Business Case
LV Network Safety

Part of the Energy Queensland Group

Executive Summary

This document seeks funding for a Low Voltage (LV) Network Safety monitoring program in the 2020-25 regulatory control period to the total capex value of $30.9M for Energex and $50.0M for Ergon. This initiative targets the highest safety risks arising from neutral integrity failures associated with LV services in the Energex and Ergon Energy networks.

EQL aims to minimise expenditure in order to keep pressure off customer prices, however understands that this must be balanced against critical network performance objectives. These include network risk mitigation (e.g. safety, bushfire), regulatory obligations (e. safety), customer reliability and security and preparing the network for the ongoing adoption of new technology by customers (e.g. solar PV). In this business case customer and community safety is the critical driver of investment.

Under the *Queensland Electrical Safety Act* and associated regulations, Ergon Energy and Energex have 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 they do all that is reasonably practicable (including that which was reasonably able to be done at a time) to ensure electrical safety risks are managed to the level So Far as Is Reasonably Practicable (SFAIRP). To date, Ergon Energy and Energex's existing service inspection and replacement programs have been assessed and determined as a reasonably practicable approach to manage neutral integrity risks. However, the emergence and availability of evolving technology solutions for network monitoring have now triggered Ergon Energy and Energex to re-assess what is reasonably practicable to manage safety risks to the level SFAIRP.

A recent report from the Western Australian electrical safety regulator into an incident that occurred in Beldon in March 2018 is significant in relation to this business case. The incident occurred due to neutral integrity failure and resulted in an electric shock. The report[1] makes it clear that general maintenance is labour intensive and therefore impracticable and not a cost effective use of resources. The report also highlighted that continuous condition monitoring of data to assess varying neutral impedances with changes to the premises load over a "long period of time" is the ***most*** effective method of preventing dangerous situations due to open circuit supply neutral connections issues.

Experience in Victoria has shown that near real-time LV monitoring has the capability to substantially lower safety risks to customers, through actively monitoring real-time network parameters, detecting and alarming for neutral integrity failures before they cause customer shocks. EQL has also commenced some limited trials in gathering and monitoring real-time field data to demonstrate monitoring capability. Given the better knowledge of the issue and emergence of this capability, Ergon Energy and Energex are obliged to explore options to reduce customer safety risks to the level SFAIRP.

Detailed quantitative risk assessments have shown an escalating trend of customer shocks is likely to occur, especially in the case of the Ergon network, and the quantified economic value of the risks exceed the costs of a monitoring program. Such a monitoring program will provide an overall better economic outcome for customers and reduce the customer safety risks to the level SFAIRP.

Several Options were considered to address the limitations and to enable improved customer and community safety outcomes. The options considered in the NPV analysis were:

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[1] Government of Western Australia, Department of Mines, Industry Regulation and Safety, Building and Energy, Electrical Accident Report, 240 Eddystone Avenue Beldon Western Australia, 3 March 2018, (25 September 2019)

Counterfactual (Option 1) – Historical physical Service Replacement Volumes for Energex and Ergon

Option 2 (Preferred) – Proposed Service Replacement Volumes plus Network Monitoring

Option 3 – Proposed Service Replacement Volumes plus Detailed Service Inspection Program

Option 4 - Proposed Service Replacement Volumes plus Additional Service Replacements

The preferred option was Option 2, as it delivers the highest NPV result and a prudent approach to risk minimisation. The capex value of the program is $30.9M for Energex and $50.0M for Ergon.

The direct cost of the project 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
EGX Capex $50.4M EE Capex $50.0M	EGX $0M EE $0M	EGX Capex $30.9M EE Capex $50.0M

To ensure that the monitoring program is both prudent and efficient, EQL is proposing a governance approach of engaging customer representatives to consult on the optimal roll-out approach for each year of the program. In addition, EQL proposes to conduct suitable market testing to ensure that field data is sourced in an efficient manner through either smart meters or purpose-installed field sensors, where smart meters are not practicable or efficient.

Contents

1. Introduction

Safety by design is fundamental to the Energy Queensland Limited (EQL) network strategy, providing safe and reliable electricity to almost 2.5 million residents and businesses across Queensland and is at the core of EQL's corporate values. Neutral integrity failures on the Low Voltage (LV) network are a significant cause of customer safety incidents. EQL is committed to customer safety imperatives and considers that the detection of neutral integrity failures is critical to mitigating customer safety risks. This proposal is for an investment by EQL over the 2020-2025 regulatory control period in equipment, systems and processes to detect neutral integrity failures. The scope provides for gathering of field data, through purpose-built sensors or through smart meters, derivation of information from the field data, and detection and raising of alerts for neutral integrity failures in the EQL network or in customer installations.

1.1 Purpose of document

This document recommends the optimal capital investment necessary for improving customer safety by reducing the risks associated with neutral related shocks.

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 Energy Queensland 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 investment governance processes. The costs presented are in $2018/19 direct dollars.

1.2 Scope of document

This document seeks investment funding from the AER for a program of LV safety monitoring. It compares the benefits of a monitoring program with higher quantities of inspections and service replacements as alternatives. It does not eliminate the need for LV service replacements, which are contained in other business cases[2], but rather complements these programs to provide an overall lower safety risk to customers at an efficient price. This document should be read in conjunction with the EQ Asset Management Plan Services and the Ergon Energy business case for LV Services. This business case is primarily aimed at improving customer safety through LV monitoring. However, this approach does provide additional benefits to the network and is complementary to other monitoring strategies detailed in Energy Queensland's, *Low Voltage Network Monitoring Strategy [7.080],* (31 January 2019).

1.3 Identified Need

The need for this work is in two parts:

a. A detailed quantitative risk assessment has shown that this investment is required to provide optimal economic outcomes, balancing the value of risks with the cost of managing the risks. The risk analysis also shows that this optimal outcome reduces customer safety risks from neutral integrity failures to the level So Far as Is Reasonably Practicable (SFAIRP). This analysis is based on the forecast of escalating neutral integrity failure rates, especially in the Ergon network area; and
b. New technology has become available that can proactively detect neutral integrity degradation in most cases prior to failure and shock incidents occurring, which promotes greater overall effectiveness in reducing customer safety risks to the level SFAIRP.

[2] Ergon Energy Business Case – Low Voltage Services

EQL aims to minimise expenditure in order to keep pressure off customer prices, however understands that this must be balanced against critical network performance objectives. These include network risk mitigation (e.g. safety, bushfire), regulatory obligations (e.g. safety), customer reliability and security and preparing the network for the ongoing adoption of new technology by customers (e.g. solar PV). In this business case customer and community safety is the critical driver of investment.

These issues are elaborated in subsequent sections. This proposal aligns with the CAPEX objectives and criteria from the National Electricity Rules (NER) as detailed in Appendix C .

1.4 Energy Queensland Strategic Alignment

Table 1 details how this LV Safety program contributes to EQL's corporate and asset management 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	This monitoring initiative complements LV service replacement programs to provide safety risk reduction SFAIRP for the community.
Meet customer and stakeholder expectations	Customers expect a safe and reliable electricity supply and this monitoring program supports network reliability and promotes delivery of a safe electrical energy service at optimal cost.
Manage risk, performance standards and asset investments to deliver balanced commercial outcomes	Neutral integrity failure can result in increased public safety risk, disruption of the electricity network, and disruption of customer amenity. Understanding asset performance through monitoring allows optimal investment to achieve efficient outcomes. Asset longevity assists in minimising future capital and operational expenditure.
Develop Asset Management capability & align practices to the global standard (ISO55000)	This approach of monitoring is consistent with AS ISO 55000 objectives and drives asset management capability by promoting continuous and targeted improvement.
Modernise the network and facilitate access to innovative energy technologies	This approach of monitoring promotes replacement of assets at end of economic life as necessary to suit modern standards and requirements.

1.5 Applicable service levels

EQL has established target performance levels for shock volumes relating to neutral integrity. These targets were established internally with an objective of driving down the level of neutral integrity related shocks. These targets have changed Ergon Energy's asset management strategy in relation to LV services, and is the subject of a separate Business Case as highlighted earlier. It has now become evident that performance levels in other Australian jurisdictions have been substantially improved by the introduction of neutral circuit monitoring, and consistent with Ergon Energy and Energex's Duty of Safety under the *Electrical Safety Act*, EQL seeks to achieve similar performance outcomes. This requires another step-change in overall asset management approach.

Public shock incidents in Queensland are monitored monthly, with shocks related to neutral integrity making up some 60-70% of network-related incidents. Figure 1 illustrates the performance in the Ergon Energy network. Over recent years there have been up to 180 shocks per annum directly attributable to LV Services and related connections.

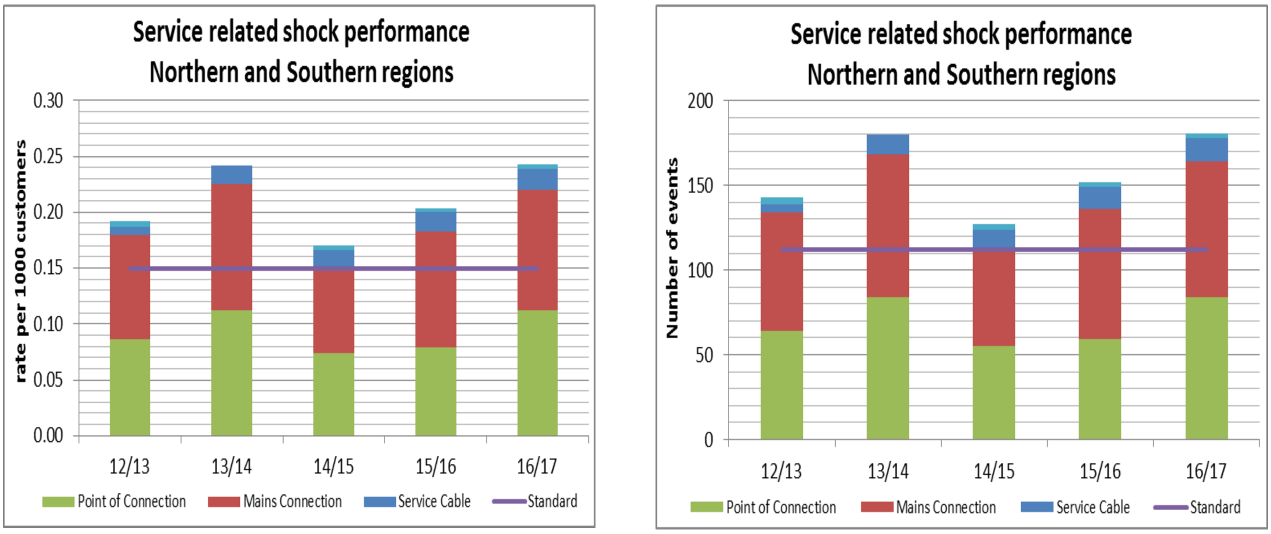

Figure 1. Service-related shock performance trend – Ergon Energy Network

Figure 2 illustrates the performance in the Energex network. Over recent years there have been around 80 shocks per annum directly attributable to overhead services and related connections.

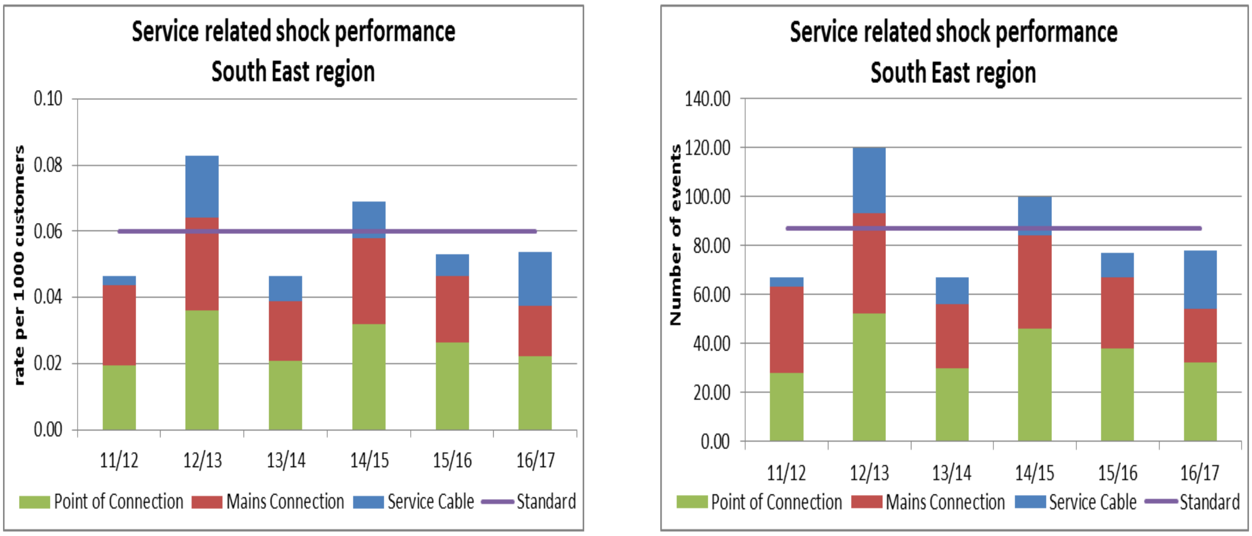

Figure 2. Service related shock performance trend – Energex network

It should also be noted that the rate of service-related shock incidents in the Ergon Energy network is about 4 times higher than for the Energex network (approximately 0.2 incidents / 1000 customers compared to 0.05 incidents/1000 customers).

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 **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: • Pursuant to the Electrical Safety Act 2002, as a person in control of a business or undertaking (PCBU), Ergon Energy and Energex have obligations to ensure that their 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 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 network-related incidents. The Act includes a duty to ensure that both Energex and Ergon Energy do all that is reasonably practicable (including that which was reasonably able to be done at a time) to ensure electrical safety risks are managed to the level So Far as Is Reasonably Practicable (SFAIRP). To date, EQL's existing service inspection and replacement programs had been assessed and determined as a reasonably practicable approach to manage neutral integrity risks. However, the emergence and availability of evolving technology solutions for network monitoring have now triggered EQL to re-assess what is reasonably practicable to manage safety risks to the level SFAIRP.
Distribution Authority for Ergon Energy or Energex issued under section 195 of *Electricity Act 1994* (Queensland)	Under its Distribution Authority: • 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.	This proposal relates to LV services neutral integrity monitoring to ensure that safety risks are managed. 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

The current approach to dealing with neutral integrity issues is a combination of proactive replacements for known problem service populations and inspection and remediation programs.

Energex has undertaken large programs to replace LV Services, replacing more than 30,000 services per year on average over the last 6 years. This has resulted in the population of LV Services being significantly younger than in Ergon Energy Network, and hence Energex has lower network related shocks and tingles per customer. However, the safety improvement for Energex has plateaued in recent years. The experiences of other Australian DNSPs has demonstrated that with improved sensing technology it is now practicable to further reduce the electrical safety risks without the need to undertake even larger replacement programs.

Figure 3 and Figure 4 show the relative ages of the Ergon Energy and Energex services populations.

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

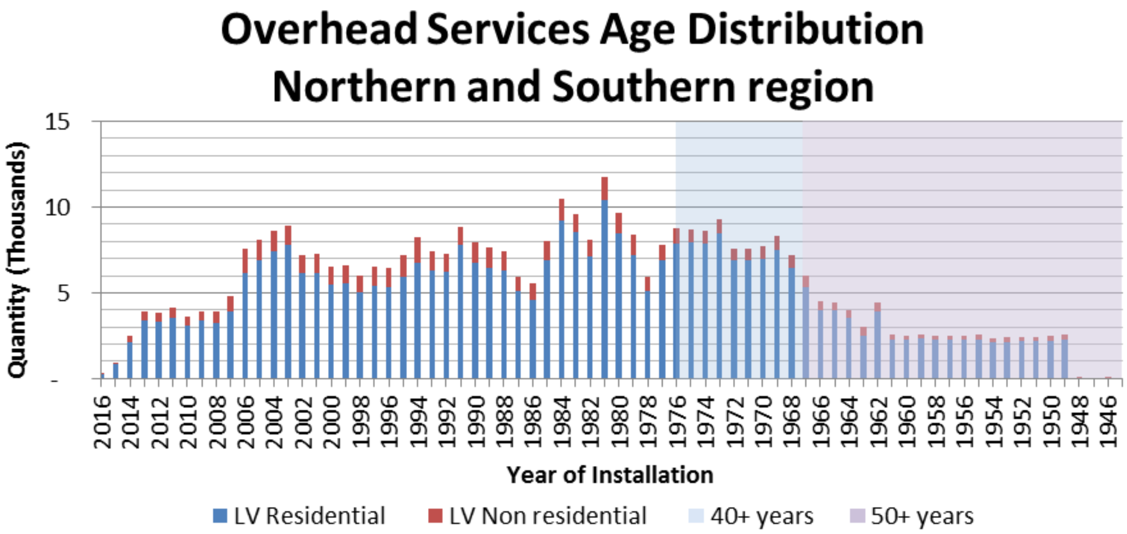

Figure 3. LV Service Ages – Ergon Energy

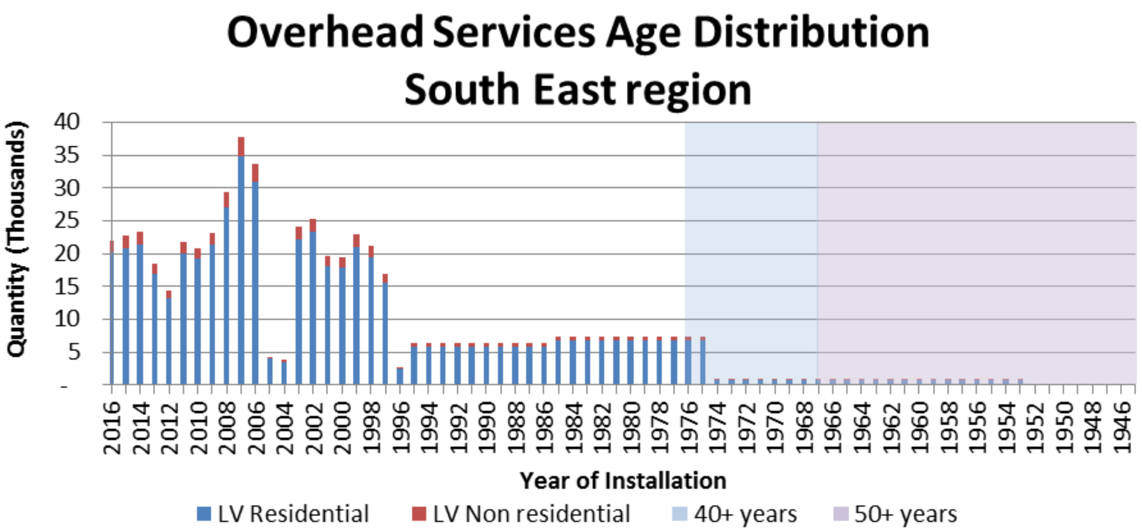

Figure 4. LV Service Ages – Energex

Age is recognised as a strong determinant in failure rates for services. However, installation date information has only been recorded in recent years. This means that accurate age distribution information for Services, especially the older elements of the population, is not available.

For the Ergon Energy and Energex services populations:

- As per the Energex and Ergon Energy Category Regulatory Information Notices (RINs), the mean asset expected life for an LV service is approximately **35 years**.
- For Ergon, approximately **37%** of the population is over **40** years of age and without bulk replacements this percentage will increase substantially to about **50%** by 2025.
- Energex's services population is substantially younger with only about 18% of the Energex services more than 40 years by 2025.
- Ergon Energy has experienced an average of approximately **1300** overhead service asset failures annually and more than 1700 failures in recent years with an increasing trend.
- Energex has experienced an average of approximately 1250 overhead service asset failures in recent years and up until 2015/16 this was trending down, however more recently the failure numbers have increased to near the average levels.

In addition to the regular LV Service inspection programs, several risk mitigation initiatives were trialled recently - including fault loop impedance testing at customer switchboards, an expanded double clamping standard in regional areas and a trial of 4,000 "WireAlert[5]" devices in regional Queensland.

The list below is generally considered good industry practice to improve the integrity of overhead LV Neutral connections:

1. Neutral integrity/loop impedance checks at time of initial customer connection.
2. Ground based visual inspections of overhead (OH) services, mains conductor, joints and connections.
3. Condition based replacement of identified degraded services and connections.
4. Program based replacement of known high risk service cables.
5. Double clamping of neutral mains in higher risk areas (e.g. coastal regions) at time of installation.
6. 24 hr emergency contact number for the public to report shocks and tingles, with crews on call for immediate investigation.

Ergon Energy Network and Energex have already adopted these practices.

As part of a recent shock analysis study, EQL conducted an audit of 1,000 Customer Services to determine the condition of various components including customer connection mains boxes. The audit was conducted in the first few months of 2018 and consisted of an average of 45 detailed inspections of services and services connections in each of the larger Ergon Energy communities and in three separate parts of the Energex region. Some 6.5% of the sites inspected were identified as having defects and 20.1% were identified as in "poor condition" (typically with surface corrosion and some minor burn marks).

Public shocks are predominantly occurring in the coastal regions, where the population of services is higher. Corrosion appears to be a major factor in the asset related failures. Service conductors and terminations are subject to deterioration in the presence of oxygen, dissimilar metals and electrolytes. Figure 5 shows a heat map for recorded network related public shocks in the Ergon Energy Network. The shock index is calculated based on number of recorded public shocks in each postcode and the total number of residential customers in that area. The darker colours indicate areas with higher frequency of public shocks. This information provides a valuable basis to target service replacements in higher risk areas and informs areas for targeted rollout of appropriate monitoring technologies.

[5] WireAlert is a proprietary product that plugs into a power-point and produces an alarm if it detects a neutral integrity problem

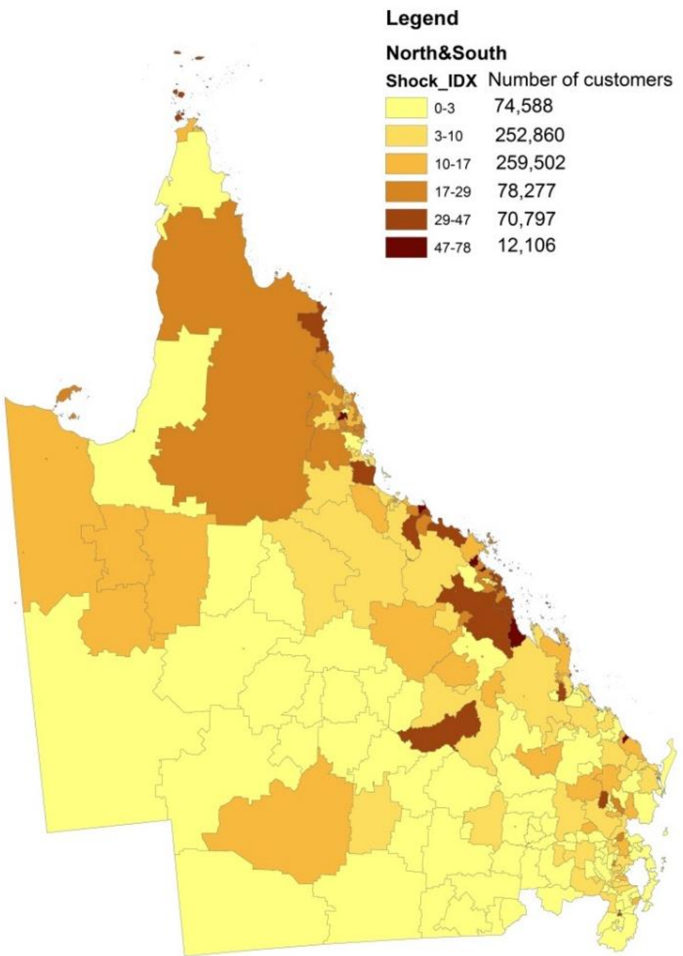

Figure 5. Heat map for recorded network related public shocks in Ergon Energy Network

Despite the adoption of these approaches and the very large service replacement program in Energex, areas have been identified where improvement is now possible. The implementation of the proposed monitoring program together with the LV replacement program will ensure that Ergon and Energex can continue to meet their electrical safety duties. New technologies have now emerged and have been demonstrated elsewhere to show that a significant improvement in customer safety risk can be achieved through neutral integrity monitoring. The proposed approach can detect a range of failure modes in both the customer installation and also in the network through measurement of voltage and current parameters.

On 27 September 2019 the Western Australian Government released a report from the Western Australian electrical safety regulator into an incident that occurred in Beldon in March 2018. The incident occurred due to neutral integrity failure and resulted in an electric shock. The report[6] makes it clear that general maintenance is labour intensive and therefore impracticable and not a cost effective use of resources. A maintenance approach would only work if it was targeted to areas that have already been identified or flagged with issues.

The report also highlighted that continuous condition monitoring of data to assess varying neutral impedances with changes to the premises load over a "long period of time" is the ***most*** effective method of preventing dangerous situations due to open circuit supply neutral connections issues.

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[6] Government of Western Australia, Department of Mines, Industry Regulation and Safety, Building and Energy, Electrical Accident Report, 240 Eddystone Avenue Beldon Western Australia, 3 March 2018, (25 September 2019)

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, the customer earthing system is intended to provide bonding of metallic objects within a premise and provide an electrical path to earth to limit voltages to low levels and ensure protective devices operate if any of these metallic components become energised. The customer earthing system is also directly connected to the customer neutral circuit to limit voltage rise. Earth Leakage Circuit Breakers (ELCBs) rely upon the integrity of this connection to earth for effective operation.

In the event of a supply neutral circuit integrity issue, a very low impedance neutral-earth connection will limit voltage rise between the general mass of earth and the customer switchboard so that neutral circuit integrity issues are often not detected by the customer. However, a medium level impedance or open circuit customer neutral-earth connection, in conjunction with a supplier neutral circuit integrity issue can result in dangerous or lethal touch-voltages being present in the customer premise. This condition often manifests as flickering lights, shocks and tingles. This is the reason for promotion of the need for reporting shocks and tingles, and the corresponding emergency response by Ergon and Energex.

The volume of public shocks and tingles reported per annum per customer is therefore considered to have a substantial relationship with the level of public electrical safety that can be achieved.

Legislation does not require any form of routine inspection or testing of the customer earthing system and it is generally accepted that most customer earthing systems are not inspected or tested following initial connection integrity checks.

The large scale roll out of smart meters in Victoria has provided an opportunity for utilities to monitor and detect the faults in a more proactive and efficient way. AusNet Services has identified and remediated more than 1,500 neutral integrity failures reducing the number of reported electrical shocks by 75%. United Energy notes that in one year (2014), neutral integrity testing, undertaken remotely, avoided site visits and manual testing of approximately 65,000 premises resulting in savings of around $26 million[7].

Given the analytical monitoring approach has been demonstrated to be reasonably practicable, EQL believes that the adoption of this more effective and efficient approach will significantly eliminate the public safety risks associated with neutral integrity failures. Regardless of EQL's risk appetite, once alternative risk mitigation measures become reasonably practicable it is a legislative obligation for EQL to further mitigate this risk.

It is the intent of this Business Case to establish the level of expenditure that is also "Reasonably" Practicable" through economic analysis, and hence achieve the legislative standard with electrical risk minimised SFAIRP.

[7] Energy Networks Australia, *Smart Metering,* (September 2019) <https://www.energynetworks.com.au/smart-metering>

2.2 Business-as-usual service costs

The ongoing OPEX costs for Services are relatively minor with most costs directed at inspection and remediation of defective assets. Significant costs do arise through failures however, with shock / tingle incidents requiring emergency response, incident investigation, replacements works and reporting to the Safety Regulator.

2.3 Key assumptions

Refer to Appendix F for the methodology and input assumptions associated with quantification of risk of failures due to condition associated with the LV Service population. The counterfactual case is assumed as historical replacement volumes of service replacements are carried out in both Energex and Ergon.

Table 3 shows the number of LV Services in Energex and Ergon Energy networks.

Table 3. Overhead Service Quantity[8]

Asset Type	Ergon Energy	Energex	Total
LV Residential	345,661	546,281	891,942
LV Non-Residential	51,972	47,473	99,445
Total (OH services only)	397,633	593,754	991,387

2.4 Risk assessment

EQL has conducted both full quantitative and semi-quantitative risk assessments for various options, including the counterfactual business-as-usual scenario. These risk assessments are in accordance with the EQL Network Risk Framework and the Risk Tolerability table from the framework is shown in Appendix E .

The figures below show the results of a quantitative forecast of emerging risk associated with the Energex and Ergon LV services asset population failure due to condition related failure modes.

[8] EQL Asset Management Plan – Services

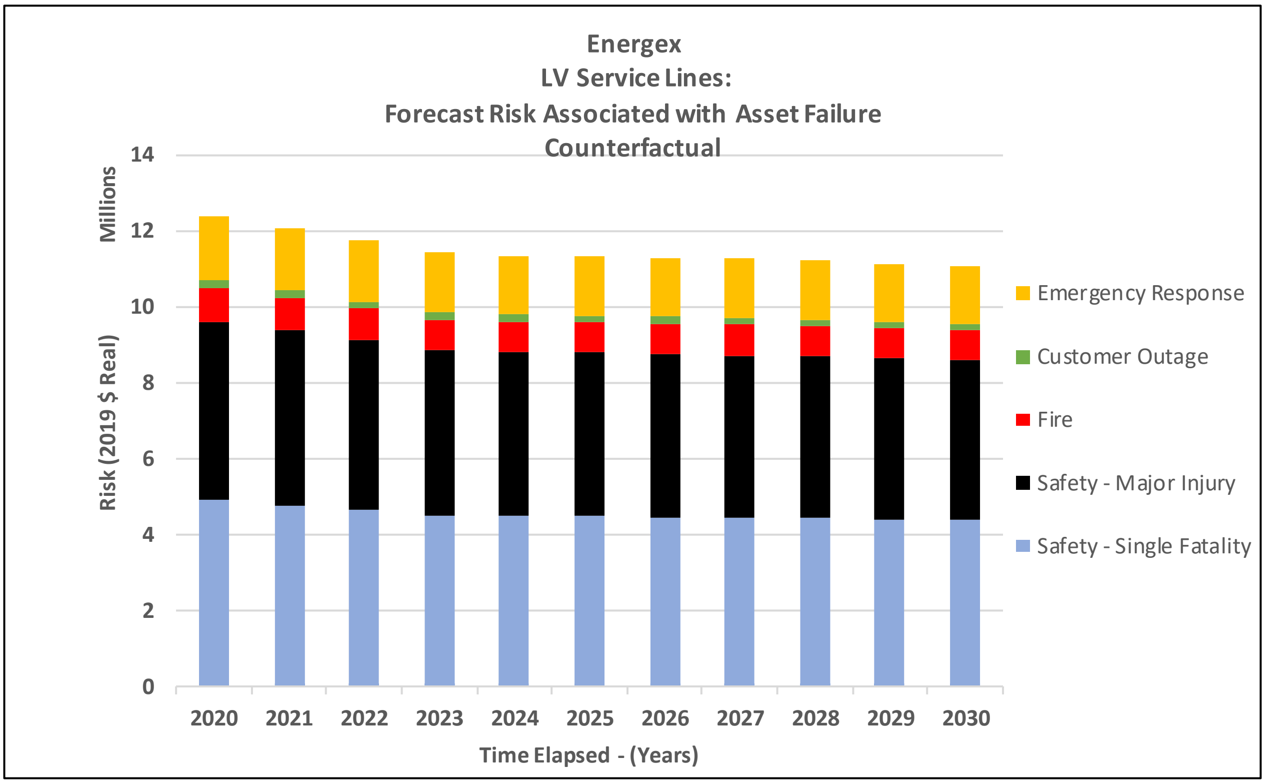


Figure 6. Counterfactual Risks Associated with LV Service Failures for Energex

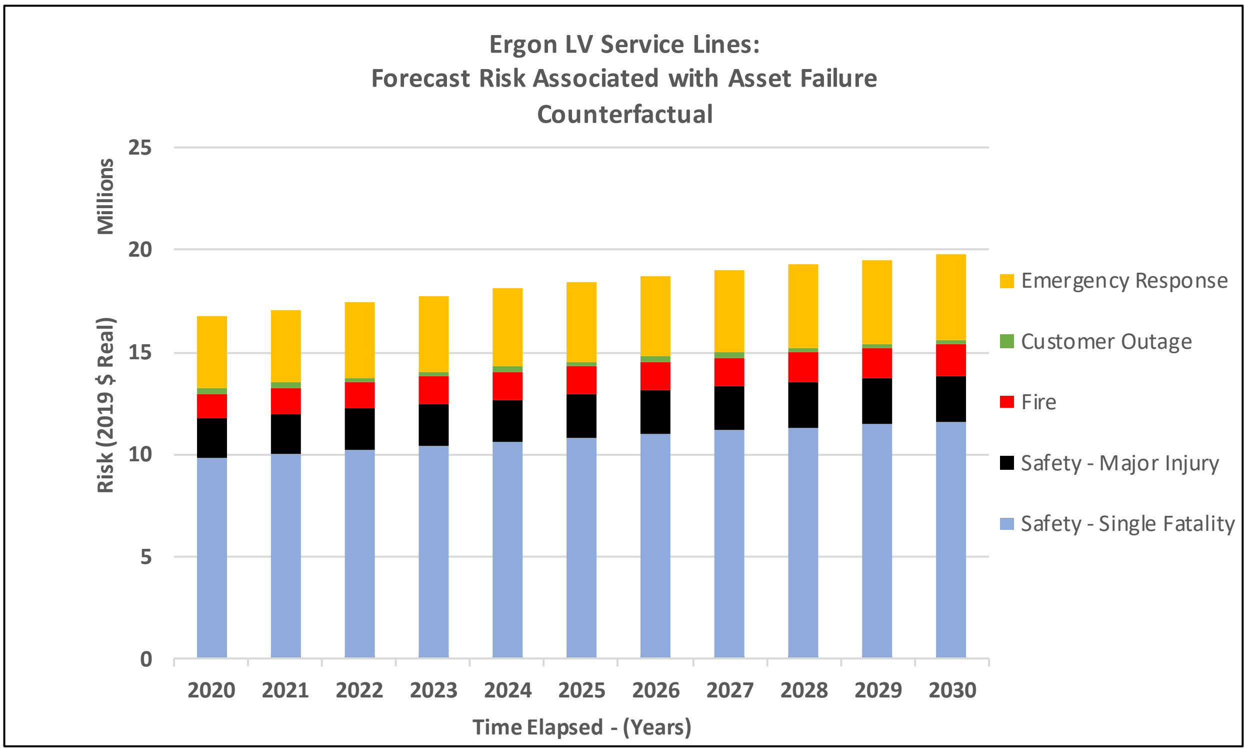


Figure 7. Counterfactual Risks Associated with LV Service Failures for Ergon Energy

Significant risk costs arise in the counterfactual due predominantly to safety risks associated with service neutral failures. The cost of these risks increases over the period shown, driven mainly by the age profile of the existing population. These charts highlight the significantly higher quantified risk in the case of Ergon.

Table 4 and Table 5 show the semi-quantitative risk assessment results for both Energex and Ergon.

Table 4. Risk Scenario and Scores – Ergon Energy

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 or incurable fatal illness)*	3 *(Unlikely)*	**15** ***(Moderate)***	2020
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 contacts live mains resulting in **a single fatality.**	Safety	5 *(Single fatality or incurable fatal illness)*	3 *(Unlikely)*	**15** ***(Moderate)***	2020
Due to corrosion, service wire losses mechanical strength and breaks. Supply i**nterruption to customer premises** until 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

Table 5. Risk Scenario and Scores – Energex

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 or incurable fatal illness)*	2 *(Very unlikely)*	**15** ***(Moderate)***	2020
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 contacts live mains resulting in **a single fatality** due to electric shock.	Safety	5 *(Single fatality or incurable fatal illness)*	2 *(Very unlikely)*	**15** ***(Moderate)***	2020
Due to corrosion, service wire losses mechanical strength and breaks. Supply i**nterruption to customer premises** until 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

Services are sized with a capacity that is usually sufficient to prevent overloading, so annealing due to overloading is not a normal failure mode. 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 amenity.

These assets are fundamental to customers' electricity supply therefore retirement in 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

Rollout of a “WireAlert” device to customers.

This device is plugged into a power point in the customers’ premises. It measures the supply voltage, as well as the loop impedance back to the transformer. If an abnormal condition is detected, the device will trigger an alarm, ideally prompting the customer to act.

To effectively mitigate potential neutral issues at customer premises, the WireAlert device relies on the customer keeping the device plugged in, regularly checking the device to observe the alarm light and making a call to report any issues immediately, after an alarm is observed. It is anticipated that this is not going to occur in the majority of cases – rather, customers are more likely to ignore the device, wait for a tingle to occur and then make a call to report the issue. It is envisaged that a significant proportion of customers would not actively participate in the process, either by not installing the device, not monitoring the device effectively, or not contacting their network provider if there is an issue. This is supported by evidence from trials of the device previously carried out by Ergon Energy and Energex, as well as feedback from other distributors who have utilised the device to mitigate risks associated with neutral integrity. Insights from the trials are contained in Appendix H

Due to the reliance of this approach on customers taking initiative, and the evidence to date that this does not occur, this approach has been deemed to be ineffective and this option has been rejected.

3.2 Identified options

Option 1: Historical Replacement Volumes (counterfactual)

Under this option, historical planned replacements would be carried out and no network monitoring would be established. The risks associated with this approach are detailed in the risk charts above. Service failure quantities under this approach are forecast to be in Energex approximately 1700 in 2020 and dropping slightly over the future period. In the case of Ergon Energy, service failures are forecast to be approximately 2000 failures by 2020 escalating to approximately 2400 by 2030.

Option 2 (Proposed) - Network Monitoring

The modelling of this plus options 3 and 4 includes the under-lying proposed services replacement programs for both Energex and Ergon. The quantities for each of these programs are shown in Appendix J

In addition to the forecasted physical replacements, it is also proposed to install Safety Monitors in customer premises to detect neutral integrity failures. The measurements from these monitors can be utilised to detect neutral integrity problems and then a suitable response can be initiated to avoid any customer shock. The sourcing of neutral integrity data at customers’ premises can be achieved in two ways:

- install specific network monitoring devices at customers’ premises in high risk areas; or
- purchase neutral integrity data from customers’ existing Advanced Metering Infrastructure (AMI) through their Retailer / Metering Coordinator

This option does not lock down the source of data, but rather seeks to identify the costs and benefits of the monitoring program. It then leaves open the future path of sourcing the data, to provide the most prudent and efficient outcomes for customers. Further details of the monitoring approach and rationale are contained in Appendix I .

Table 6 and There is no proposed program for 2020/21 to allow time for program preparation.

Table 7 summarises the total proposed number of network devices / smart meters proposed to be utilised on Energex and Ergon Energy Networks over the period 2020 to 2025. EQL is currently installing 20,000 monitoring devices in 2019/20 as part of a pilot project to develop capability required to support the LV monitoring roll out for 2020-2025. The proposed timeline allows one year for procurement of the field data and incremental increases each year as the program develops.

The total proposed quantity of network monitoring devices in Ergon Energy targets the highest risk areas of Ergon Energy and represents approximately 50% of the total Ergon Energy overhead service population. The total proposed network monitoring devices in Energex again targets the highest risk areas in Energex but only represents approximately 16% of the total Energex overhead service population. This balance has been struck based on the higher per capita rates of shocks and tingles reported in Ergon Energy, and the greater consequent risk to be managed in regional Queensland.

Table 6. Proposed Monitors Quantities & Costs – Energex

	20/21	21/22	22/23	23/24	24/25	Total Over 2020-25 period
Quantity Monitors	0	30,000	30,000	25,000	10,000	95,000
Capex Cost ($k)	0	9,750	9,750	8,125	3,250	30,875
Opex Cost ($k)	0	1,200	1,200	1,000	400	3,800

There is no proposed program for 2020/21 to allow time for program preparation.

Table 7. Proposed Monitors Quantities & Costs – Ergon Energy

	20/21	21/22	22/23	23/24	24/25	Total Over 2020-25 period
Quantity Monitors	0	30,000	45,000	60,000	65,000	200,000
Capex Cost ($k)	0	7,500	11,250	15,000	16,250	50,000
Opex Cost ($k)	0	1,200	1,800	2,400	2,600	8,000

Proposed Approach to Ensuring a Prudent and Efficient Roll-Out

The exact costs for this option are unknown at present, due to the likely blending of both purpose-built field monitoring devices, plus use of smart meters. The costs above represent a best estimate of the costs and are based on the installation of field monitoring devices. This does not pre-suppose the outcome, which is likely to be a blend of smart meter and field monitoring devices. It is proposed that the following two mechanisms be used to ensure that the program roll-out is managed in an efficient and prudent manner:

- Use of a customer consultative forum to provide governance over each specific part of the roll-out. EQL would engage with customer groups and consult on appropriate field data sources prior to seeking internal approvals for each annual program; and

- Conduct market testing as required to obtain efficient pricing.

This option provides significant improvements in customer safety outcomes as follows:

- For the Energex network the 2020 service failure rate is approximately 1700, reducing to approximately 1000 by 2030, due to the combined service replacement and LV monitoring programs.
- For the Ergon Energy network, the 2020 service failure rate is approximately 2000, reducing to approximately 680 by 2030, due to the combined service replacement and LV monitoring programs.

Option 3 - Detailed Risk Based Inspection and Replacement Program

Option 3 is a targeted program of detailed inspection and replacement, over and above the proposed physical program identified in the Energex and Ergon services business cases shown in Appendix J . This inspection program would be a comprehensive, intrusive program, similar to the audit of 1,000 overhead services carried out in 2018, referred to in 1.7 above. The high-risk areas were determined based on number of factors including historical records of public shocks, LV Services age profile, proximity of the LV Service to coastal areas and recent surveys. The volumes in this option have been made the same as option 2 to provide the same risk reduction benefits. The service failure reductions are the same as described in option 2 above as the benefits involving inspections are identical to the benefits involved with physical replacements.

Table 8. Proposed Inspection Quantities & Costs – Energex

	20/21	21/22	22/23	23/24	24/25	Total Over 2020-25 period
Quantity	0	30,000	30,000	25,000	10,000	95,000
Capex Cost ($k)	0	13,200	13,200	11,000	4,400	41,800

Table 9. Proposed Inspection Quantities & Costs – Ergon Energy

	20/21	21/22	22/23	23/24	24/25	Total Over 2020-25 period
Quantity	0	30,000	45,000	60,000	65,000	200,000
Capex Cost ($k)	0	13,200	19,800	26,400	28,600	88,000

The unit cost for these inspections has been targeted at a conservatively low level – in practice the unit cost is likely to be higher for this approach.

Option 4 Increased Proactive Service Replacement Program

Under Option 4 increased volumes of proactive service replacements would be carried out, in addition to the base replacement quantities (0, to reduce the risk of service failures. The volumes in this option are the same as options 2 and 3 to provide the same risk reduction benefits. The service failure reductions are the same as described in option 2 above.

Table 10. Proposed Physical Service Replacement Quantities & Costs – Energex

	20/21	21/22	22/23	23/24	24/25	Total Over 2020-25 period
Quantity	0	30,000	30,000	25,000	10,000	95,000
Capex Cost ($k)	0	12,192	12,192	10,160	4,064	38,607

Table 11. Proposed Physical Service Replacement Quantities & Costs – Ergon

	20/21	21/22	22/23	23/24	24/25	Total Over 2020-25 period
Quantity	0	30,000	45,000	60,000	65,000	200,000
Capex Cost ($k)	0	24,000	36,000	48,000	52,000	160,000

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 discounted over the program lifetime from FY2020/21 to FY2029/30 at the Regulated Real Pre-Tax Weighted Average Cost of Capital (WACC) rate of 2.62%, using EQL's standard NPV analysis tool.

Table 12 contains the results of the NPV analysis of the identified options, as well as the Present Value (PV) of costs and benefits for each option. This table shows that Option 2: Planned replacement program plus LV Monitoring provides the most positive NPV and is therefore the preferred option from an economic perspective.

Table 12: Net present value of options

Option		NPV ($M)	PV of costs ($M)	PV benefits($M)
Option 2 (Proposed) - Network Monitoring Plus Service Replacements	EGX	$15	$35	$50
	EE	$124	$88	$211
	Total	$138	$123	$261
Option 3 - Detailed Risk Based Inspections plus Service Replacement Program	EGX	$11	$39	$50
	EE	$102	$110	$211
	Total	$113	$148	$261
Option 4 Increased Proactive Service Replacement Program	EGX	$14	$36	$50
	EE	$36	$175	$211
	Total	$50	$211	$261

As can be seen from the above table, option 2 (Proposed) **-** Network Monitoring Plus Service Replacements, delivers higher NPVs for Energex, Ergon Energy and in total.

3.4 Scenario Analysis

3.4.1 Sensitivities

Extensive sensitivity analysis was carried out as part of the Ergon LV Services business case to demonstrate that the base services replacement volumes are suitable. This includes variations in failure rates, cost of consequences and probability of severity assumptions. This analysis demonstrated the robust nature of the services replacement program.

The remainder of this business case relates to the additional cost for monitors for both Energex and Ergon Energy with the key variable the capital cost of the monitors, hence sensitivity analysis has been carried out on the unit costs for monitors to test the preferred option. The table below shows that increased monitor costs in Energex will favour option 4 due to the relatively low comparative cost of service replacements in Energex. For all other cases option 2 remains to preferred option with the highest NPV.

Table 13: Sensitivity Analysis of Options

Sensitivity	Applied Parameter	Preferred Option	NPV of Preferred Option 2
Energex	+20% Monitor Costs	Option 4	$8M
	-20% Monitor Cost	Option 2	$22M
Ergon Energy	+20% Monitor Cost	Option 2	$112M
	-20% Monitor Cost	Option 2	$135M
Total	+20% Monitor Cost	Option 2	$120M
	-20% Monitor Cost	Option 2	$157M

3.4.2 Value of regret analysis

The key regret identified in this business case is the fatality of a customer through a service neutral failure. The value of this risk has been quantified as part of this analysis. Although Option 2 is the preferred approach based on the economic analysis, it is useful to consider the impact of each option on the key regret scenario. The value of this key risk is shown for each option in the table below.

Table 14: Relative Values of Fatality Risk (Total EGX and EE)

Option	Risk Cost 2021 ($M)	Risk Cost 2030 ($M)	Total Risk Cost 2021-2030 ($M)
Option 1: Historical Replacement Volumes	$14.8	$16.0	$153.7
Option 2 (Proposed) - Network Monitoring	$14.4	$5.0	$70.8
Option 3 - Detailed Risk Based Inspections	$14.4	$5.0	$70.8
Option 4 Increased Proactive Service Replacement Program	$14.4	$5.0	$70.8

All of Options 2, 3 and 4 produce the same risk cost since the risk reduction benefits are the same in all options, either through monitors or replacement of services. Hence the proposed option 2 provides the highest NPV as well as providing the equal highest reduction in fatality risk costs. In reality the monitoring approach in option 2 is likely to provide greater risk reductions than Option 3, since the detailed inspection is limited in the extent to which it can detect every defect.

3.5 Qualitative comparison of identified options

3.5.1 Advantages and disadvantages of each option

Table 15 details the advantages and disadvantages of each option considered.

Table 15: Qualitative assessment of options

Options	Advantages	Disadvantages
Option 1: Historical Service Replacement Volumes	• Reduce upfront expenditure and resources	• Doesn't mitigate risks of customer shocks and tingles and does not achieve the regulatory obligation to reduce the risks to the level of SFAIRP. • Likely to increase failure volumes over time
Option 2 (Proposed) - Network Monitoring Plus Service Replacements	• Reduce risk of customer shocks and tingles • Data obtained drives immediate replacement of faulty services • Provides flexibility to procure monitoring data from the market in future years as market and platforms mature • Data obtained from network device provides network visibility • Can be deployed to all customers subject to future business case study • Can detect faults in both customer premises and in the network • This approach assists EQL to progressively build the data analytics capability required for the operation of the network. The exact economic value of this capability is difficult to estimate at this stage hence not included in the NPV, however such capabilities cannot be built overnight. This is one of the key capabilities for the future network. • This approach enables Energex and Ergon to take the first step in unlocking real values of smart meters and AMI data in collaboration with metering providers. The benefits of similar approach in Victoria clearly demonstrate how networks and ultimately customer can benefit from investment in data.	• May require additional devices to be installed in the customer's meter box including communications capability • Will require outages to the customer for installation • Will require additional work in customer switchboards
Option 3 - Detailed Risk Based Inspections plus Service Replacement Program	• Reduce risk of customer shocks and tingles to some extent	• Doesn't guarantee that ALL failure modes are covered • It is only a "point in time" record and requires future site visits. • Doesn't provide network data for ongoing data driven decision making. • The site remains at some levels of risk between the inspection cycles

Options	Advantages	Disadvantages
Option 4 Increased Proactive Service Replacement Program	• Reduce risk of customer shocks • Reduce the mean age of the LV Services	• Doesn't provide network data for ongoing data driven decision making. • The site remains at some levels of risk between the inspection cycles

3.5.2 Alignment with network development plan

This proposal is consistent with the Distribution Annual Planning Report and aligns with the Asset Management Objectives outlined. 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

This proposal is strongly aligned with the Future Grid Roadmap and Intelligent Grid Technology Plan. Enabling monitoring of LV network power flows improves Energy Queensland's ability to understand and manage two-way energy flows in LV networks. This in turn will allow for more efficient investment into works to address issues threatening the compliance, safety, or correct functioning of the network, and will enable Energy Queensland to facilitate more customer Solar PV and other DER connections in a safe and effective manner.

3.5.4 Risk Assessment Following Implementation of Proposed Option

Table 16 documents the treated risks for Ergon (and Energex where stated). In the case of Energex, the levels of risk have reduced but the categorisation has remained the same except where stated below.

Table 16: 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. (Both Energex and Ergon)	Safety	(Original) 5 (Mitigated) 5 *(Single fatality or incurable fatal illness)*	3 1 *(Very unlikely)*	**15** **10** ***(Low)***	2025
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. (Both Energex and Ergon)	Safety	(Original) 5 (Mitigated) 5 *(Single fatality or incurable fatal illness)*	3 1 *(Very unlikely)*	**15** **10** ***(Low)***	2025

Risk Scenario	Risk Type	Consequence (C)	Likelihood (L)	Risk Score	Risk Year
Due to corrosion, service wire losses mechanical strength and breaks. **Interruption to customer premises** while repairs are made.	Customer	*(Original)* 1 (Mitigated) 1 *(N/A)*	6 6 *(Very unlikely)*	**6** **6** ***(Low)***	2025
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	(Original) 2 (Mitigated) 2 *(business impact of >$100,000 in damage)*	3 2 *(Very Unlikely)*	**6** **4** ***(Very Low)***	2025

The quantitative residual risk and risk reduction benefits are shown in the figures below.

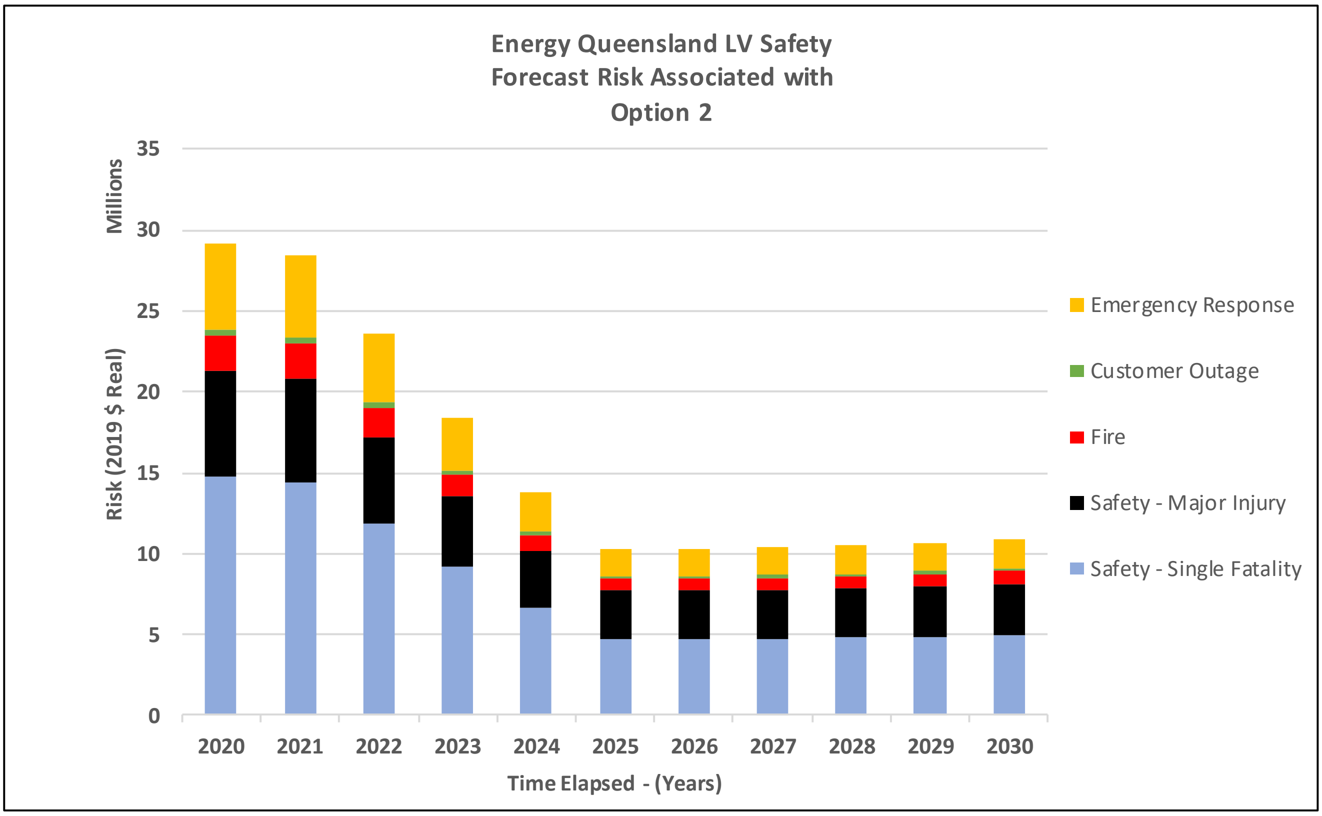


Figure 8. Residual Risk for Proposed Option 2 – Total Energex and Ergon

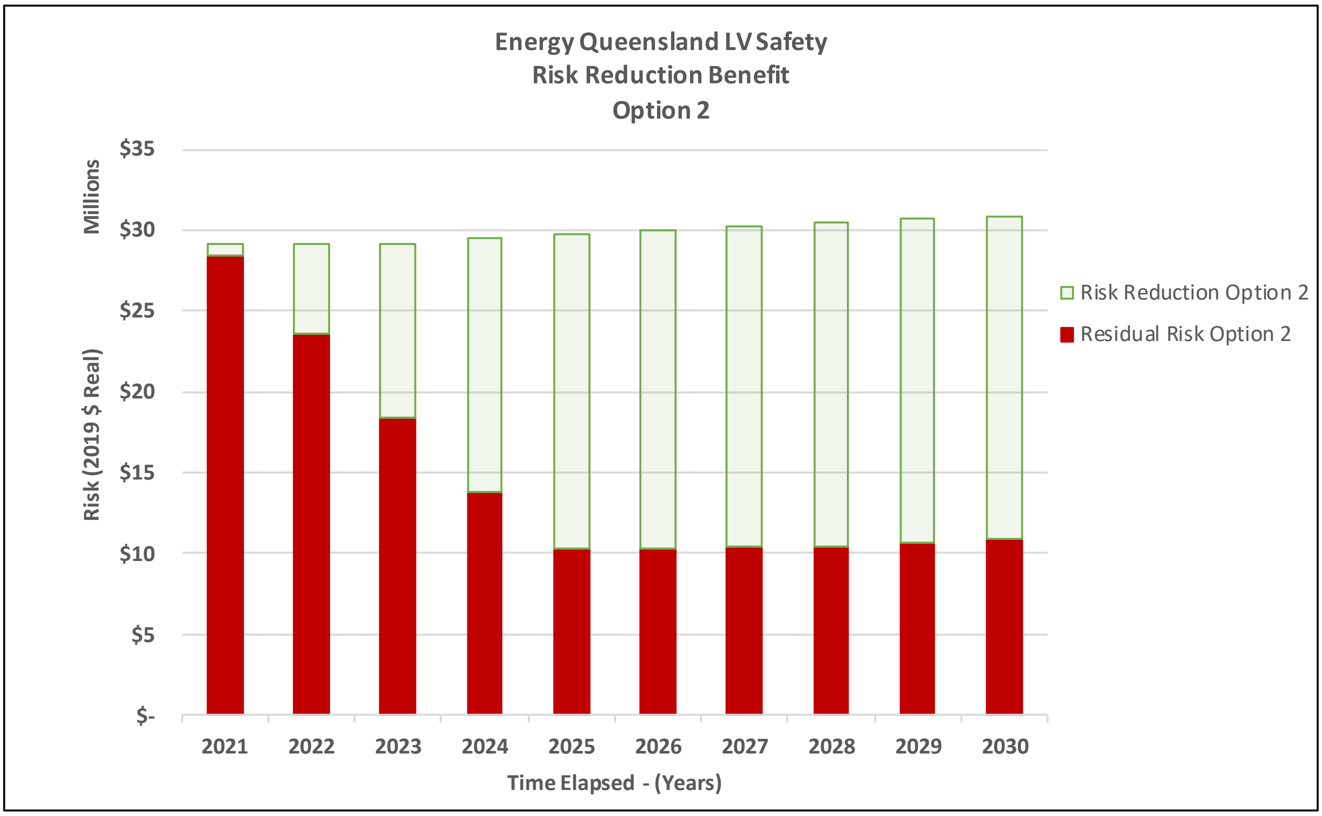


Figure 9. Risk Reduction Benefits for Proposed Option 2 – Total Energex and Ergon

4 Recommendation

4.1 Preferred option

The preferred option in this proposal is the highest NPV option 2. It provides the overall greatest economic benefit and addresses key safety risks.

4.2 Scope of preferred option

The total costs included for this business case are $34.7M for Energex and $58.0M for Ergon.

Table 17. Proposed Monitors Quantities & Costs – Energex

	20/21	21/22	22/23	23/24	24/25	Total Over 2020-25 period
Quantity Monitors	0	30,000	30,000	25,000	10,000	95,000
Capex Cost ($k)	0	9,750	9,750	8,125	3,250	30,875
Opex Cost ($k)	0	1,200	1,200	1,000	400	3,800

Table 18. Proposed Monitors Quantities & Costs – Ergon Energy

	20/21	21/22	22/23	23/24	24/25	Total Over 2020-25 period
Quantity Monitors	0	30,000	45,000	60,000	65,000	200,000
Capex Cost ($k)	0	7,500	11,250	15,000	16,250	50,000
Opex Cost ($k)	0	1,200	1,800	2,400	2,600	8,000

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).

Energex, *Distribution Annual Planning Report (2018-19 to 2022-23) [7.050]*, (21 December 2018).

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, *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).

Energex, *Justification Statement - Services [7.072]*, (31 January 2019).

Ergon Energy, *Justification Statement - Services [7.073]*, (31 January 2019).

Government of Western Australia, Department of Mines, Industry Regulation and Safety, Building and Energy, *Electrical Accident Report, 240 Eddystone Avenue Beldon Western Australia, 3 March 2018*, (25 September 2019)

Appendix B Acronyms and Abbreviations

The following abbreviations and acronyms appear in this business case.

Abbreviation or acronym	Definition
$k	Thousands of dollars
$M	Millions 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
AMI	Advanced Metering Infrastructure
AMP	Asset Management Plan
Augex	Augmentation Capital Expenditure
BAU	Business as Usual
CAPEX	Capital expenditure
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
ELCB	Earth Leakage Circuit Breakers
EQL	Energy Queensland Ltd
IT	Information Technology
KRA	Key Result Areas
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
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
VCR	Value of Customer Reliability
WACC	Weighted average cost of capital

Appendix C Alignment with 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 19: Alignment with NER

Capital Expenditure Requirements	Rationale
6.5.7 (a) (2) 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), Energex and Ergon Energy have 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 the key obligations in relation to ensuring that the works are electrically safe.
6.5.7 (a) (3) The forecast capital expenditure is required in order to: (iii) maintain the **quality, reliability and security of supply** of supply of standard control services (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) 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), Energex and 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 and Energex's key obligation in relation to ensuring that it works are electrically safe. The Act includes a duty to ensure that both Energex and Ergon Energy do all that is reasonably practicable (including that which was reasonably able to be done at a time) to ensure electrical safety risks are managed to the level So Far as Is Reasonably Practicable (SFAIRP). To date, EQL's existing service inspection and replacement programs have been assessed and determined as a reasonably practicable approach to manage neutral integrity risks. However, the emergence and availability of evolving technology solutions for network monitoring have now triggered EQL to re-assess what is reasonably practicable to manage safety risks SFAIRP.
6.5.7 (c) (1) (i) 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: • Option analysis to determine preferred solutions to network constraints • Strategic forecasting of material, labour and contract resources to ensure deliverability • Effective management of project costs throughout the program and project lifecycle, and • Effective performance monitoring to ensure the program of work is being delivered effectively. The unit costs that underpin our forecast have also been independently reviewed to ensure that they are efficient (Attachments 7.004 and 7.005 of our initial Regulatory Proposal).
6.5.7 (c) (1) (ii) The forecast capital expenditure reasonably reflects the costs that **a prudent operator** would require 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. 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 of our initial 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 20: 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** ***Operate safely as an efficient and effective organisation*** 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** ***Be Community and customer focused*** 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** ***Strengthen and grow from our core*** 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** ***Operate safely as an efficient and effective organisation*** 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** ***Create value through innovation*** 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) Introduce new or changed risk treatments to reduce level of risk 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 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 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 10: A Risk Tolerability Scale for evaluating Semi-Quantitative risk score

Appendix F Quantitative Risk Assessment Details

LV Safety Modelling Assumptions

Age Profile and Replacements				
	Energex	**Ergon**	**Description**	**Source**
Total Population	593,754	397,633	Total amount of LV services owned by EGX and EE	Attachment 7.040 of our initial regulatory proposal.
Counterfactual	18,642	5,309	EGX – Average historical annual replacements within the 2015-2020 regulatory period. EE - Average historical annual replacements within the 2015-2020 regulatory period.	EGX – Attachment 7.072 of our initial regulatory proposal. EE - Attachment 7.073 of our initial regulatory proposal.
Replacements – From Services Programs	19,214	13,809	EGX - Forecasted annual replacements within the 2020-2025 regulatory period. EE - Forecasted annual replacements within the 2020-2025 regulatory period.	EGX – Attachment 7.072 of our initial regulatory proposal. EE - Attachment 7.073 of our initial regulatory proposal
Replacements - Option 2	19,214 + Monitors	13,809 + Monitors	Consists of Option 1 replacements and added LV monitors.	Input data provided by EQ
Replacements - Option 3	19,214 + Inspections	13,809 + Inspections	Consists of Option 1 replacements and added detailed inspections	Input data provided by EQ
Replacements - Option 4	19,214 + Additional Replacements	13,809 + Additional Replacements	Consists of Option 1 service replacements and added service replacements	Input data provided by EQ

Costs				
Cost Category ($)	**EGX**	**EE**	**Description/Justification**	**Source**
LV Services Unit Rate	406	800	EGX – Average forecasted expenditure within the 2020-2025 regulatory period. EE – Average forecasted expenditure within the 2020-2025 regulatory period.	EGX – Attachment 7.072 of our initial regulatory proposal. EE - Attachment 7.073 of our initial regulatory proposal.
LV Monitor CAPEX	325	250	-	Attachment 7.093 of our initial regulatory proposal.
LV Monitor Initial OPEX	40	40	OPEX involved throughout the 2020-2025 replacement period.	Attachment 7.093 of our initial regulatory proposal.
LV Monitor Ongoing OPEX	10	10	OPEX involved 10 years after the 2020-2025 replacement period.	Attachment 7.093 of our initial regulatory proposal.
Inspection Unit Rate	440	440	-	Attachment 7.093 of our initial regulatory proposal.

Energex LV Services Modelling Assumptions

Asset Class Data Input			
		Description	**Source**
Asset Class	EGX LV Services	-	-
Asset Median Life (years)	70.8	Calculated from Weibull parameters	-
NPV Period (years)	20	-	-
Historical Unit Rate ($)	416	Average historical expenditure within the 2015-2020 regulatory period.	Attachment 7.073 of our initial regulatory proposal.
Forecasted Unit Rate ($)	406	Average forecasted expenditure within the 2020-2025 regulatory period.	Attachment 7.073 of our initial regulatory proposal.

Age Profile and Replacements			
		Description	Source
Total Population	593,754	Total amount of LV services owned by Energex	Attachment 7.073 of our initial regulatory proposal.
Replacements - Counterfactual	18,642	Average historical annual replacements within the 2015-2020 regulatory period.	Attachment 7.073 of our initial regulatory proposal.
Replacements - Option 1		Forecasted annual replacements within the 2020-2025 regulatory period.	Attachment 7.073 of our initial regulatory proposal.
Replacements - Option 2	Spare	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: Ausgrid - Revised Proposal - Attachment 5.13.M.4 - Low Voltage Overhead Service Lines program CBA summary - January 2019 https://www.pmc.gov.au/sites/default/files/publications/value-of-statistical-life-guidance-note_0_0.pdf 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	1,015	1	Cost of an emergency response scaled by a factor of 1 as the DF is not relevant to this consequence.	

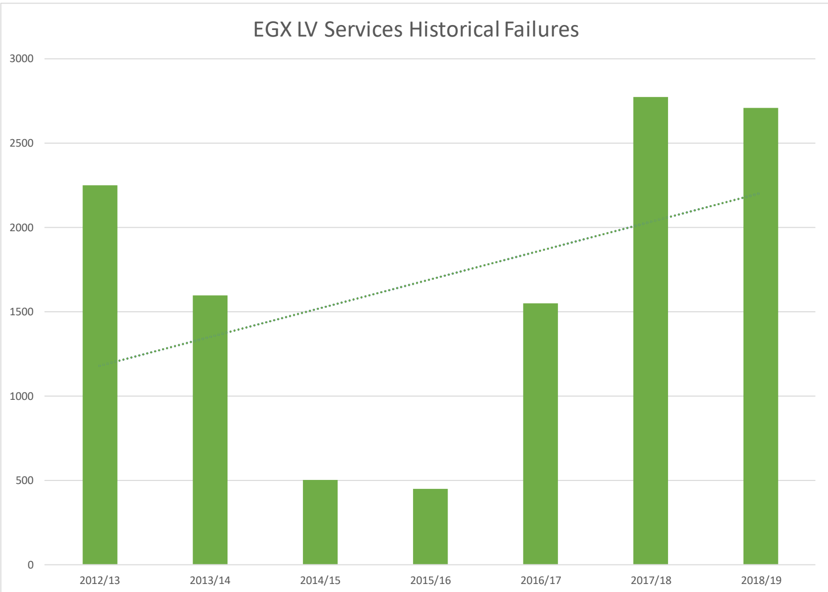
[1] Disproportionality factors are applied to the consequence monetisation to offset the gross disproportion (perceived point at which the cost of implementing a safety measure exceeds its expected benefits). The above factors are based on a review of peer organisations, as well as other industries,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

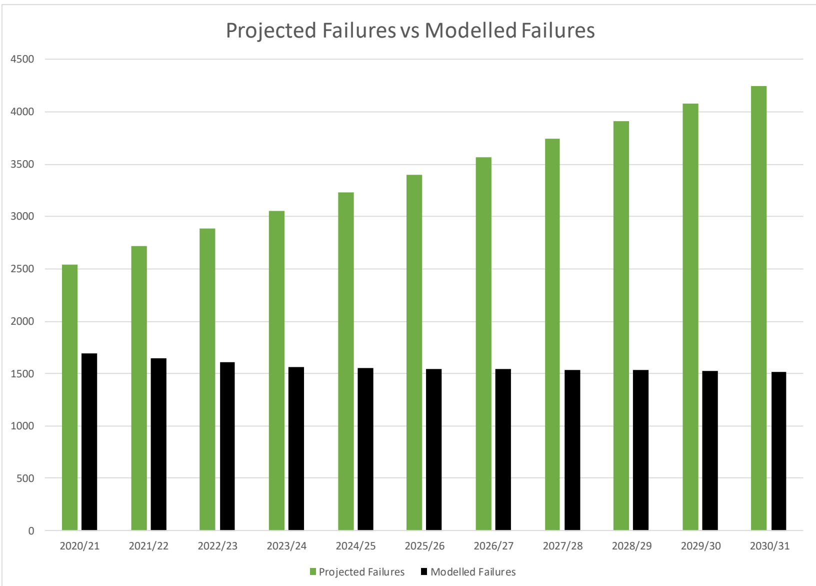
Customer Risk Inputs				
			Description/Justification	**Source**
Residential	**VCR ($/MWH)**	25,420	The value different types of customers place on having reliable electricity supplies under different conditions. Determined from survey results conducted by AEMO.	AEMO Value of Customer Reliability Fact Sheet
	Load (MVA)	0.0035	Load lost per residential LV service failure. Typical ADMD for a residential customer.	Based on EQL planning information.
	Hrs to restore	3	Time taken to get a failed residential LV service operating as usual. Based on typical travel and labour involved with residential customers.	As agreed with EQL.
	Power Factor	0.85	The ratio which determines the real power used by EQL residential customers. Based on the typical uncompensated power factor for an EQL zone substation.	EQL 2018 DAPR – typical values
	Load Factor	0.2	A ratio of average load to peak load within a specific time. Acts as a measure of EQL's utilisation rate. Conservative value based on typical values for EQL residential load profiles.	As agreed with EQL.
	Percentage of Mix	88%	Percentage of EQL customers who are considered as residential loads. Based on the approximate mix of residential versus commercial customers in the EQL network as informed by customer type information.	As agreed with EQL.
Commercial	**VCR ($/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	Source
Single Fatality	80	Safety	5	0.103%	ICR - 80 of historical incidents involving LV Services incidents are considered to be dangerous. PoC - Calibrated to represent 1 fatality every 10 years. Based on EQL data which showcases 0 LV Service related fatalities within approximately the last 10 years.	ICR - Attachment 7.040 of our initial regulatory proposal. PoC – Input data provided by EQL.
Major Injury	80	Safety	4	1.24 %	ICR - 80 of historical incidents involving LV Services incidents are considered to be dangerous. PoC - Calibrated to represent the historically expected 1 major injury every 1.2 years.	ICR - Attachment 7.040 of our initial regulatory proposal. PoC – Input data provided by EQL.
Fire	14	Fire	2	20%	ICR – 1% of incidents are attributed to fire. Calibrated based on the expected costs involved with fire risks relative to costs involved with safety in the case of LV Services. PoC - 20% of incidents result in a fire. Based on the severity of the consequence being considered as moderate	ICR – As agreed with EQL. PoC - Assumed based on EQL and peer organisation industry experience.
Customer Outage	1400	Customer	1	100%	ICR - 100% of incidents are attributed to outages PoC - 100% of incidents result in an outage	ICR - Assumed based on EQL and peer organisation industry experience. PoC – Assumed based on EQL and peer organisation industry experience.
Emergency Response	1400	Environment			ICR - 100% of incidents are attributed to emergency response PoC - 100% of incidents result in emergency	ICR – Assumed based on EQL and peer organisation industry experience. PoC – Assumed based on EQL and peer organisation industry experience.

Total No. of Incidents	**1400**	-	-	-	Based on average known LV Service failures within the 2012/13 to 2018/19 period.	Attachment 7.040 of our initial regulatory proposal.

Statistical Calibration			
		Description	**Source**
Reliability Model Used	Weibull	Weibull parameters are calibrated to project the trend in historical failures as shown in the below charts The annual reduction in failures in the model is attributed to the large amount of replacements being made in Energex's historical replacement rate i.e. the counterfactual case.	Attachment 7.040 of our initial regulatory proposal.
Shape parameter (β)	3		
Characteristic life (η)	80		
Guaranteed Min Life (γ)	0		





Ergon LV Services Modelling Assumptions

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. 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	-

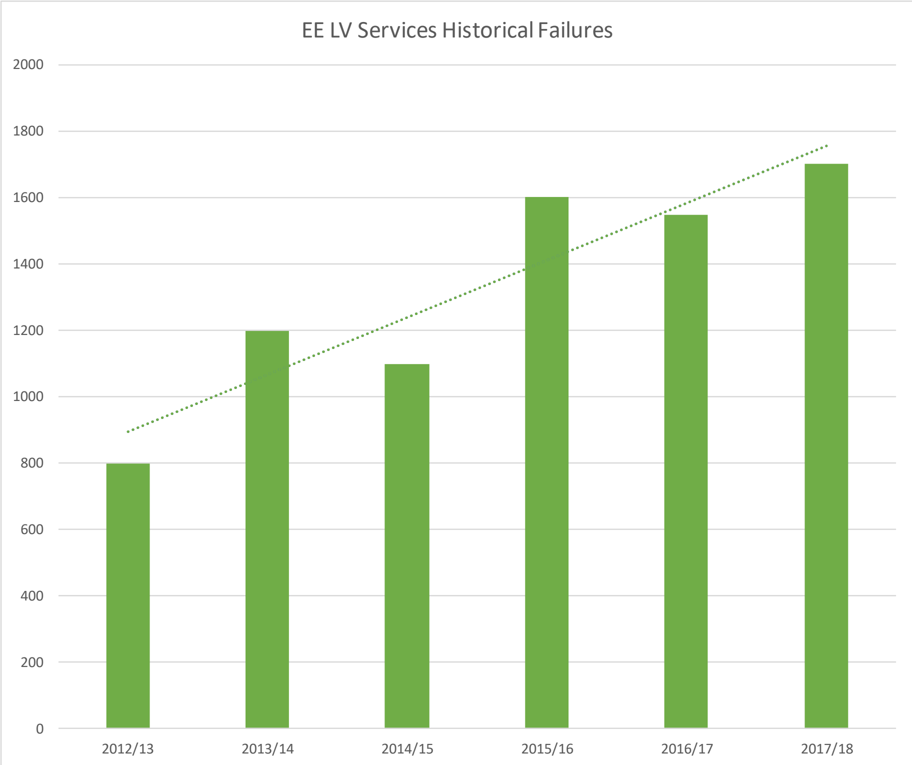
Safety Risk Inputs				
Consequence	**Monetisation ($)**	**Disproportionality Factor**	**Description/Justification**	**Source**
Single Fatality	4,900,000	10	Cost of a single fatality scaled by factor of 10.	[1] The sources used to develop the Disproportionality Factors are as follows: Ausgrid - Revised Proposal - Attachment 5.13.M.4 - Low Voltage Overhead Service Lines program CBA summary - January 2019 https://www.pmc.gov.au/sites/default/files/publications/value-of-statistical-life-guidance-note_0_0.pdf 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.	

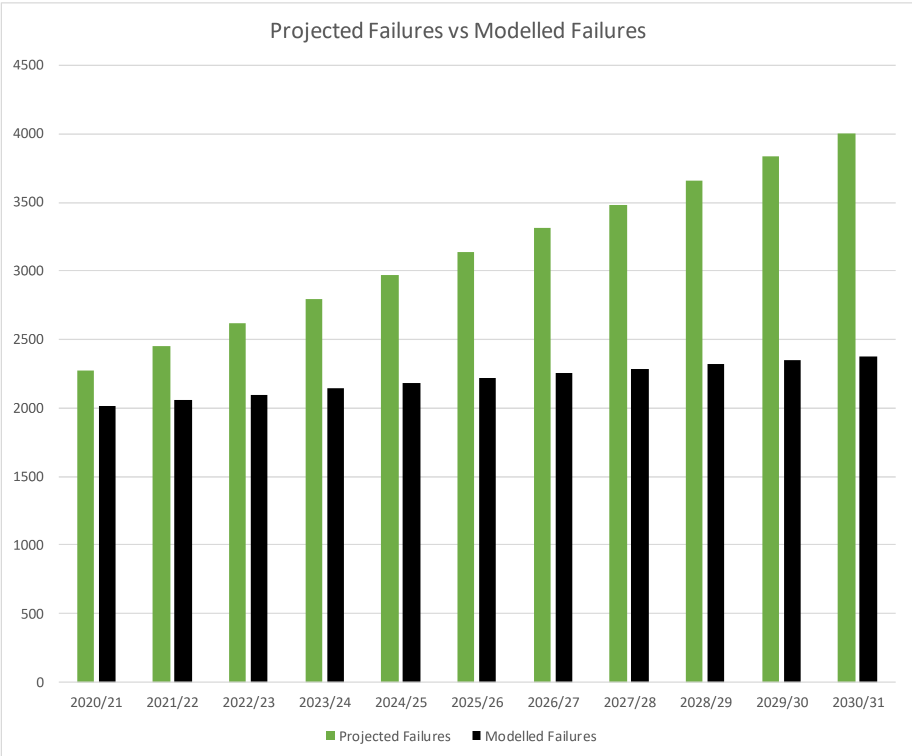
[1] Disproportionality factors are applied to the consequence monetisation to offset the gross disproportion (perceived point at which the cost of implementing a safety measure exceeds its expected benefits). The above factors are based on a review of peer organisations, as well as other industries, 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. PoC - Calibrated to represent the historically expected 1 fatality every 5 years.	ICR – Attachment 7.040 of our initial regulatory proposal. 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. PoC - Calibrated to represent the historically expected 1 major injury every 4 years.	ICR – Attachment 7.040 of our initial regulatory proposal. PoC – Input data provided by EQL.
Fire	20	Fire	2	20%	ICR – 1% of incidents are attributed to fire. Calibrated based on the expected costs involved with fire risks relative to costs involved with safety in the case of LV Services. PoC - 20% of incidents result in a fire. Based on the severity of the consequence being considered as minor to moderate.	ICR – As agreed with EQL. 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. PoC - 100% of incidents result in a customer outage. Based on customers not having a redundant supply.	ICR - Assumed based on EQL and peer organisation industry experience. 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 PoC - 100% of incidents result in an emergency response.	ICR - Assumed based on EQL and peer organisation industry experience. 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. 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		





Appendix G Reconciliation Table

Reconciliation Table Conversion from $18/19 to $2020	
Business Case Value	
(M$18/19)	$34.70
Business Case Value	
(M$2020)	$36.32

Appendix H Summary Results of WireAlert Trials

Insights from ENERGEX WireAlert Trial Project

The WireAlert is a device that customer plugs into a power point at a customer's premises. It measures the voltage at the GPO as well as loop impedance back to the transformer. If an abnormal condition is detected the device will alarm, prompting the customer to act. The WireAlert offers a means of monitoring the neutral integrity of both the customer and the network.

ENERGEX conducted a trial of 200 WireAlert devices in the homes of staff who had volunteered to participate to assess this technology when it first emerged. The trial was conducted from 13 December 2010 until 24 January 2011 in the Metro North and Central West regions of the ENERGEX network.

No defective devices were detected during the trial. The WireAlert device was shown to function correctly. However, 90% of the devices did not alarm during the trial project. This may have been because the devices were not necessarily installed in areas with high risk of broken neutral.

Seventeen calls were received during the trial period. This was approximately twice as large as anticipated, based on extrapolations of calls received by Aurora during their WireAlert roll out. Two reasons for this were offered: firstly, the participants in the ENERGEX trial were all staff volunteers and therefore more likely to be proactive about using the device and contacting the utility when necessary. Secondly, the trial was conducted over a period which saw the ENEREGX network impacted by an unusually large number of storms and particularly devastating floods

The key findings of the trial can be summarised as below:

- The device was shown to function correctly in detecting neutral related problems as well as very high/very low voltage issues. However, it required the customer to notice the alarm, make a judgment call to understand the type of alert and severity of alert finally choose to contact Energex to provide network visibility of potential issues
- The device needs to be placed in highly visible area of the house (e.g. kitchen) for customer to visually notice the alert. This is practically difficult as the power point in these areas of the house are often needed for other electrical appliances every day.
- The customer participation was anticipated to be maximum 80%. The investment cost associated with the remaining 20% (who decide to unplug the device) would be significant for a large scale roll out.
- While the devices appeared to be working and installed correctly, neither the customer nor Energex had any way of knowing for sure.
- Energex did not have any visibility on the performance of the devices and there was no remote communication with the device.
- Many positive comments were received related to the participants' peace of mind knowing that their home was constantly being monitored for electrical abnormalities.
- Given the device was only trialled by Energex employees who volunteered to participate, customer acceptance of the device was generally positive (due to industry knowledge and self-selection bias). However, it was concluded that better education and a substantial customer communications plan would be required for large scale roll out.
- At the time of the program, it was anticipated that the WireAlert device would be rendered obsolete, when voltage and impedance monitoring at the customer premises became available in the then-emerging smart meter specification. Smart meters would allow for continuous monitoring of customer voltage and impedance by the utility, whereas the

WireAlert would allow for only intermittent monitoring by the customer, and only if the customer understood how to use the device properly.

- The long-term recommendation of the report was to monitor developments with the national smart meter specification; specifically, whether loop impedance measurement as to be incorporated.
- It was expected that the timeline for smart meter deployment would have a large impact on the lifecycle cost/benefit analysis of deploying the WireAlert device to all ENERGEX customers.
- The Aurora Energy statistics showed that the highest volume of calls was received immediately after the customers received the device, and the call rate decreases at a roughly linear rate for ten months, after which call rates remain relatively stable. It is unclear if this is either due to the devices detecting issues early or whether customer usage and monitoring of the device declines over time.

Conclusion:

The insights from the Energex WireAlert trial indicated that WireAlert device can technically and successfully detect the neutral related problems at customer's premises and reduce the risk of public shock. It can also prevent potential damage to customer appliances due to identification of very high localised voltages. However, practically it was not considered an effectively reliable solution as it required that; the customer keep the device plugged in at all times; the customer continued to monitor the device over an extended period; and finally, the customer contact Energex as soon as the device alerted to provide network visibility of potential safety issues

The alternative option (Use of Smart Meters) was considered more appropriate through potential benefits of the anticipated smart meter rollout with associated monitoring technology and capability. This rollout was anticipated to provide continuous monitoring of customer voltage and impedance by Energex (via smart meter or a network device). This was the preferred option as it did not require customer input and provided 24/7 monitoring. At the time of the WireAlert trial (2011), the Smart Meter approach was unproven and considered not cost effective and available at large scale. However, the proliferation of Smart Metering since then, and the advancements in Smart Meter functions, IoT platforms and cloud-based services have combined to support that near real-time monitoring of the neutral circuit integrity be very cost competitive in a more effective way.

The proposed Energy Queensland approach with network monitoring devices uses currently available technology to provide network visibility and assured detection of issues in areas of identified high priority. When augmented with growing smart meter population and capability it is anticipated that this program will provide the level of safety and fault detection consistent with EQL's Safety Duty obligations.

Insights from Ergon Energy Trial Project

In 2010 an employee pilot (The WireAlert Pilot Project) was approved with the key objective to determine the viability of a full customer rollout of the WireAlert device as a suitable solution that would mitigate public shock and tingle risk in a cost-effective manner. The key objective of the employee pilot was to determine the viability of a full customer rollout of the WireAlert device as a suitable solution that would mitigate shock and tingle risk in a cost-effective manner.

The employee pilot concluded that, assuming independent WireAlert detection and a 100% plug in rate, Ergon Energy could expect a reduction of the annual average reported neutral related shocks and tingles from 717 to 249 within the initial three years deployment with subsequent spontaneous detection to at least maintain this level year on year. It was acknowledged that the future intention to plug in the WireAlert device (24/7) by employees at the end of the trial was only 71% and the realities of a full customer implementation would require significant and ongoing behavioural marketing and education campaigns to maintain an acceptable (target 90 to 95%) customer plug in rate. In comparison Tasmania experienced an initial 86% plug in rate which dropped significantly to 66% due to a lack of ongoing marketing and education to their customer base.

Enhance Research was commissioned to conduct research to seek vital information to assess the success of the WireAlert pilot. Only %28 of the participants responded to the survey. The key research results are outlined below:

- 80% indicated they kept the device plugged in and turned on the entire time and 71% said in the future, they intended to plug in the device and keep it turned on at all times. This means 30% of the investment for a large scale roll out would be lost.
- Most respondents (83%) were highly satisfied with the booklet (educational material on the device) sent with the device to the participants.
- 70% of respondents understood the alarm types but only 63% indicated they should contact the Ergon Energy after noticing an alarm.
- Most of the participants who did receive an alarm, tended to diagnose the problem themselves, rather than contact Ergon Energy in the first instance.
- It was acknowledged that prevention of reported shocks/tingles was directly associated with customer attitudes and behaviour toward proper use of the WireAlert device.

The key findings of the trial can be summarised as below:

- The device was shown to function correctly in detecting neutral related problems as well as very high/very low voltage issues. However, it required customers to notice the alarm, customer judgment calls to understand the type of alert and finally an active decision to contact Ergon Energy to provide network visibility of potential issues.
- The NPV model estimate revealed that the cost of full implementation did not warrant the risk mitigation expected as the overall benefits were subject to customers keep the devices plugged in, continuously monitor the device and report any alarm to Ergon Energy.
- To overcome the continuous monitoring challenge, it was recommended to incorporate the WireAlert technology into electronic metering functionality or as an attachment to a smart meter installation when communications were available if the incremental cost increase can be justified in the future.
- To make sure customers keep the WireAlert device plugged in, an on-going marketing, either on its own or in conjunction with other marketing efforts would be required.
- The device detects issues from the point it's plugged in (GPO) back to the distribution transformer. This means the fault can be either on customer's circuit or on Ergon Energy network. But the location of the fault cannot be determined before a site visit by Ergon Energy crew after the incident is reported.

Conclusion:

The insights from the Ergon Energy WireAlert trial indicates that WireAlert device can technically detect the neutral related problems at customer's premises and reduce the risk of public shock. However, it was not considered an effectively reliable solution as it required that; the customer keep the device plugged in at all times; the customer continued to monitor the device over an extended period; and finally, the customer contact Ergon Energy as soon as the device alerts to provide network visibility of potential safety issues. For these reasons, the roll out was not expanded beyond the pilot trial stage.

Since the Ergon Energy WireAlert trial (2010), smart meter functionalities and network monitoring devices based on IoT platforms have been developed and became commercially available. These technologies enable (24/7) continuous monitoring of the customers' neutral connection without customers' involvement. In addition to safety benefits, the collected data also provides potential insight and benefit for monitoring the quality of supply.

Appendix I Proposed LV Safety Monitoring Approach

Approach

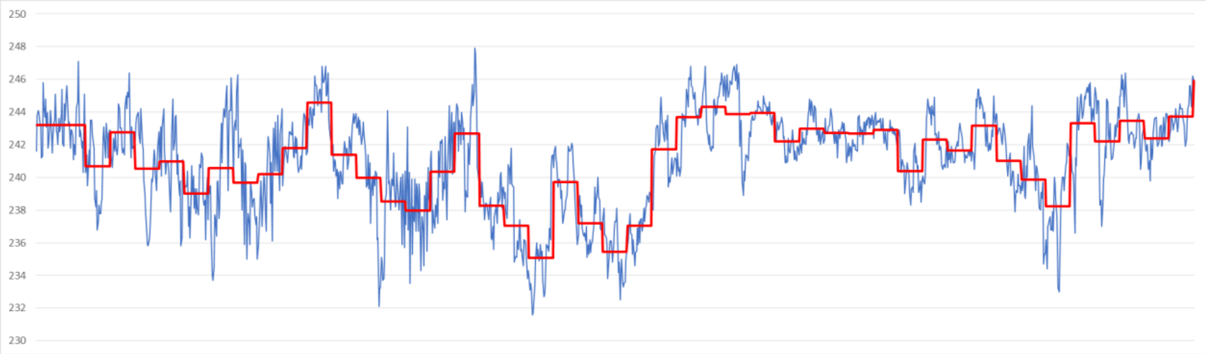
The monitoring approach proposes use of data from either network monitoring devices or smart meters, in targeted areas with high risk of public shocks, over the 2020-25 regulatory control period. A separate business case will be established to review the success of this approach and if suitable extend the program beyond 2025.

The data collected from the field data devices will be analysed to detect broken neutral or asset degradation and enable detection of all high resistance connections between the customer site and the distribution transformer. Action can then be taken to mitigate the risk, including notification of the customer as required.

Public shocks and tingles are caused due to several failure modes such as high resistance neutral connections and broken neutrals. High resistance connections are mainly caused by corrosion and develop over a period of time. Visual inspection is an inefficient way to detect these failure modes as it is labour intensive and more importantly it fails to detect failure modes before it occurs. The experience of Victorian utilities with monitoring broken neutrals using smart meter data over the past 8 years indicates that:

- Victorian smart meters (owned and operated by Victorian DNSPs) measure instantaneous voltage and current every 5 minutes and the data is read every 15 minutes (with the aim to move to 5-minute reading interval)
- 5 minutes instantaneous measurements of voltage and current is the minimum data required.
- Successful detection of sustained faults requires higher resolution data (One-minute interval)
- Detection of early signs of failure requires very short interval data to capture the very intermittent voltage spikes/dips. Average interval data is not sufficient.
- Converting data to useful information requires complex analytics. Raw interval data from sensors/smart meters is not sufficient.
- $\Delta V/\Delta I$ approach at the house level is a common and relatively effective way to detect sustained faults, however due to the dynamic nature of the LV network, this needs to be verified with the data from other nearby houses as well as the transformer and the substation.

Insights from a recent Energex trial confirms the above insights from Victorian experience that measuring and collecting one-minute data from the house in real-time is the effective way to accurately detect failure modes at the connection point. This data together with the available network monitoring data from distribution transformers and substations can also be used to detect network faults such as LV conductor on the ground. The graph below illustrates the instantaneous voltage data (Blue) from a customer site over a 24-hour period versus averaged data (Red). This clearly shows how significant intermittency and fluctuations in the voltage profile can become much less pronounced using slower data sampling.



Historically, the high cost of data transfer and storage has made the use of one-minute data prohibitively expensive. Today, the cost of using near real-time data is only marginally more than the alternative averaged interval data by leveraging IoT platforms, and the benefits are significant.

EQL understands that some of the Victorian utilities, who have been using the smart meter data (5-minute intervals read every 15 minutes) for several applications including detection of broken neutrals, are planning to move to reading every 5 minutes to reduce the lag time and improve neutral integrity failure detection (sources from United Energy).

When considering smart meter data for operational network services such as monitoring broken, it is important to take couple of practical issues into consideration:

- The ICT infrastructure supporting the current PoC smart meters are designed to collect energy data for billing purposes to comply with minimum meter requirements.
- The costs associated with system and platform upgrades required for existing meters to provide 5 minutes data suitable for operational purposes should not be underestimated.
- The smart meter cost only accounts for a part of the lifecycle cost of delivering required monitoring for each site (including ongoing data collection, storage and analysis costs).
- While smart meter data can be procured from meter providers (where available), the key component is the data analytics platform capable of securely accepting data from multiple third-party sources.

The main objective of this proposal is to create a solution with the lowest overall cost. The proposed approach will enable proper assessment of lowest practical option available over the next regulatory period. To further reduce the costs of rolling our network devices, a number of initiatives will be trialled including partnership with retailers. The analytical platform supporting the network devices will also be used to analyse the data procured from smart meters. This contributes in building a solution with overall lowest cost for consumers in long-term.

This strategy is also aligned with the recent AEMC Grid of Future that suggests improved LV visibility can be achieved by limited number of network devices supplemented by the data procured from metering data providers.

Scope and timing

Historical public shock data reveals that customers with overhead (OH) connections are exposed to a higher risk of neutral integrity failures. Generally, OH LV networks with high penetration of solar PV are also facing more voltage issues. Due to lesser numbers of incidents on underground (UG) LV networks and to reduce the upfront monitoring cost for the proposed program, new network devices would not generally be installed in premises with UG services.

Appendix J LV Service Replacements Included in Modelling

The following physical replacement volumes have been examined as part of the LV Services business cases for Energex and Ergon Energy.

Table 21. Proposed Physical Service Replacement Quantities & Costs – Energex

	20/21	21/22	22/23	23/24	24/25	Total Over 2020-25 period
Quantity	19,004	19,060	19,177	19,415	19,416	96,072
Cost ($k)	7,723	7,746	7,793	7,890	7,891	39,043

Table 22. Proposed Physical Service Replacement Quantities & Costs – Ergon Energy

	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