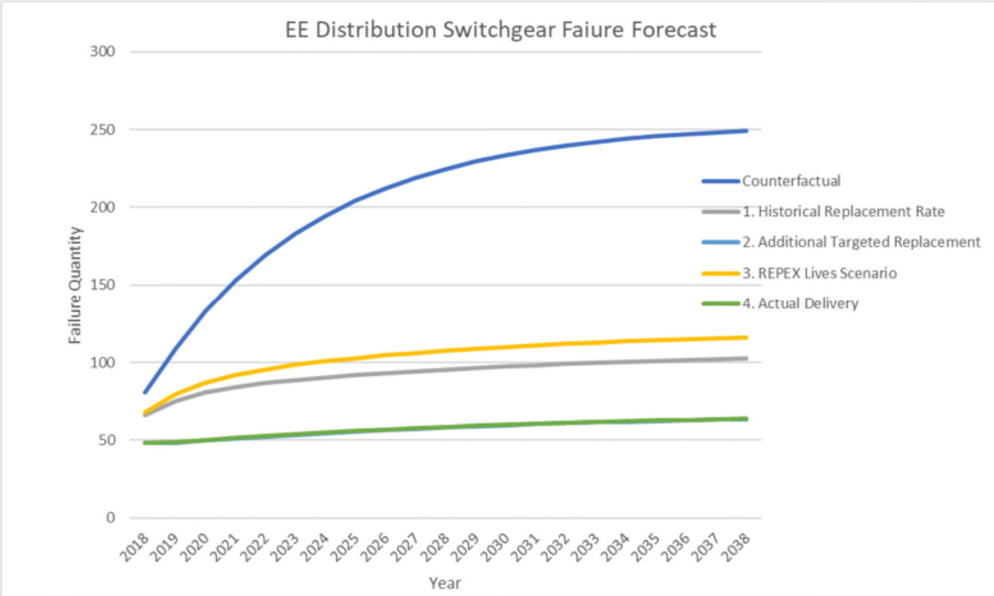

Figure 9: Failure Forecast - Intervention options

8.2 Economic Analysis

The NPV of the cost benefit analysis of the options is summarised in Table 8 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.
- Even though Option 1 and Option 3 provide positive NPV against counterfactual these options still lead to poor asset performance.

Options	Rank	Net NPV	Intervention CAPEX NPV	Intervention Benefits NPV
Counterfactual	5	$0	$0	$0
1. Historical Replacement Rate	3	$83,696,133	-$11,158,162	$94,854,295
2. Additional Targeted Replacement	2	$113,734,285	-$16,595,479	$130,329,764
3. REPEX Lives Scenario	4	$74,568,751	-$8,860,488	$83,429,239
4. Actual Delivery	1	$114,401,718	-$15,122,850	$129,524,567

Table 10: NPV Modelling Outcomes

Table 9 summarises the volume replacements for all options.

Delivery Volumes All Options	2018-19	2019-20	2020-21	2021-22	2022-23
Counterfactual – AER Final Determination	21% Defect Replacement				
Option 1 – Historical Volumes	57% Defect Replacement				
Option 2- Additional Targeted Replacement	100% Defect Replacement + 104/yr targeted				
Option 3 – AER REPEX Live Scenario	Average 44% Defect Replacement				
Option 4 – Actual Delivery	100 % Defect Replacement				

Table 11: 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.

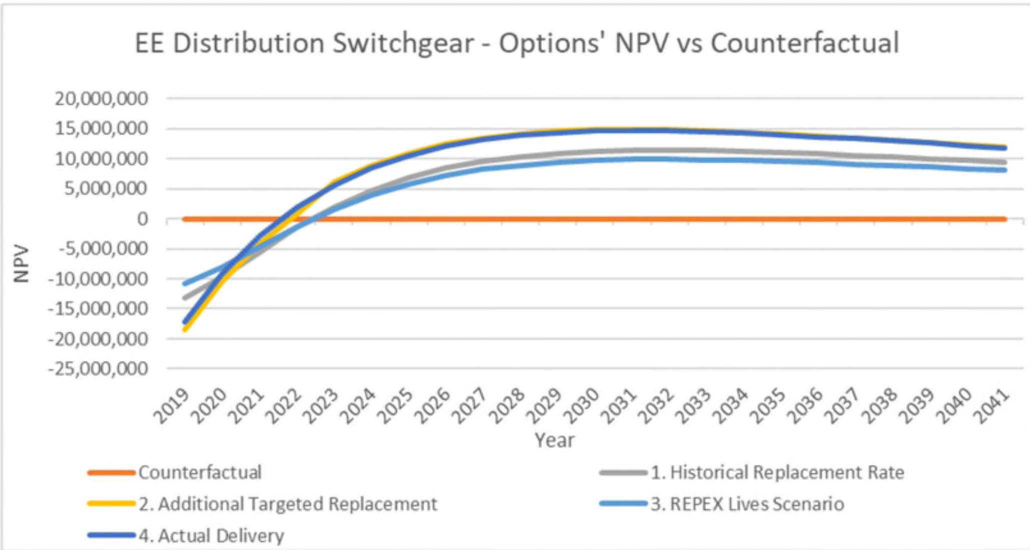

Figure 10: Benefits for all options

The analysis presented in Table 10 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	$83.7m	$113.7m	$74.6m	**$114.4m**
Investment Risk	Low	High	Low	High
Benefits	Med	High	Med	High
Delivery Constraint	Low	High	Low	High
Detailed analysis – Advantage	• Better performance than counterfactual	• Improvement in the asset performance. • Remove all identified defect asset. • Improved safety and reliability	• Better performance than counterfactual • Aligns with AER model.	• Prudent Option • Maintain the current safety and reliability performance • Remove all identified defective assets from the network
Detailed analysis – Disadvantage	• Leaving high volume defects unattended. • Elevated risk to the community • Significant increase in near term investment	• Not a material benefit compared to actual delivery option 4 • Additional investment • Resource impact	• Leaving high volume defects unattended. • Elevated risk to the community • Significant increase in near term investment	• Resource impact compared to counterfactual.

Table 12: 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 period.

- The modelling confirms that the total investment of defective Switch replacements of $44m provided a positive NPV benefit 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 unassisted asset failures and defects leads to increasing customer safety and reliability risks. The risk reduction value over the next 20 years of undertaking this program is $129.5m. This equates to around NPV of $114.4m including asset failure reduction, demonstrating the value of the total program for our customers.

It is noted that the modelled result for Option 4 shows that failure rate and defects of switches are likely to maintain at current level as a minimum or possibly reduce the in the longer term.

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 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 represents an acceptable risk position which balances the achievement of asset management objectives and customer service levels and ensures a sustainable level of investment.