# Business Case
# Overhead LV Services Replacement Program

ERGON ENERGY NETWORK

# Executive Summary

This document seeks funding for a program of Service replacements in Ergon Energy with a total quantity of 69,045 and a total value of $55.2M over the 5-year 2020-25 AER regulatory control period. This initiative is an important component of replacement expenditure to ensure customer safety is maintained and service targets are met.

Under the Queensland Electrical Safety Act and associated regulations, Ergon Energy has an obligation to ensure that its works are electrically safe, are operated in a way that is electrically safe and to ensure the electrical safety of all persons and property likely to be affected by the electrical work. This includes a duty to ensure that it does all that is reasonably practicable (including that which was reasonably able to be done at a particular time) to ensure electrical safety risks are managed to the level so far as is reasonably practicable (SFAIRP). The service replacement program is one important part of delivering an overall safe outcome for the community.

Ergon Energy has an LV services asset population of almost 400,000. Significant quantities of these services are at or near end of life and failure rates are increasing. A replacement program is required to address this critical ageing population and ensure Ergon Energy remains compliant with the Queensland Electrical Safety Act.

Three options were considered but rejected for this business case; installation of off-grid generation, in-situ repair and installation of underground services. All three were deemed unviable due to initial cost estimates being prohibitive relative to other proposed options, without delivering significant additional benefits. Two options have been evaluated in this business case:

**Counterfactual** – Replacement of defective services based on historical volumes

**Option 1** – Replacement of defective services plus an additional program of targeted proactive replacements

Ergon Energy aims to minimise expenditure in order to keep pressure off customer prices but understands that this must be balanced against critical network performance objectives including safety, customer reliability, and security. In this case customer safety is a strong driver, based on the need to replace ageing assets within the population to avoid an increase in failure rates and the associated safety consequences for customers.

To this end, Option 1 is the preferred option. Detailed quantitative risk analysis has shown an escalating trend of expected service failures and customer safety risks based on the counterfactual, assuming a historical replacement approach. Based on the expected numbers of failures, the counterfactual is likely to result in a significant increase in the number of Dangerous Electrical Events (DEEs) and as such would result in Ergon failing to comply with the requirements of the Electrical Safety Act. The quantified economic value of the risks exceeds the costs of the significant replacement program under Option 1, which has a Net Present Value (NPV) of $20.9M.

The direct cost of the program for each submission made to the AER is summarised in the table below. Note that all figures are expressed in 2018/19 dollars and apply only to costs incurred within the 2020-25 regulatory period for the preferred option.

| Regulatory Proposal | Draft Determination Allowance | Revised Regulatory Proposal |
|---|---|---|
| $60.3M | N/A | $55.2M |

# Contents

# 1. Introduction

The purpose of the Low Voltage (LV) services replacement program is to manage the existing and emerging customer and safety risks associated with LV service assets.

## 1.1 Purpose of document

This document recommends the optimal capital investment necessary for the asset lifecycle management of Ergon Energy's LV service population.

This is a preliminary business case document and has been developed for the purposes of seeking funding for the required investment in coordination with the Ergon Energy Revised Regulatory Proposal to the Australian Energy Regulator (AER) for the 2020-25 regulatory control period. Prior to investment, further detail will be assessed in accordance with the established Energy Queensland (EQL) investment governance processes. The costs presented are in $2018/19 direct dollars.

## 1.2 Scope of document

This document presents the economic justification for Ergon Energy's proposed asset lifecycle management approach for LV services. The preferred option is selected based an economic analysis and quantified risk reduction benefit.  This document integrates with the Energy Queensland LV Safety business case that proposes monitoring of LV services to ensure safety outcomes are achieved.  This document should also be read in conjunction with the Energy Queensland Asset Management Plan (AMP) Services.

## 1.3 Identified Need

Ergon Energy has an LV services asset population of almost 400,000.  Significant quantities of these services are at or near end of life and failure rates are increasing.  A replacement program is required to address this critical ageing population.  The need for this work is also based on a detailed quantitative risk assessment that has shown that this investment is required to provide optimal economic outcomes, balancing the value of risks with the cost of managing the risks.

Ergon Energy aims to minimise expenditure in order to keep pressure off customer prices but understands that this must be balanced against critical network performance objectives including safety, customer reliability, and security. In this case customer safety is a strong driver, based on the need to replace ageing assets within the population to avoid an increase in failure rates and the associated safety consequences for customers.

This section of the document describes the need for the proposed investment in relation to EQL's strategy, applicable service levels, compliance obligations and limitations of the existing asset population. This proposal aligns with the CAPEX objectives and criteria from the National Electricity Rules as detailed in Appendix C.

## 1.4 Energy Queensland Strategic Alignment

Consistent with best practice asset management as per ISO55000, Table 1 below summarises how investment in the LV services asset class contributes to EQL's strategic objectives. The linkages between these Asset Management Objectives and EQL's Corporate Objectives are shown in Appendix D.

**Table 1: Asset Function and Strategic Alignment**

| Objectives | Relationship of Initiative to Objectives |
|---|---|
| **Ensure network safety for staff contractors and the community** | Overhead (OH) LV services are an asset which is attached to customer premises. The failure of these assets can result in live conductors on the ground, dangerous voltages on the neutral conductor and/or the customer earthing system, which can impact the safety of any earthed metallic appliance. Given the regular proximity of this asset to people (including children), in and around these premises, plus the consequences of failure of these assets, this initiative targets reductions in the safety risks associated with asset failure So Far as Is Reasonably Practicable (SFAIRP). |
| **Meet customer and stakeholder expectations** | Failure of overhead LV service assets will result in interruption to customer supply and the associated cost of unserved energy. This initiative reduces the economic costs associated with loss of supply due to LV service failure. |
| **Manage risk, performance standards and asset investments to deliver balanced commercial outcomes** | Investment in LV services considers a total lifecycle cost approach as well as the overall state of the asset population to promote a commercially sustainable direction to manage risk, cost and performance for this asset class. |
| **Develop Asset Management capability & align practices to the global standard (ISO55000)** | The initiative is aligned with the EQL Asset Management Plan for LV Services. Refer to the AMP for further details of ISO55000 alignment. |
| **Modernise the network and facilitate access to innovative energy technologies** | Services are the “final link” between the shared electricity network and customer’s premises. They are therefore critical as an enabling asset for potential future customer revenue streams such as customer self-generation power export into the distribution network. |

## 1.5 Applicable service levels

Corporate performance outcomes for this asset are rolled up into Asset Safety & Performance group objectives, principally the following Key Result Areas (KRA):

- Customer Index, relating to Customer satisfaction with respect to delivery of expected services
- Optimise investments to deliver affordable & sustainable asset solutions for our customers and communities

Corporate Policies relating to establishing the desired level of service are detailed in Appendix D.

The key applicable service level for this business case relates to safety obligations in the Electrical Safety Act 2002. As a person in control of a business or undertaking (PCBU), Ergon Energy has an obligation to ensure that its works are electrically safe and are operated in a way that is electrically safe.[1] This duty also extends to ensuring the electrical safety of all persons and property likely to be affected by the electrical work.[2]

[1] Section 29, *Electrical Safety Act 2002*
[2] Section 30 *Electrical Safety Act 2002*

## 1.6 Compliance obligations

Table 2 shows the relevant compliance obligations for this proposal.

**Table 2: Compliance obligations related to this proposal**

| Legislation, Regulation, Code or Licence Condition | Obligations | Relevance to this investment |
|---|---|---|
| **QLD Electrical Safety Act 2002**<br>**QLD Electrical Safety Regulation 2013** | We have a duty of care, ensuring so far as is reasonably practicable, the health and safety of our staff and other parties as follows:<br>• Pursuant to the Electrical Safety Act 2002, as a person in control of a business or undertaking (PCBU), Ergon Energy has an obligation to ensure that its works are electrically safe and are operated in a way that is electrically safe. This duty also extends to ensuring the electrical safety of all persons and property likely to be affected by the electrical work. | This proposal is a key component in the management of safety for electricity customers. Customer shocks related to neutral integrity are the most significant proportion of network shock incidents, making up some 60-70% of recorded network-related shock incidents. Over recent years there have been around 157 shocks per annum directly attributable to faulty LV Services. |
| **Distribution Authority for Ergon Energy issued under section 195 of *Electricity Act 1994* (Queensland)** | Under its Distribution Authority:<br>• The distribution entity must plan and develop its supply network in accordance with good electricity industry practice, having regard to the value that end users of electricity place on the quality and reliability of electricity services.<br>• The distribution entity must use all reasonable endeavours to ensure that it does not exceed in a financial year the Minimum Service Standards (MSS) | Fundamentally, this proposal aims to ensure LV services are replaced at an adequate rate to effectively manage safety risks and improve safety performance. However, it is also noted that some reliability consequences arise from LV Service failures and these have been factored into the analysis contained in this proposal. |

## 1.7 Limitation of existing assets

Relevant failure modes driving end-of-life for this asset are summarised in Table 5: Overhead Service Life Limiting Factors of the EQL AMP Services document.

Typical condition related failure modes which drive end of life and the subsequent safety risks for this asset are conductor corrosion and insulation aging.

- Ergon Energy has an aging population of LV Services. Approximately **37%** of the population is over **40** years of age.
- Ergon has experienced an average of approximately **1300** overhead service asset failures annually and more than 1700 failures in recent years with an increasing trend.

LV Service failure data in the EQL AMP Services document indicates that historically, approximately 150 LV Service failures resulted in safety consequences annually with this figure rising to approximately 180 in recent years with an **increasing trend**. Figure 1 and Figure 2 outline the frequency of failures and shock events in Ergon Energy networks.

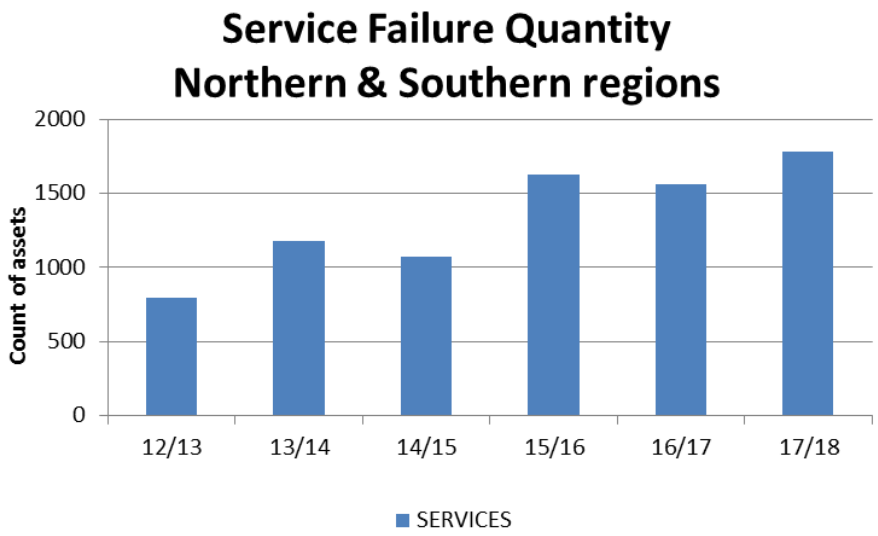



**Figure 1: Service Failure Quantity – Ergon Energy (EQL AMP – Services)**

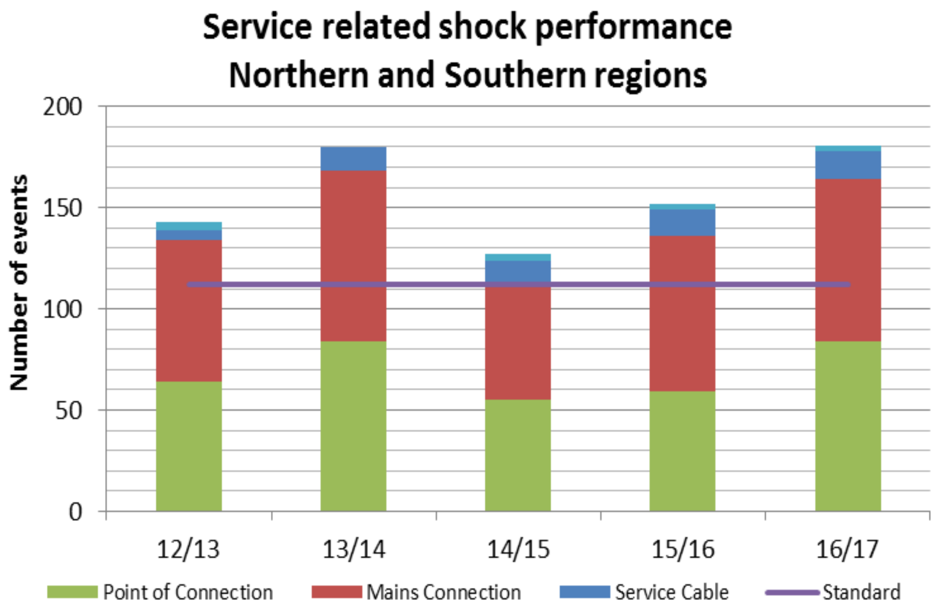



**Figure 2: Service Failures and Shock Trends – Ergon Energy (EQL AMP – Services)**

# 2 Counterfactual Analysis

## 2.1 Purpose of asset

LV Services connect electricity supply from the network to customer premises. The service neutral conductor integrity is crucial to ensuring that house appliances do not become “live” resulting in the potential for shocks inside the house. This integrity can be compromised due to various service failures including failure in the network, failure of clamps connecting to the network, failure of the service line itself, failure of the connection to the customer installation and failure within the customer installation. By design, a customer earthing system provides backup in the event of a neutral failure, however this customer earthing system is generally not tested after installation and cannot be relied on when a neutral integrity problem occurs.

## 2.2 Business-as-usual service costs

The ongoing costs for these assets are relatively minor, with most costs directed at inspection and remediation of defective assets and vegetation clearance works. However, significant costs arise through failures, with shock / tingle incidents requiring emergency response, incident investigation, replacements works, and reporting to the Safety Regulator.

## 2.3 Key assumptions

The counterfactual case is assumed to be the approximate historical rate of a targeted approach including condition-based replacements of 5309 / year (based on historical rates). The total and per-year quantities and costs for this option are summarised in Table 3 below. Appendix F details the methodology and input assumptions associated with quantification of risk of condition-related failure for Ergon’s LV Service population.

**Table 3:** Counterfactual - Volumes and Costs

| | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | Total Over 2020-25 period |
|---|---|---|---|---|---|---|
| Quantity | 5,309 | 5,309 | 5,309 | 5,309 | 5,309 | 26,545 |
| Cost ($k) | 4,600 | 4,600 | 4,600 | 4,600 | 4,600 | 23,000 |

Under this option the service failures are forecast to increase steadily over the future from around 2,000 in 2020 to around 2,400 by 2030. This option fails to adequately address the growing failure rate of LV services and irrespective of complementary programs such as LV Safety would not reverse the growing failures and consequent risks.

## 2.4 Risk assessments

Figure 3 provides the results of a quantitative forecast of emerging risk associated with Ergon's LV Service asset population failure due to condition related failure modes and replacement at historical rates.

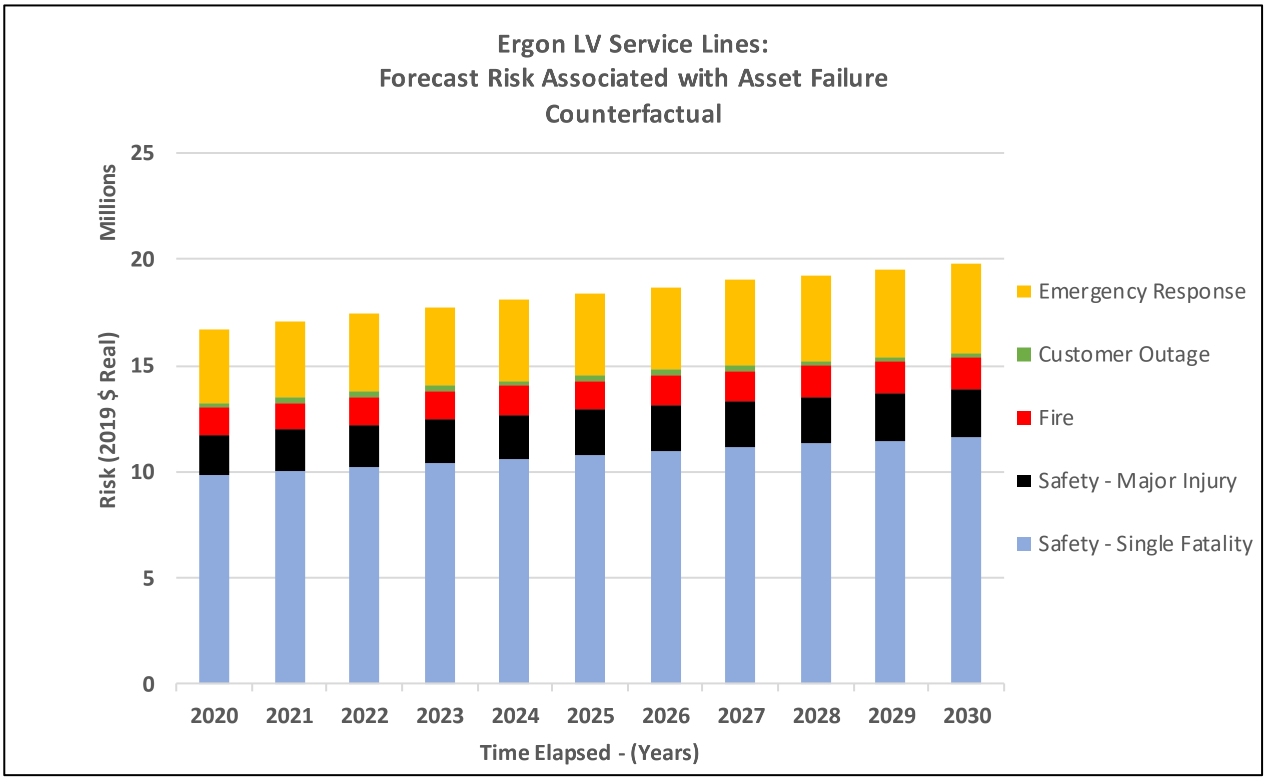



**Figure 3: Counterfactual quantitative risk assessment**

Significant risk costs arise in the counterfactual, due predominantly to safety risks associated with service neutral failures. The cost of a failure includes economic costs relating to safety, fire, reliability and emergency response. The cost of these risks increases substantially over the 10-year period shown, driven mainly by the age profile of the existing population.

A semi-quantitative risk assessment has also been conducted in accordance with the EQL Network Risk Framework and the Risk Tolerability table from the framework is shown in Appendix E. The risk scores are shown for the current risk and this is expected to escalate going forward if the ageing population and increasing failure rates are not addressed.

**Table 4: Counterfactual qualitative risk assessment**

| Risk Scenario | Risk Type | Consequence (C) | Likelihood (L) | Risk Score | Risk Year |
|---|---|---|---|---|---|
| Due to degradation / corrosion, a service neutral is broken. A member of the public contacts an energised appliance in their house resulting in **a single fatality** due to electric shock. | Safety | 5 *(Single Fatality)* | 3 *(Unlikely)* | **15** ***(Moderate)*** | 2020 |

| Risk Scenario | Risk Type | Consequence (C) | Likelihood (L) | Risk Score | Risk Year |
|---|---|---|---|---|---|
| Due to degradation / corrosion, service wire loses mechanical strength and breaks. Fuse does not operate due to high impedance fault. Nearby member of the public physically contacting live mains resulting in **a single fatality** due to electric shock. | Safety | 5 *(Single Fatality)* | 3 *(Unlikely)* | **15** ***(Moderate)*** | 2020 |
| Due to corrosion, service wire losses mechanical strength and breaks. **Interruption to customer premises** while repairs are made. | Customer | 1 *(N/A)* | 6 *(Almost certain)* | **6** ***(Low)*** | 2020 |
| Due to corrosion, service wire losses mechanical strength and breaks. Fuse does not operate due to high impedance fault. **Fire results causing property damage and business impact of >$100,000 in damages**. | Business | 2 *(business impact of >$100,000 in damage)* | 3 *(Unlikely)* | **6** ***(Low)*** | 2020 |

Further Details of the risk ratings and descriptions can be found in Energy Queensland's Network Risk Framework.

## 2.5 Retirement or de-rating decision

LV Services are sized with a capacity that is usually sufficient to prevent overloading, so annealing due to overloading is an unusual failure mode. The life limiting factors described above are predominantly independent of the loading of an LV Service wire asset. Derating would therefore be an ineffective strategy for reducing the risk profile for the asset class.

Additionally, operating these assets at a reduced capacity would involve imposing lower demand limits on customers which would increase customer risk and drive associated cost.

These assets are fundamental to customers' electricity import or export; therefore, retirement is not an option.

Retirement or de-rating are therefore not considered as economical or practical solutions to managing lifecycle risk associated with these assets.

# 3 Options Analysis

## 3.1 Options considered but rejected

The following options have been considered and rejected for the reasons described in Table 5 below.

**Table 5: Options considered but rejected**

| Option Considered | Reason for rejection: |
|---|---|
| **Off-grid Generation Solution:** Installation of 6kVA of rooftop Solar generation, a residential battery and a backup diesel generator to provide an integrated off-grid supply solution. Initial capital cost: $25k | Unit rate for an LV Service replacement is ~$1k. This is 96% lower cost than an off-grid generation storage solution.<br>Unlikely to be a feasible or scalable solution for all customers due to lack of roof-space and existing wiring arrangements. In addition, the maintenance costs for an off-grid supply solution are significantly higher than for an LV Service across the life of the asset. |
| **In-Situ Repair:** Repairing Components of LV service wires on failure. | The cost of repairing an LV Service or some of its components (e.g. Terminations) is not expected to be an efficient or effective method of remediating service failures or extending service life. Irrespective of the repair method, the most significant cost is labour to examine the faulted service, effect repairs or replacement, and carry out relevant testing, including polarity testing. Hence, the full replacement is likely to have a relatively similar or lower cost to a repair and provides a much more effective long-term solution, since all components are replaced.<br>Additionally, some failure modes such as insulation degradation are unrepairable. |
| **Replacement with Underground service** | The use of an underground service replacement could mitigate risks of overhead service failures in future due to the lower exposure to some causes of failure (e.g. Ultraviolet (UV) degradation of overhead services). The cost to install underground services, mainly driven by civil works and footpath repairs, is prohibitive compared to the cost of overhead service replacement. |

## 3.2 Identified options

### 3.2.1 Network options

Identified network options are as follows:

#### Option 1: Planned replacement program (proposed)

This option applies a targeted approach including condition-based replacements of 5309 / year (based on historical rates) plus a proactive replacement program of 8500 / year replacing known problematic service types. It should be noted that the proposed replacement cost in the 2020-25 period reflects lower unit costs of $800 / service, based on the expected unit rate savings from larger volumes of planned works. The proactive program will allow for greater economies of scale through doing more work in a concentrated area, rather than an approach of responding piece-meal to a greater proportion of condition-based defects as has occurred in the past. The saving in the approach proposed for the future is approximately 8% compared to the historical unit cost. The total and per-year quantities and costs for this option are summarised in Table 6 below.

**Table 6: Option 1 - Volumes and Costs**

| | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | Total Over 2020-25 period |
|---|---|---|---|---|---|---|
| **Quantity** | 13,809 | 13,809 | 13,809 | 13,809 | 13,809 | 69,045 |
| **Cost ($k)** | 11,047 | 11,047 | 11,047 | 11,047 | 11,047 | 55,236 |

Under this proposed approach the modelled service failures reduce steadily over a 10-year period from around 2,000 in 2020 to around 1,900 in 2030. While this is still a significant failure rate, this is complemented by the LV Safety program that further mitigates the safety risk through a neutral failure detection approach. The replacement program needs to be large enough to address the under-lying increasing failures and reverse the increasing trend irrespective of LV monitoring, otherwise the service failure rate will continue to rise into the future. This proposed replacement program is adequate to address the increasing failure trend. Ergon Energy believes that the option should be complemented by an LV Safety program, which is the subject of a separate business case.

### 3.2.2 Non-network options

Refer to Table 5 in section 3.1 of this report.

## 3.3 Economic analysis of identified options

### 3.3.1 Cost versus benefit assessment of each option

The Net Present Value (NPV) of each option has been determined by considering costs and benefits compared to the counterfactual over a 20-year period, discounted at the Regulated Real Pre-Tax Weighted Average Cost of Capital (WACC) rate of 2.62%, using EQL's standard NPV analysis tool.

Table 7 below contains the results of the NPV analysis of the identified options, outlining the Present Value (PV) of Costs and Benefits of each option, and the total NPV of each option. This table confirms that Option 1: Planned replacement program has an NPV benefit of $21M compared to the counterfactual and is therefore the preferred option from an economic perspective.

**Table 7: Summary of Net present value of options (20 year)**

| Option | NPV ($M) | PV Costs ($M) | PV Benefits ($M) |
|---|---|---|---|
| **Option 1:** Planned replacement program – condition based plus proposed proactive quantities | $21M | $30M | $51M |

## 3.4 Scenario Analysis

### 3.4.1 Sensitivities

Identified material sensitivities and their corresponding impact on selection of the preferred option as well as the preferred option NPV have been identified in Table 8 below. The sensitivities tested include the Weibull parameters (failure rates), Cost of Consequence (CoC), and Probability of Severity (PoS). This shows that Option 1 remains the preferred option under 9 out of the 10 sensitivities tested. For the remaining one sensitivity, the counterfactual became the best NPV option. Based on this scenario analysis, Option 1 remains the preferred economic option.

**Table 8: Sensitivity analysis.**

| Sensitivity | Baseline | Applied Parameter | Preferred Option | NPV of Preferred Option 1 |
|---|---|---|---|---|
| Weibull β (Low) | 3.5 | 3 | Option 1 | $20M |
| Weibull β (High) | | 4 | Option 1 | $19M |
| Weibull η (Low) | 89 | 84 | Option 1 | $30M |
| Weibull η (High) | | 94 | Option 1 | $12M |
| LV service unit rate (Low) | $800 | $600 | Option 1 | $34M |
| LV service unit rate (High) | | $1000 | Option 1 | $8M |
| CoC single fatality (Low) | $49M | $45M | Option 1 | $19M |
| CoC single fatality (High) | | $54M | Option 1 | $24M |
| PoS single fatality (Low) | 0.094% | 0.01% | Counterfactual | -$6M |
| PoS single fatality (High) | | 0.15% | Option 1 | $39M |

### 3.4.2 Value of regret analysis

In terms of selecting a decision pathway of 'least regret', Option 1 presents an economically efficient, balanced approach to investment by targeting replacement works based on asset criticality and assessed condition and reducing risk to the greatest extent without bringing forward unnecessary expenditure.

The key regret identified in this business case is the fatality of a customer through a service neutral failure. The economic value of this risk has been quantified as part of the analysis. Although Option 1 is the preferred approach based on the economic analysis, it is instructive to consider the impact of each option on the key regret scenario. The value of this key risk (cost of fatality) is shown for each option in Table 9.

**Table 9: Risk Costs**

| Option | Fatality Risk Cost 2021 ($M) | Fatality Risk Cost 2030 ($M) | Total Fatality 2021-2030 Risk Cost ($M) |
|---|---|---|---|
| **Option 1:** Planned replacement program – proposed quantities | 9.6 | 9.3 | 91 |
| **Counterfactual:** Planned replacement program – historical quantities | 10.0 | 11.6 | 109 |

Option 1 produces the lowest risk cost in relation to fatality risk. It has an $18M lower fatality risk cost over the 10-year period compared to the counterfactual. This makes Option 1 clearly the least regret option.

## 3.5 Qualitative comparison of identified options

### 3.5.1 Advantages and disadvantages of each option

Table 10 below details the advantages and disadvantages of each option considered.

**Table 10: Assessment of options**

| Option | Advantages | Disadvantages |
|---|---|---|
| **Option 1:** Planned replacement program – condition based plus proactive quantities | • Provides safety and customer risk reduction benefits<br>• Strong economic value when considering overall costs and benefits<br>• Deliverable within resource constraints<br>• Progressively removes known problematic assets from the population | • Highest capital costs, but strong economic value when considering overall costs and benefits. |
| **Counterfactual:** Planned replacement program – condition based, historical volumes | • Deliverable within resource profiles | • Risk reduction benefit lower than program cost<br>• Known problematic assets may remain in service<br>• Does not reduce safety risks adequately |

### 3.5.2 Alignment with network development plan

The preferred option aligns with the Asset Management Objectives in the Distribution Annual Planning Report. In particular it manages risks, performance standards and asset investment to deliver balanced commercial outcomes while modernising the network to facilitate access to innovative technologies.

### 3.5.3 Alignment with future technology strategy

LV Services provide the link between a customer's premises and the distribution network. The asset is therefore critical for the customer to export or import power from the network and derive the corresponding emerging value streams associated with grid connection, e.g.:

- Ability to participate in demand response incentive schemes
- Ability to export rooftop PV generated power into the grid
- Peer to peer energy trading with nearby energy prosumers
- Ability to participate in virtual power plant (VPP) platform in the future

By improving safety and quality of supply associated with LV Services, this business case supports the initiatives outlined in the Future Grid Roadmap and Intelligent Grid Technology Plan, enabling expanded customer interaction with the distribution network through distributed energy resources.

### 3.5.4 Risk Assessment Following Implementation of Proposed Option

Table 11 provides a semi-quantitative analysis of the risk reduction benefit for the preferred option.

**Table 11: Semi-quantitative risk assessment showing risks mitigated following Implementation**

| Risk Scenario | Risk Type | Consequence (C) | Likelihood (L) | Risk Score | Risk Year |
|---|---|---|---|---|---|
| Due to degradation / corrosion, a service neutral is broken. A member of the public contacts an energised appliance in their house resulting in a single fatality due to electric shock. | Safety | (Original)<br>*5*<br>*(Single Fatality)*<br>(Mitigated)<br>5<br>*(As above)* | <br>*3*<br>*(Unlikely)*<br><br>2<br>*(Very unlikely)* | <br>***15***<br>***(Moderate)***<br><br>**10**<br>***(Low)*** | 2025 |
| Due to corrosion, service wire losses mechanical strength and breaks. Fuse does not operate due to high impedance fault. Nearby member of the public physically contacting live mains resulting in single fatality due to electric shock. | Safety | (Original)<br>*5*<br>*(Single Fatality)*<br>(Mitigated)<br>5<br>*(As above)* | <br>*3*<br>*(Unlikely)*<br><br>2<br>*(Very unlikely)* | <br>***15***<br>***(Moderate)***<br><br>**10**<br>***(Low)*** | 2025 |
| Due to corrosion, service wire losses mechanical strength and breaks. Loss of supply to customer premises while repairs are made. | Customer | (Original)<br>*1*<br>*(N/A)*<br>(Mitigated)<br>1<br>*(N/A)* | <br>*6*<br>*(Almost Certain)*<br><br>5<br>*(Very likely)* | <br>***6***<br>***(Low)***<br><br>**5**<br>***(Very Low)*** | 2025 |

The following figures provides a quantitative summary of the risk reduction benefit for Option 1. The total in each year represents the counterfactual level of risk as described above.

The green bar is the annual reduction risk following the implementation of the option. The red bar is the remaining total risk that Ergon would be accepting following implementation of the option. This residual risk will be further addressed in the LV Safety business case. Note these graphs assume that the volumes for Option 1 are carried through into the 2025-2030 regulatory period.

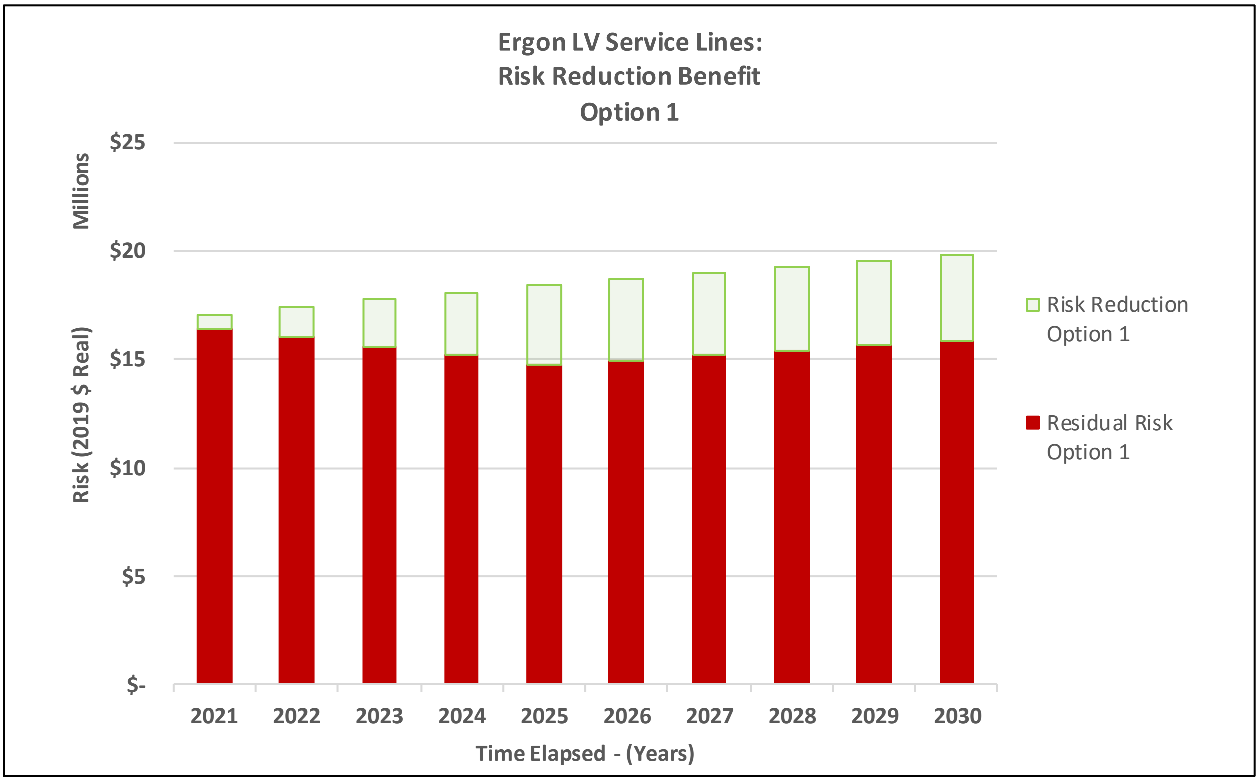



**Figure 4: Ergon LV Service Lines - Risk Reduction Benefit Option 1**

From the above chart the relative merits of Option 1 can be seen. Option 1 provides the optimal economic outcome plus a significantly improved risk reduction outcome compared to the counterfactual.

# 4 Recommendation

## 4.1 Preferred option

Based on the analysis contained in this report, the preferred option is Option 1: Planned replacement program – condition based plus proactive quantities.

## 4.2 Scope of preferred option

The scope of the preferred option is shown in Table 12.

**Table 12: Proposed Option 1 - Volumes and Costs ($18/19 real)**

| | 20/21 | 21/22 | 22/23 | 23/24 | 24/25 | Total Over 2020-25 period |
|---|---|---|---|---|---|---|
| **Quantity** | 13,809 | 13,809 | 13,809 | 13,809 | 13,809 | 69,045 |
| **Cost ($k)** | 11,047 | 11,047 | 11,047 | 11,047 | 11,047 | 55,236 |

The expenditure information in this business case is represented in the same manner as the Reset RIN Repex template. For example, if a project/program contains multiple assets (e.g. OH conductor, poles & pole top structures), the total expenditure is apportioned to respective RIN assets individually as per the Ergon Energy RIN expenditure allocation methodology.

# Appendix A. References

**Note:** Documents which were included in Energy Queensland's original regulatory submission to the AER in January 2019 have their submission reference number shown in square brackets, e.g. Energy Queensland, *Corporate Strategy [1.001], (31 January 2019).*


AEMO, *Value of Customer Reliability Review, Final Report,* (September 2014).

Energy Queensland, *Asset Management Overview, Risk and Optimisation Strategy [7.025]*, (31 January 2019).

Energy Queensland, *Asset Management Plan, Services [7.040]*, (31 January 2019).

Energy Queensland, *Corporate Strategy [1.001],* (31 January 2019).

Energy Queensland, *Future Grid Roadmap [7.054],* (31 January 2019).

Energy Queensland, *Intelligent Grid Technology Plan [7.056],* (31 January 2019).

Energy Queensland, *Justification Statement – Services [7.073]*, (31 January 2019).

Energy Queensland, *Low Voltage Network Monitoring Strategy [7.080],* (31 January 2019).

Energy Queensland, *Network Risk Framework*, (October 2018).

Ergon Energy, *Distribution Annual Planning Report (2018-19 to 2022-23) [7.049]*, (21 December 2018).

# Appendix B. Acronyms and Abbreviations

The following abbreviations and acronyms appear in this business case.

| Abbreviation or acronym | Definition |
|---|---|
| $M | Millions of dollars |
| $k | Thousands of dollars |
| $ nominal | These are nominal dollars of the day |
| $ real 2019-20 | These are dollar terms as at 30 June 2020 |
| 2020-25 regulatory control period | The regulatory control period commencing 1 July 2020 and ending 30 Jun 2025 |
| AEMC | Australian Energy Market Commission |
| AEMO | Australian Energy Market Operator |
| AER | Australian Energy Regulator |
| AMP | Asset Management Plan |
| Augex | Augmentation Capital Expenditure |
| BAU | Business as Usual |
| CAPEX | Capital expenditure |
| CoC | Cost of Consequence |
| Current regulatory control period or current period | Regulatory control period 1 July 2015 to 30 June 2020 |
| DAPR | Distribution Annual Planning Report |
| DC | Direct Current |
| DNSP | Distribution Network Service Provider |
| EQL | Energy Queensland Ltd |
| IT | Information Technology |
| KRA | Key Result Areas |
| kVA | Kilovolt Amperes |
| LV | Low Voltage |
| MSS | Minimum Service Standard |
| NEL | National Electricity Law |
| NEM | National Electricity Market |
| NEO | National Electricity Objective |
| NER | National Electricity Rules (or Rules) |
| Next regulatory control period or forecast period | The regulatory control period commencing 1 July 2020 and ending 30 Jun 2025 |
| NPV | Net Present Value |
| OH | Overhead |

| Abbreviation or acronym | Definition |
|---|---|
| OPEX | Operational Expenditure |
| PCBU | Person in Control of a Business or Undertaking |
| PoS | Probability of Severity |
| Previous regulatory control period or previous period | Regulatory control period 1 July 2010 to 30 June 2015 |
| PV | Present Value |
| Repex | Replacement Capital Expenditure |
| RIN | Regulatory Information Notice |
| RIT-D | Regulatory Investment Test – Distribution |
| RTS | Return to Service |
| SAIDI | System Average Interruption Duration Index |
| SAIFI | System Average Interruption Frequency Index |
| SAMP | Strategic Asset Management Plan |
| SCADA | Supervisory Control and Data Acquisition |
| SFAIRP | So Far as Is Reasonably Practicable |
| UV | Ultraviolet |
| VCR | Value of Customer Reliability |
| VPP | Virtual Power Plant |
| WACC | Weighted average cost of capital |

# Appendix C. Alignment with the National Electricity Rules (NER)

The table below details the alignment of this proposal with the NER capital expenditure requirements as set out in Clause 6.5.7 of the NER.

**Table 13: Alignment with NER**

| Capital Expenditure Requirements | Rationale |
|---|---|
| **6.5.7 (a) (2)**<br>The forecast capital expenditure is required in order to **comply with all applicable regulatory obligations or requirements** associated with the provision of standard control services | Pursuant to the Electrical Safety Act 2002, as a person in control of a business or undertaking (PCBU), Ergon Energy has an obligation to ensure that its works are electrically safe and are operated in a way that is electrically safe.[3] This duty also extends to ensuring the electrical safety of all persons and property likely to be affected by the electrical work.[4] This proposal addresses Ergon's key obligation in relation to ensuring that its works are electrically safe SFAIRP. |
| **6.5.7 (a) (3)**<br>The forecast capital expenditure is required in order to:<br>(iii) maintain the **quality, reliability and security of supply** of supply of standard control services<br>(iv) maintain the **reliability and security of the distribution system** through the supply of standard control services | While the primary purpose of this program is the delivery of safe outcomes for customers, it does also address reliability issues associated with service failures. |
| **6.5.7 (a) (4)**<br>The forecast capital expenditure is required in order to maintain the **safety of the distribution system** through the supply of standard control services. | Pursuant to the Electrical Safety Act 2002, as a person in control of a business or undertaking (PCBU), Ergon Energy has an obligation to ensure that its works are electrically safe and are operated in a way that is electrically safe. This duty also extends to ensuring the electrical safety of all persons and property likely to be affected by the electrical work. This proposal addresses Ergon's key obligation in relation to ensuring that it works are electrically safe SFAIRP. |
| **6.5.7 (c) (1) (i)**<br>The forecast capital expenditure reasonably reflects the **efficient costs** of achieving the capital expenditure objectives | The Unit Cost Methodology and Estimation Approach sets out how the estimation system is used to develop project and program estimates based on specific material, labour and contract resources required to deliver a scope of work. The consistent use of the estimation system is essential in producing an efficient CAPEX forecast by enabling:<br>• Option analysis to determine preferred solutions to network constraints<br>• Strategic forecasting of material, labour and contract resources to ensure deliverability<br>• Effective management of project costs throughout the program and project lifecycle, and<br>• Effective performance monitoring to ensure the program of work is being delivered effectively.<br>The unit costs that underpin our forecast have also been independently reviewed to ensure that they are efficient (Attachments 7.004 and 7.005 to the January 2019 regulatory proposal). |

[3] Section 29, *Electrical Safety Act 2002*
[4] Section 30 *Electrical Safety Act 2002*

| Capital Expenditure Requirements | Rationale |
|---|---|
| **6.5.7 (c) (1) (ii)**<br>The forecast capital expenditure reasonably reflects a realistic expectation of the demand forecast and cost inputs required to achieve the capital expenditure objectives | The prudency of this proposal is demonstrated through the options analysis conducted and the quantification of risk and benefits of each option.<br>The prudency of our CAPEX forecast is demonstrated through the application of our common frameworks put in place to effectively manage investment, risk, optimisation and governance of the Network Program of Work. An overview of these frameworks is set out in our Asset Management Overview, Risk and Optimisation Strategy (Attachment 7.026 to the January 2019 regulatory proposal). |

# Appendix D. Mapping of Asset Management Objectives to Corporate Plan

This proposal has been developed in accordance with our Strategic Asset Management Plan. Our Strategic Asset Management Plan (SAMP) sets out how we apply the principles of Asset Management stated in our Asset Management Policy to achieve our Strategic Objectives.

Table 1: “Asset Function and Strategic Alignment” in Section 1.4 details how this proposal contributes to the Asset Management Objectives.

The Table below provides the linkage of the Asset Management Objectives to the Strategic Objectives as set out in our Corporate Plan (Supporting document 1.001 to our Regulatory Proposal as submitted in January 2019).

**Table 14: Alignment of Corporate and Asset Management objectives**

| Asset Management Objectives | Mapping to Corporate Plan Strategic Objectives |
|---|---|
| **Ensure network safety for staff contractors and the community** | EFFICIENCY<br>***Operate safely as an efficient and effective organisation***<br>Continue to build a strong safety culture across the business and empower and develop our people while delivering safe, reliable and efficient operations. |
| **Meet customer and stakeholder expectations** | COMMUNITY AND CUSTOMERS<br>***Be Community and customer focused***<br>Maintain and deepen our communities’ trust by delivering on our promises, keeping the lights on and delivering an exceptional customer experience every time |
| **Manage risk, performance standards and asset investments to deliver balanced commercial outcomes** | GROWTH<br>***Strengthen and grow from our core***<br>Leverage our portfolio business, strive for continuous improvement and work together to shape energy use and improve the utilisation of our assets. |
| **Develop Asset Management capability & align practices to the global standard (ISO55000)** | EFFICIENCY<br>***Operate safely as an efficient and effective organisation***<br>Continue to build a strong safety culture across the business and empower and develop our people while delivering safe, reliable and efficient operations. |
| **Modernise the network and facilitate access to innovative energy technologies** | INNOVATION<br>***Create value through innovation***<br>Be bold and creative, willing to try new ways of working and deliver new energy services that fulfil the unique needs of our communities and customers. |

# Appendix E. Risk Tolerability Table

**Network Risks - *Risk Tolerability Criteria and Action Requirements***

| Risk Score | Risk Descriptor | Risk Tolerability Criteria and Action Requirements | | | |
|---|---|---|---|---|---|
| 30 – 36 | ***Intolerable*** *( stop exposure immediately)* | | | | |
| 24 – 29 | ***Very High Risk*** | ***ALARP** Risk in this range managed to As Low As Reasonably Practicable | **Executive Approval** ( required for continued risk exposure at this level ) | May require a full Quantitative Risk Assessment (QRA)<br>Introduce new or changed risk treatments to reduce level of risk<br>Periodic review of the risk and effectiveness of the existing risk treatments | **SFAIRP** Risks in this area to be mitigated So Far as is Reasonably Practicable |
| 18 – 23 | ***High Risk*** | | **Divisional Manager Approval** (required for continued risk exposure at this level ) | Introduce new or changed risk treatments to reduce level of risk<br>Periodic review of the risk and effectiveness of the existing risk treatments | |
| 11 – 17 | ***Moderate Risk*** | | **Group Manager / Process Owner Approval** (required for continued risk exposure at this level) | Introduce new or changed risk controls or risk treatments as justified to further reduce risk<br>Periodic review of the risk and effectiveness of the existing risk treatments | |
| 6 – 10 | **Low Risk** | | | | |
| 1 to 5 | ***Very Low Risk*** | | No direct approval required but evidence of ongoing monitoring and management is required | *Periodic review of the risk and effectiveness of the existing risk treatments* | |

**Figure 5: A Risk Tolerability Scale for evaluating Semi-Quantitative risk score**

# Appendix F. Quantitative Risk Assessment Details

| Asset Class Data Input | | | |
|---|---|---|---|
| | | **Description/Justification** | **Source** |
| **Asset Class** | Ergon LV Services | - | - |
| **Asset Median Life (years)** | 80.2 | Calculated from Weibull parameters | - |
| **NPV Period (years)** | 20 | - | - |
| **Historical Unit Rate ($)** | 866 | Average historical expenditure within the 2015-2020 regulatory period. | Attachment 7.073 of our initial regulatory proposal. |
| **Forecasted Unit Rate ($)** | 800 | A lower unit rate is used when calculating the cost of the proposed replacements within the 2020-2025 regulatory period.<br>Based on bulk replacements in coastal towns reducing the above historical unit rate. | As agreed with EQL. |

| Age Profile and Replacements | | | |
|---|---|---|---|
| | | **Description/Justification** | **Source** |
| **Total Population** | 397,633 | Total amount of LV services owned by Ergon. | Attachment 7.040 of our initial regulatory proposal. |
| **Replacements - Counterfactual** | 5,309 | Average historical annual replacements within the 2015-2020 regulatory period. | Attachment 7.073 of our initial regulatory proposal. |
| **Replacements - Option 1** | 13,809 | Forecasted annual replacements within the 2020-2025 regulatory period. | Attachment 7.073 of our initial regulatory proposal. |
| **Replacements - Option 2** | - | Spare | - |

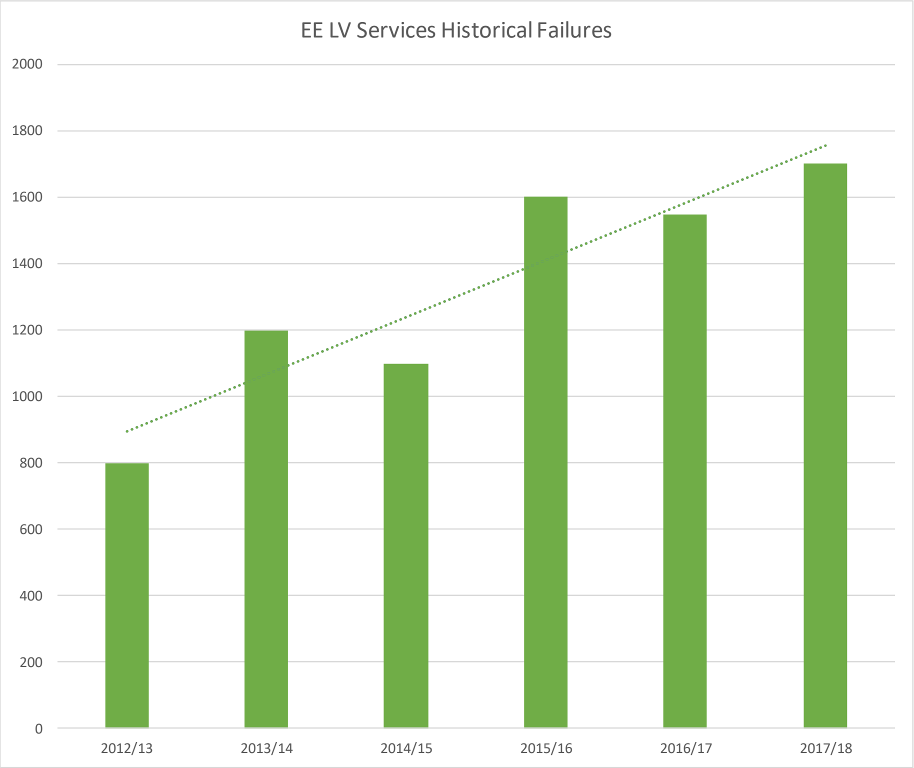
| Safety Risk Inputs | | | | |
|---|---|---|---|---|
| **Consequence** | **Monetisation ($)** | **Disproportionality Factor** | **Description/Justification** | **Source** |
| **Single Fatality** | 4,900,000 | 10 | Cost of a single fatality scaled by factor of 10. | [1] The sources used to develop the Disproportionality Factors are as follows:<br><br>Ausgrid - Revised Proposal - Attachment 5.13.M.4 - Low Voltage Overhead Service Lines program CBA summary - January 2019<br><br>https://www.pmc.gov.au/sites/default/files/publications/value-of-statistical-life-guidance-note_0_0.pdf<br><br>https://www.hse.gov.uk/risk/theory/alarpcba.htm |
| **Single Series Injury** | 490,000 | 8 | Cost of a single serious injury scaled by a factor of 8. | |
| **Fire** | 66,000 | 4 | Cost of a fire scaled by a factor of 4. | |
| **Emergency Response** | 1,750 | 1 | Cost of an emergency response scaled by a factor of 1 as the DF is not relevant to this consequence. | |

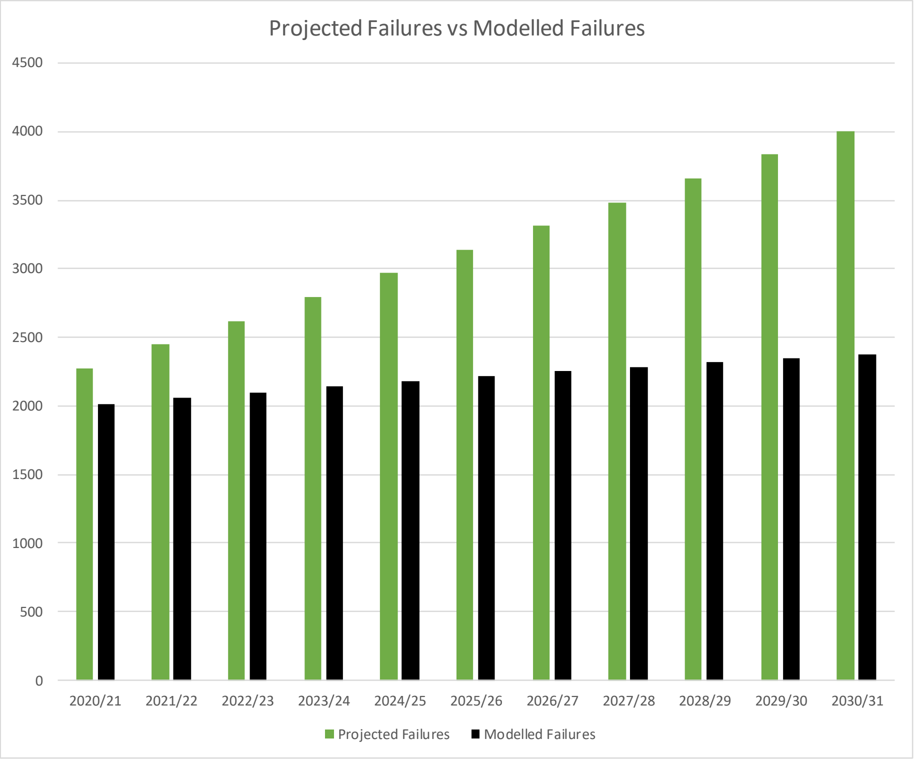
[1] Disproportionality factors are applied to the consequence monetisation to offset the gross disproportion (perceived point at which the cost of implementing a safety measure exceeds its expected benefits). The above factors are based on a review of peer organisations, as well as other industries, to identify a single factor within the approximate median of the range of factors identified in the review.

| Customer Risk Inputs | | | | |
|---|---|---|---|---|
| | | | Description/Justification | Source |
| Residential | VCR ($/MWH) | 25,420 | The value different types of customers place on having reliable electricity supplies under different conditions. Determined from survey results conducted by AEMO. | AEMO Value of Customer Reliability Fact Sheet |
| | Load (MVA) | 0.0035 | Load lost per residential LV service failure. Typical ADMD for a residential customer. | Based on EQL planning information. |
| | Hrs to restore | 3 | Time taken to get a failed residential LV service operating as usual. Based on typical travel and labour involved with residential customers. | As agreed with EQL. |
| | Power Factor | 0.85 | The ratio which determines the real power used by EQL residential customers. Based on the typical uncompensated power factor for an EQL zone substation. | EQL 2018 DAPR – typical values |
| | Load Factor | 0.2 | A ratio of average load to peak load within a specific time. Acts as a measure of EQL's utilisation rate. Conservative value based on typical values for EQL residential load profiles. | As agreed with EQL. |
| | Percentage of Mix | 88% | Percentage of EQL customers who are considered as residential loads. Based on the approximate mix of residential versus commercial customers in the EQL network as informed by customer type information. | As agreed with EQL. |
| Commercial | VCR ($/MWH) | 44,390 | The value different types of customers place on having reliable electricity supplies under different conditions. Determined from survey results conducted by AEMO. | AEMO Value of Customer Reliability Fact Sheet |
| | Load (MVA) | 0.0065 | Load lost per commercial LV service failure. Typical ADMD for a commercial customer. | Based on EQL planning information. |
| | Hrs to restore | 4 | Time taken to get a failed commercial LV service operating as usual. Based on typical travel and labour involved with commercial customers. | As agreed with EQL. |
| | Power Factor | 0.85 | The ratio which determines the real power used by EQL commercial customers. Based on the typical uncompensated power factor for an EQL zone substation. | EQL 2018 DAPR – typical values |
| | Load Factor | 0.6 | A ratio of average load to peak load within a specific time. Acts as a measure of EQL's utilisation rate. Conservative value based on typical values for EQL commercial load profiles. | As agreed with EQL. |
| | Percentage of Mix | 12% | Percentage of EQL customers who are considered as commercial loads. Based on the approximate mix of residential versus commercial customers in the EQ network as informed by customer type information. | As agreed with EQL. |

| Incident Conversion Rate (ICR) & Probability of Consequence (PoC) | | | | | | |
|---|---|---|---|---|---|---|
| ICR | | PoC | | | | |
| Consequence | Incidents Attr. to Cons. | Category | Risk Scale | Probability of Severity | Description/Justification | Source |
| **Single Fatality** | 180 | Safety | 5 | 0.09% | ICR - Based on an average 180 annual shock incidents involved with LV Services.<br><br>PoC - Calibrated to represent the historically expected 1 fatality every 5 years. | ICR – Attachment 7.040 of our initial regulatory proposal.<br><br>PoC – Input data provided by EQL. |
| **Major Injury** | 180 | Safety | 4 | 0.23% | ICR - Based on an average 180 annual shock incidents involved with LV services.<br><br>PoC - Calibrated to represent the historically expected 1 major injury every 4 years. | ICR – Attachment 7.040 of our initial regulatory proposal.<br><br>PoC – Input data provided by EQL. |
| **Fire** | 20 | Fire | 2 | 20% | ICR – 1% of incidents are attributed to fire.<br>Calibrated based on the expected costs involved with fire risks relative to costs involved with safety in the case of LV Services.<br><br>PoC - 20% of incidents result in a fire.<br>Based on the severity of the consequence being considered as minor to moderate. | ICR – As agreed with EQL.<br><br>PoC - Assumed based on EQL and peer organisation industry experience. |
| **Customer Outage** | 1700 | Customer | 1 | 100% | ICR – Assumes that 100% of incidents are attributed to a customer outage.<br><br>PoC - 100% of incidents result in a customer outage.<br><br>Based on customers not having a redundant supply. | ICR - Assumed based on EQL and peer organisation industry experience.<br><br>PoC - Assumed based on EQL and peer organisation industry experience. |
| **Emergency Response** | 1700 | Other | 1 | 100% | ICR - 100% of incidents are attributed to emergency response<br><br>PoC - 100% of incidents result in an emergency response. | ICR - Assumed based on EQL and peer organisation industry experience.<br><br>PoC - Assumed based on EQL and peer organisation industry experience. |
| **Total No. of Incidents** | **1700** | - | - | - | Based on known LV Service failures within the 2017/2018 period. | Attachment 7.040 of our initial regulatory proposal. |

| Statistical Calibration | | | |
|---|---|---|---|
| | | **Description/Justification** | **Source** |
| **Reliability Model Used** | Weibull | Weibull parameters are calibrated to project the trend in historical failures as shown in the below charts.<br><br>Modelled failures are less than the projected historical failures, this is conservative. | Attachment 7.040 of our initial regulatory proposal |
| **Shape parameter (β)** | 3.5 | | |
| **Characteristic life (η)** | 89 | | |
| **Guaranteed Min Life (γ)** | 0 | | |


EE LV Services Historical Failures
2000
1800
1600
1400
1200
1000
800
600
400
200
0
2012/13
2013/14
2014/15
2015/16
2016/17
2017/18


Projected Failures vs Modelled Failures
4500
4000
3500
3000
2500
2000
1500
1000
500
0
2020/21
2021/22
2022/23
2023/24
2024/25
2025/26
2026/27
2027/28
2028/29
2029/30
2030/31
Projected Failures
Modelled Failures

# Appendix G. Reconciliation Table

| Reconciliation Table<br>Conversion from $18/19 to $2020 | |
|---|---|
| **Business Case Value** | |
| **(M$18/19)** | $55.20 |
| | |
| **Business Case Value** | |
| **(M$2020)** | $57.61 |