Business Case
Pittsworth, Broxburn & Yarranlea South Refurbishment and Reinforcement

NETWORK

Executive Summary

Broxburn Zone Substation (BROX) has two 5MVA 33/11kV transformers supplying the township of Pittsworth and surrounding rural areas. Peak demand is expected to exceed the substation emergency cyclic capacity by 2022. Yarranlea South Substation (YASO) also has two 33/11kV transformers rated at 1.5MVA and 1MVA that supply the rural area to the west of Pittsworth. Transformer 2 is a fixed tap unit which means load cannot be shared, causing loading concerns for Transformer 1. Additionally, both Broxburn and Yarranlea South transformers and a number of isolators are at an advanced age, having been manufactured in the 1960s. Neither has bunding or oil containment systems, which poses an environmental risk for aged transformers in poor condition should failure occur.

Due to the risk of load shedding for the Broxburn Substation and load concerns for Transformer 1 at Yarranlea South Substation, as well as environmental risks due to asset age and lack of bunding, these substations have been identified as due for replacement in order to reduce risks to levels as low as reasonably practical (ALARP).

A counterfactual, ‘do nothing’ option was considered but rejected due to significant reliability, safety and environmental risks. Three network options were evaluated as part of this business case:

Option 1 – Installation of two 10MVA skids at BROX, and a 10MVA skid at YASO in stages to align with the demand, replacement date of aged assets and mitigation of risk.

Option 2 – Installation of two 10MVA skids at BROX simultaneously by 2021, and a 10MVA skid at YASO by 2021.

Option 3 – Full rebuild of Broxburn into a standard 2x20MVA zone substation and decommissioning of Yarranlea South.

Ergon Energy 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 both safety and customer reliability are strong drivers, due to the ageing of assets at both substations and the forecast increase in demand in the Pittsworth area over the 2020-25 regulatory period.

To this end, Option 1 is the preferred option. It has the least negative Net Present Value (NPV) result of the three options considered (-$6.3M), while still addressing the risks associated with the ageing assets at BROX and YASO, and increasing demand in the Pittsworth area.

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

Regulatory Proposal	Draft Determination Allowance	Revised Regulatory Proposal
$6.3M	N/A	$7.8M

Contents

Executive Summary i

1 Introduction 1

1.1 Purpose of document 1

1.2 Scope of document 1

1.3 Identified Need 1

1.4 Energy Queensland Strategic Alignment 2

1.5 Applicable service levels 3

1.6 Compliance obligations 3

1.7 Limitation of existing assets 4

2 Counterfactual Analysis 8

2.1 Purpose of asset 8

2.2 Business-as-usual service costs 8

2.3 Key assumptions 8

2.4 Risk assessment 8

2.5 Retirement or de-rating decision 9

3 Options Analysis 10

3.1 Options considered but rejected 10

3.2 Identified options 10

3.2.1 Network options 10

3.2.2 Non-network options 11

3.3 Economic analysis of identified options 12

3.3.1 Cost versus benefit assessment of each option 12

3.4 Scenario Analysis 12

3.4.1 Sensitivities 12

3.4.2 Value of regret analysis 12

3.5 Qualitative comparison of identified options 13

3.5.1 Advantages and disadvantages of each option 13

3.5.2 Alignment with network development plan 14

3.5.3 Alignment with future technology strategy 14

3.5.4 Risk Assessment Following Implementation of Proposed Option 14

4 Recommendation 17

4.1 Preferred option 17

4.2 Scope of preferred option 17

Appendix A. References ... 18
Appendix B. Acronyms and Abbreviations ... 19
Appendix C. Alignment with the National Electricity Rules (NER) ... 21
Appendix D. Mapping of Asset Management Objectives to Corporate Plan ... 23
Appendix E. Risk Tolerability Table ... 24
Appendix F. Safety Net Obligations ... 25
Appendix G. Reconciliation Table ... 27
Appendix H. Additional information ... 28
Appendix I. Condition Report Attachments ... 35

1 Introduction

Broxburn Substation (BROX) has two 5MVA 33/11kV transformers supplying the township of Pittsworth and surrounding rural areas. Yarranlea South Substation (YASO) also has two 33/11kV transformers rated at 1.5MVA and 1MVA that supply the rural area to the west of Pittsworth.

Increases in forecasted load have led to the identification of risks of load shedding for the Broxburn Substation and load concerns for Transformer 1 at Yarranlea South Substation. Combined with existing environmental risks due to advanced asset age and a lack of appropriate bunding, these substations have been identified as due for replacement based on condition, in order to reduce risks to levels as low as reasonably practical (ALARP).

1.1 Purpose of document

This document recommends the optimal capital investment necessary to reduce the risk of load shedding or environmental damage through replacement and refurbishment of the Broxburn and Yarranlea South Substations.

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

1.2 Scope of document

This document will outline the rationale, benefits, and drivers for asset replacement and refurbishment, as well as present options to address the limitations. These options, their associated risk assessments, delivery timeframes and project costs will be outlined and compared to provide a recommendation for the option that minimises risk and optimises cost efficiency.

1.3 Identified Need

Ergon Energy 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 both safety and customer reliability are strong drivers, due to the ageing of assets at both substations and the forecast increase in demand in the Pittsworth area over the 2020-25 regulatory period.

Pittsworth is a township south-west of Toowoomba. Electricity is supplied to 2,877 customers including 2,258 domestic customers and 619 industrial loads. These customers are supplied by substations at Broxburn (BROX) and Yarranlea South (YASO). BROX has two 33/11kV transformers each rated at 5MVA, for a total of 10MVA nameplate capacity. YASO also has two 33/11kV transformers, one rated at 1MVA and the other at 1.5MVA. The YASO 1.5MVA transformer has a failed on-load tap changer (OLTC) and is placed on fixed tap, meaning the transformers cannot share load. For a schematic diagram please refer to Figure 6 in Appendix J.

Customer, safety and environmental risks are increasing, caused by forecasted and current capacity exceedance for both substations. Maximum demand in February 2018 was measured at 10.46MVA at BROX and 1.80MVA at T1 YASO, higher than nameplate capacity in each case (see Figure 8 and Figure 11). A further increase in demand is anticipated at BROX in 2019 and 2022 following two customer connection applications, Alpair Micro Grid for 1.5MVA and LRDM Pty Ltd for 2MVA respectively. Agreements have been signed with both customers, with the Alpair Micro Grid connection design finalised and the LRDM Pty Ltd design nearing completion. In 2022 the load on BROX is forecast to be approximately 13MVA, in excess of the substation Normal Cyclic Capacity (NCC) of 11MVA. At this point additional customers will not be able to be connected, and without addressing this emerging constraint proactively, forced load shedding may be required during peak load times. The secondary driver relates to the advanced age of the two power transformers at BROX and all ten 11kV isolators, all of which have been operational for over 50 years and are now past their design life. The continual loading, condition and exposure to network faults of the elevates the risk of failure of the power transformers, the consequence of which could be compounded by the lack of bunding on site.

This proposal aligns with the CAPEX objectives and criteria from the National Electricity Rules as detailed in Appendix C.

1.4 Energy Queensland Strategic Alignment

Table 1 details how Pittsworth, Broxburn & Yarranlea South Refurbishment & Reinforcement contributes to Energy Queensland'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	Without addressing emerging constraints proactively, during peak load times load shedding may need to occur. There is also a risk of environmental damage due to the lack of bunding. Preventing this event increases the safety for staff contractors and the community.
Meet customer and stakeholder expectations	Customers benefit as the initiative contributes to ensuring that outage durations and severity are not impacted or worsened by ensuring Safety Net Targets are met.
Manage risk, performance standards and asset investments to deliver balanced commercial outcomes	This initiative allows for replacement of assets prior to their failure and so asset use can be maximised, contributing to risk management, maintenance of performance standards and balanced commercial outcomes.
Develop Asset Management capability & align practices to the global standard (ISO55000)	This initiative is consistent with ISO55000 objectives and drives asset management capability by promoting a continuous improvement environment.
Modernise the network and facilitate access to innovative energy technologies	This initiative allows for modernisation of the network by increasing capacity and allowing for additional customers to be connected when needed. New assets would install best practice environmental protections as well as consolidating the number of primary assets, reducing risk and maintenance costs.

1.5 Applicable service levels

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

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

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

Under the Distribution Authorities, EQL is expected to operate with an ‘economic’ customer value-based approach to reliability, with “Safety Net measures” for extreme circumstances. Safety Net measures are intended to mitigate against the risk of low probability vs high consequence network outages. Safety Net targets are described in terms of the number of times a benchmark volume of energy is undelivered for more than a specific time period. A table of safety net obligations can be found in Appendix F. EQL is expected to employ all reasonable measures to ensure it does not exceed minimum service standards (MSS) for reliability, assessed by feeder types as

- System Average Interruption Duration Index (SAIDI), and;
- System Average Interruption Frequency Index (SAIFI).

Both Safety Net and MSS performance information are publicly reported annually in the Distribution Annual Planning Reports (DAPR). MSS performance is monitored and reported within EQL daily.

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), EQL has an obligation to ensure that its works are electrically safe and are operated in a way that is electrically safe.[1] This duty also extends to ensuring the electrical safety of all persons and property likely to be affected by the electrical work.[2]	This proposal manages both environmental risk and safety risk through the update of assets that may cause harm to either the environment, the community or staff and contractors in the event of their failure. The likelihood of that failure is set to increase in coming years.
Distribution Authority for Ergon Energy 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 upgrades a network that has already exceeded its supply capacity and has new connections approved for coming years. These upgrades are crucial for ensuring the quality and

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

Legislation, Regulation, Code or Licence Condition	Obligations	Relevance to this investment
	• The distribution entity will ensure, to the extent reasonably practicable, that it achieves its safety net targets as specified. • The distribution entity must use all reasonable endeavours to ensure that it does not exceed in a financial year the Minimum Service Standards (MSS)	reliability of electricity services and adherence to safety net targets.
National Electricity Rules, Chapter 5	Schedule S5.1 of the National Electricity Rules, Chapter 5 provides a range of obligations on Network Services Providers relating to Network Performance Requirements. These include: • Section S5.1.9 Protection systems and fault clearance times • Section S5.1a.8 Fault Clearance Times • Section S5.1.2 Credible Contingency Events	This proposal works to reduce severity and frequency of contingency events by maintaining assets at a reasonable standard of operations.

1.7 Limitation of existing assets

Three key limitations exist for the BROX and YASO Zone Substations (ZS):

- System normal demand at BROX is expected to exceed normal cyclic capacity (NCC) following new customer connections
- Transformers are in poor condition at BROX. Based on condition T1 should be replaced in the next 4 years and T2 within the next 10 years.
- Transformer condition is deteriorating at YASO with increasing risk of failure, also exacerbated by future expected load NCC exceedance
- Both BROX and YASO have N-1 issues in the event of transformer failures
- Environmental consequences could be significant at YASO and BROX in the event of transformer failure due to the lack of adequate bunding

These issues are elaborated below.

System normal demand at BROX is expected to exceed capacity following new customer connections

Table 3 outlines key details of BROX transformers. The risk of load capacity exceedance is increasing, as BROX has been breaching the N-1 emergency cyclic capacity (ECC) since the beginning of 2017 and is expected to exceed normal cyclic capacity (NCC) in 2022.

Maximum demand in February 2018 was measured at 10.46MVA at BROX, higher than the nameplate capacity of 10MVA (See Figure 1 and in Appendix H). Load is forecast to exceed substation NCC and ECC in 2021/22 with new customer connections. There is a clear need for increased transformer capacity at BROX to provide secure supply to future block loads as well as allow for new customer connections in the future.

Table 3: BROX Transformers' nameplate, NCC and ECC ratings

ZS	Tx №	Nameplate Rating (MVA)	kV	Year of Manufacture (YOM)	Retirement Year per Condition Based Risk Management	NCC	ECC

					(CBRM)		
BROX	1	5	33/11	1962	2023	5.5	5.8
BROX	3	5	33/11	1966	2026	5.5	5.8

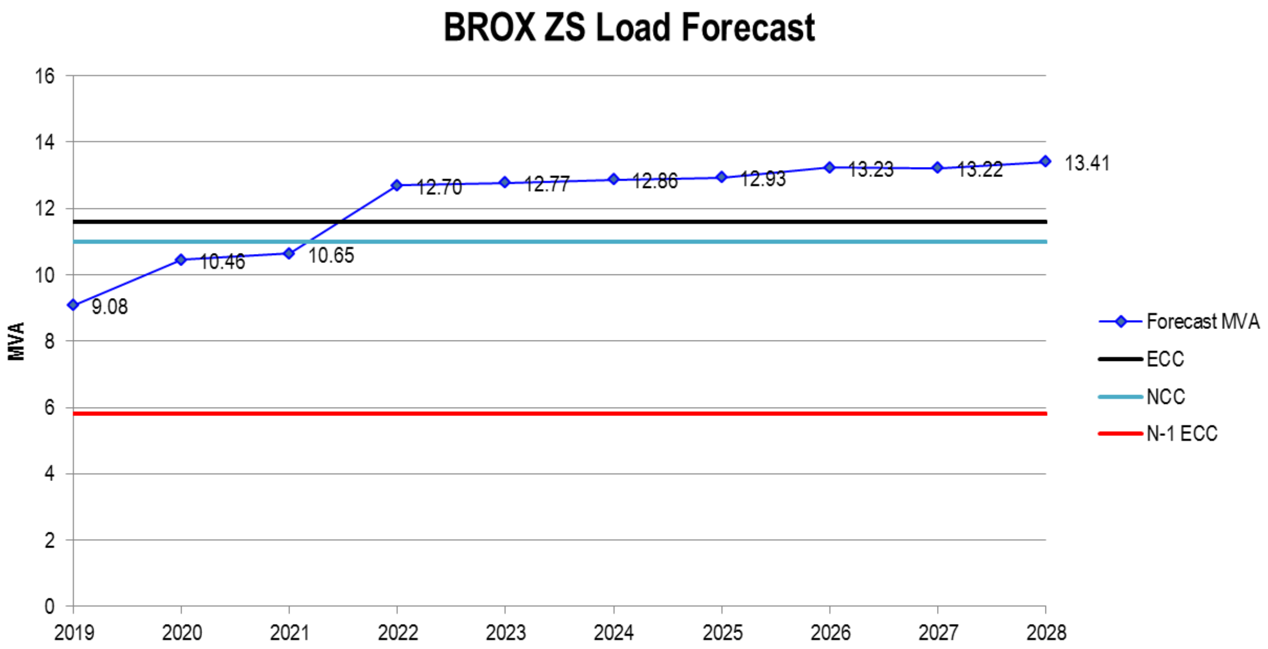

Figure 1: BROX 10POE substation forecast

Transformer condition is deteriorating at YASO with increasing risk of failure, also exacerbated by future expected load capacity exceedance

Table 4 outlines key details of YASO transformers. Possibility of unit failure is increasing at YASO due to increasing load as well as deterioration of the unit due to its advanced age. Both transformers are 50-years-old, with one unit reading elevated moisture and requiring higher levels of monitoring and maintenance (See Attachments BROX T1 oil test, BROX T3 oil test, YASO T1 oil test and YASO T2 oil test in Appendix D: Condition Report Attachments).

Forecast 10POE load at YASO exceeds the N-1 ECC rating over the entire forecast period (2019 – 2028), shown in Figure 2. Risk of capacity exceedance is heightened as the transformers at YASO are not able to share load due to their fixed tap arrangement.

Table 4: YASO Transformers' Details

ZS	Tx №	Nameplate Rating (MVA)	kV	YOM	Retirement Year per CBRM	NCC	ECC
YASO	1	1.5	33/11	1962	2025	1.6	1.8
YASO	2	1	33/11	1967	N/A[3]	1.1	1.2

[3] YASO T1 OLTC has already failed and placed on fixed tap

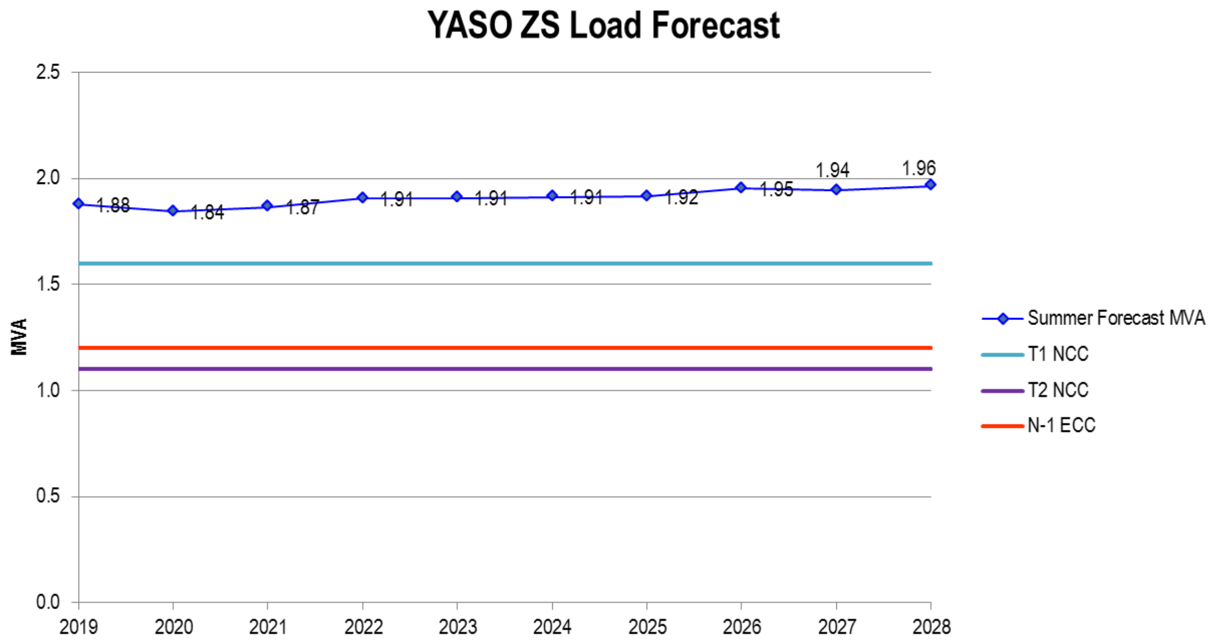

Figure 2: YASO 10POE substation forecast

Environmental consequences could be significant at YASO and BROX in the event of failure due to the lack of adequate bunding

Moisture readings in the transformer oil condition for both YASO and BROX substations are elevated suggesting they may not withstand an internal fault, leading to an increased risk of unit failure (See Table 5). Due to the advanced age of the plant there is a lack of adequate bunding which leads to an increased risk of oil spill to the environment. Should failure of the unit occur environmental consequences could be significant. This is particularly the case for the YASO unit due to its location next to a water table drain (See BROX photos in Appendix D: Condition Report Attachments, Supporting Photographs). The salient points from the insulating oil test reports for these transformers are shown in Table 5.

Table 5: Transformer oil condition

Transformer	Moisture	Degree of polymerisation (DP)
BROX T1 5MVA YOM 1962	11ppm	278
BROX T3 5MVA YOM 1966	55ppm	282
YASO T1 1.5MVA YOM 1962	14ppm	444
YASO T2 1MVA YOM 1967	5ppm	535

The degree of polymerisation of the transformers suggests the insulating paper has degraded so that it may not withstand an internal fault and are likely to fail, hence near the end of transformer life. In addition to the above the acidity levels of BROX T1 are high and have been rising over the last few years.

The degree of polymerisation of the transformers suggests the insulating paper has degraded so that it may not withstand an internal fault and are likely to fail, hence near the end of transformer life.

The continued utilisation of this asset is likely to result in an increasing number of prolonged outages into the future. As the forecast load growth at BROX begins to exceed the substation NCC and ECC ratings of the transformers, load shedding during a contingency event will be necessary to avoid overloading the aged transformers during peak demand days. Also, new customers cannot be connected without an increase in transformer capacity in BROX. Due to plant condition and associated safety risks, environmental risk and customer risk not being resolved, the replacement of these assets is recommended. The network and business risks that the organisation would be exposed to if the project was not undertaken are not deemed to be as low as reasonably practicable (ALARP).

2 Counterfactual Analysis

2.1 Purpose of asset

The infrastructure in this business case, including the power transformers, is critical to the electricity network to supply this area.

The Broxburn substation (BROX) and Yarranlea substation (YASO) supply a combined 2,877 customers, of which 2,258 are domestic and 619 are industrial. These substations are supplied via a 33kV sub-transmission feeder from the Yarranlea T10 (YARA T10) 110/33kV bulk supply point.

2.2 Business-as-usual service costs

The business as usual (BAU) service costs for these assets are the maintenance costs associated with ongoing operations. In addition to these costs, significant emergency response and replacement costs would be incurred for the counterfactual BAU case in the event that failures occur.

2.3 Key assumptions

- The counterfactual is assumed as the BAU case where equipment is allowed to run-to-fail.
- Demand is anticipated to increase with new approved customer connections.

2.4 Risk assessment

This risk assessment is in accordance with the EQL Network Risk Framework and the Risk Tolerability table from the framework is shown in Appendix E.

Table 6: Counterfactual risk assessment

Risk Scenario	Risk Type	Consequence (C)	Likelihood (L)	Risk Score	Risk Year
Substation ECC breach at BROX results in **>1 min changeover outage >3 times in one week** during high load times to allow Nomad load support connection.	Customer	3 *(5,000 customers for > 12 hours)*	5 *(Very likely to occur)*	**15 (Moderate risk)**	2019
Failure of 33kV isolator at YASO results in **unsupplied customer loads outside of Safety Net restoration timeframes >24 hours.**	Customer	3 *(5,000 customers for > 12 hours)*	3 *(Unlikely to occur)*	**9 (Low risk)**	2019
Fault or Non-Spurious Trip on 33/11kV Transformer at YASO results in **interruption >3 hours in duration** and disrupts 300 customers.	Customer	2 *(1,000 customers for > 3 hours)*	4 *(Likely to occur)*	**8 (Low risk)**	2019
Fault or Non-Spurious Trip on 33/11kV Transformer at BROX results in **interruption >24 hours.**	Customer	4 *(15,000 customers for > 1 day)*	4 *(Likely to occur)*	**16 (Moderate risk)**	2019

Risk Scenario	Risk Type	Consequence (C)	Likelihood (L)	Risk Score	Risk Year
Catastrophic failure of a 33/11kV transformer at BROX results in an **oil spill of >1000 litres** that extends beyond the property boundary (transformers not bunded).	Environment	4 *(Material environmental harm and remediation/ rectification costs <$500,000 and >$50,000)*	3 *(Unlikely)*	**12 (Moderate risk)**	2019
Catastrophic failure of a 33/11kV transformer at YASO results in an **oil spill of >1000 litres** that enters a water course (transformers not bunded).	Environment	5 *(Extensive serious environmental harm and remediation/ rectification costs <$5,000,000 and >$500,000)*	3 *(Unlikely)*	**15 (Moderate risk)**	2019
Catastrophic failure of 33kV isolator at YASO results in **serious injuries to multiple field workers or members of the public**.	Safety	4 *(Multiple serious injuries/ illnesses)*	2 *(Very unlikely)*	**8 (Low risk)**	2019
Catastrophic failure of 33kV isolator at BROX results in **serious injuries to multiple field workers or members of the public**.	Safety	4 *(Multiple serious injuries/ illnesses)*	2 *(Very unlikely)*	**8 (Low risk)**	2019
Catastrophic failure of 33/11kV transformer at BROX results in **serious injuries to multiple field workers or members of the public**. Likelihood based on condition, loading and history.	Safety	4 *(Multiple serious injuries/ illnesses)*	4 *(Likely)*	**16 (Moderate risk)**	2019
Catastrophic failure of 33/11kV transformer at YASO results in **serious injuries to multiple field workers or members of the public**.	Safety	4 *(Multiple serious injuries/ illnesses)*	3 *(Unlikely)*	**12 (Moderate risk)**	2019

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

The network (business) risks the organisation would be exposed to if the project was not undertaken (Inherent Risk) are not deemed to be as low as reasonably practicable (ALARP). The implementation of the preferred Option A will reduce Energy Queensland's risk exposure (Residual Risk).

2.5 Retirement or de-rating decision

Significant retirements of existing assets are expected through the proposed staged replacement process.

3 Options Analysis

3.1 Options considered but rejected

Base Case / Do Nothing – (not acceptable due to risk)

The 'Do Nothing' case includes maintaining aged plant at BROX and YASO until plant failure occurs, most likely due to exceedance of plant capacity.

Outcome:

- If a transformer fails during high load periods at either BROX or YASO, load shedding will be required in order to not exceed the emergency cyclic capacity of the remaining in-service transformer.
- The demand forecast (13MVA) exceeds the 11MVA of substation NCC rating at BROX in year 2021/22. Substations are not meant to operate over NCC for a sustained period under system normal conditions. Permanent load transfers to surrounding substations to de-load BROX below the NCC are not practically viable.
- Once the load exceeds the capacity of the substation new customers may not be able to connect without a capacity upgrade at BROX within normal timeframes. This may require the regulator to be notified and almost certainly will impact National Energy Customer Framework (NECF) timeframes.
- Possible environmental contamination. YASO is the higher risk site being located adjacent to a water table drain.

3.2 Identified options

3.2.1 Network options

Option A – 10MVA skid at BROX (2021) & YASO (2025) (recommended)

This will require the installation of two 10MVA skid-mounted substations at BROX, and a 10MVA skid-mounted at YASO; although it will be in stages to align with the demand, asset condition and risk. Skid-mounted substations are recommended to consolidate the number of primary assets, reducing risk, capital and maintenance costs.

Scope

- Stage 1: Install a 10MVA 33/11kV skid transformer adjacent to BROX by 2021. Retain 33/11kV T1 and T3 as hot-standby for contingency to meet Safety Net. While T1 and T3 are still retained, it is important to note the environmental risk is reduced given these transformers will not normally have any load and will not be exposed to through faults under system normal conditions.
- Stage 2: Install a 10MVA 33/11kV skid transformer adjacent to YASO by 2025, recover BROX T1 (reaching end-of-life in 2025), decommission YASO and remove aged assets. Reconductor 10km of 7/.104 HDBC with 7/4.75 AAAC Iodine conductor to create a tie feeder between BORX and YASO to meet Safety Net. The drivers for the installation of the skid at YASO are based on the condition of the existing transformers (first transformer due for replacement in 27/28) plus the N-1 requirement at BROX in the event of the failure of the BROX skid (after the recovery of T1).

- Stage 3: Install second 10MVA skid adjacent to BROX by 2029. Decommission BROX transformers and remove associated aged assets including T3 that is deemed to reach end-of-life in 2029.

Option B – 2x10MVA skid at BROX

This will require the installation of two 10MVA skids at BROX simultaneously by 2021, and a 10MVA skid at YASO by 2028.

Scope

- Stage 1: Install two 10MVA 33/11kV skid transformers adjacent to BROX by 2021. Decommission BROX and remove associated aged assets.
- Stage 2: Install a 10MVA 33/11kV skid transformer adjacent to YASO by 2028 Decommission YASO and remove aged assets. Reconductor 10km of 7/.104 HDBC with 7/4.75 AAAC Iodine conductor to create a tie feeder between BORX and YASO to meet Safety Net.

Option C – Consolidate BROX and YASO into a Z7-20D

Full rebuild of BROX with 2x20MVA to consolidate BROX and YASO, decommission YASO and build 11kV backbone.

Scope

- Stage 1: Rebuild Broxburn ZS into a standard 2x20MVA zone substation with two new 11kV feeders to supply the existing YASO 11kV feeders, “The Gap” and “Brookstead”. Decommission YASO by 2021.

3.2.2 Non-network options

Energy Queensland is committed to the implementation of Non-Network Solutions to reduce the scope or need for traditional network investments. Our approach to Demand Management is listed in Chapter 7 of our Distribution Annual Planning Report but involves early market engagement around emerging constraints as well as effective use of existing mechanisms such as the Demand Side Engagement Strategy and Regulatory Investment Test for Distribution (RIT-D).

The primary investment driver for this project is Augex, supporting customer growth and network security. A successful Non-Network Solution may be able to assist in reducing the scope or timing for this project. As the cost of options considered as part of this report is greater than $6M this investment will be subject to RIT-D as a mechanism for customer and market engagement on solutions to explore further opportunities.

The customer base in the study area is a mixture of both established and new residential, commercial and rural loads and has a medium opportunity to reduce demand or provide economic non-network solutions. A RIT-D Non-Network Options Report has been released for stakeholder consultation with submissions required by the 10 January 2020. Viable non-network options provided that meet Ergon Energy’s required service levels will be compared with the current business case.

Expenditure for the proposed project has been modelled as CAPEX and included in the forecast for the current regulatory control period. Funding of any successfully identified non-network alternative solutions will be treated as an efficient OPEX/CAPEX trade-off, consistent with existing regulatory arrangements.

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 over the program lifetime from FY2018/19 to FY2038/39, using the EQL standard NPV analysis tool. The tool incorporates any residual value for assets at the end of the program lifetime into the NPV analysis. Table 7 outlines the Present Value (PV) of CAPEX and OPEX, as well as the NPV of each option, discounted at the Regulated Real Pre-Tax Weighted Average Cost of Capital (WACC) rate of 2.62%.

Table 7: Net present value of options, $'000s

Option Name	Rank	Net NPV	CAPEX NPV
A - 10MVA skid at BROX (2021) & YASO (2025) (recommended)	1	**-6,306**	-6,306
B - 2x10MVA skid at BROX (2021) & 10MVA skid YASO (2028)	2	**-6,514**	-6,514
C - Consolidate BROX and YASO into a Z7-20D (2021)	3	**-7,085**	-7,085

The lowest cost NPV is Option A and it is therefore the preferred option. It also has the lowest initial capital cost.

3.4 Scenario Analysis

3.4.1 Sensitivities

The key sensitivities to this project are the capital costs and timing of project works.

Lower and upper bounds for cost inputs were tested (-20% lower bound and +20% upper bound respectively) to determine the sensitivity of capital variance to the selected NPV. Option A consistently presented the least cost NPV across the tested upper and lower bounds.

3.4.2 Value of regret analysis

In terms of selecting a decision pathway of 'least regret', Option A presents an economically efficient and balanced approach to investment providing a solution with the lowest initial capital and the greatest flexibility in timing for future investment. In contrast, the other options provide less flexibility in future in terms of ability to respond to changes in asset condition and demand.

3.5 Qualitative comparison of identified options

3.5.1 Advantages and disadvantages of each option

Table 8 below details the advantages and disadvantages of each option considered.

Table 8: Assessment of options

Options	Advantages	Disadvantages
Option A – 10MVA Skid at BROX, followed by skid at YASO in 2025	• **Environmental -** Conditioned transformers removed from service in 2021 and 2025; no bunding and beside table drain. • **Economics -** Lowest initial capital expenditure due to staged capacity increases in response to load. • Greatest flexibility in timing of future investment. • **Utilisation -** Highest utilisation due to incremental approach to network infrastructure – more easily scaled to lower load growth.	• **Safety -** Small stage 1 residual risk due to initial older BROX assets still in service. • Will need to de-energise to service due to access restrictions. • **Utilisation -** Broxburn forecast peak load will always be above N-1 even when the second skid is installed. • **Safety Net -** Not Safety Net compliant if skid fails.
Option 2 – 2x10MVA Skid at BROX	• **Safety -** Negligible risk. • **Environmental -** Conditioned transformers removed from service in 2021; no bunding and beside table drain. • **Economics -** Lower maintenance costs. • **Utilisation -** Broxburn forecast peak load initially will be below N-1. • **Safety Net -** Safety Net compliant.	• **Economics -** Higher capital expenditure initially despite efficiency gains of installing 2x skids at BROX. • **Operability -** Operability is better than the existing substation. Will still need feeder ties outside of substation as there is no bus tie CB. • **Utilisation -** Lower utilisation initially until load materialises. • Poor ability to respond to lower than anticipated load growth. • Broxburn forecast peak load will be above N-1 by 2028.
Option 3 – Consolidate BROX and YASO into a Z7-20D	• **Safety -** Negligible risk. • **Environmental -** Conditioned transformers removed from service in 2021; no bunding and beside table drain. • **Economics -** Minimal maintenance cost. • **Operability -** Optimal operability for customer service. • **Utilisation -** Broxburn load above N-1 from installation and into the long term. • **Safety Net -** Safety Net compliant.	• **Economics -** Highest capital expenditure initially. • **Utilisation -** Much lower utilisation initially until load materialises.

3.5.2 Alignment with network development plan

The proposed works outlined in this business case will enable Ergon Energy to proactively respond to changing network requirements. This will ensure that customer supply, network reliability and safety requirements continue to be met going forward.

In particular, the works outlined in this business case address an expected increase in peak demand in the Pittsworth area over coming years, as well as the safety risks associated with a number of aged assets which are currently servicing the area.

3.5.3 Alignment with future technology strategy

This program of work does not contribute directly to Energy Queensland's transition to an Intelligent Grid, in line with the Future Grid Roadmap and Intelligent Grid Technology Plan. However, it does support Energy Queensland in maintaining affordability of the distribution network while also maintaining safety, security and reliability of the energy system, a key goal of the Roadmap, and represents prudent asset management and investment decision-making to support optimal customer outcomes and value across short, medium and long-term horizons.

3.5.4 Risk Assessment Following Implementation of Proposed Option

Table 9 outlines the risk assessment for the Ergon Energy network following implementation of the proposed option.

Table 9: Risk assessment showing risks mitigated following Implementation

Risk Scenario	Risk Type	Consequence (C)	Likelihood (L)	Risk Score	Risk Year
Substation ECC breach at BROX results in **>1 min changeover outage > 3 times in one week** during high load times to allow Nomad load support connection.	Customer	*(Original)* *3* (Mitigated) 3 *(5,000 customers for > 12 hours)*	 *5* 1 *(Almost no likelihood to occur)*	 ***15*** **3** **(Very low risk)**	 2019 2019
Failure of 33kV isolator at YASO results in **unsupplied customer loads outside of Safety Net restoration timeframes >24 hours.**	Customer	*(Original)* *3* (Mitigated) 3 *(5,000 customers for > 12 hours)*	 *3* 1 *(Almost no likelihood to occur)*	 ***9*** **3** **(Very low risk)**	 2019 2019
Fault or Non-Spurious Trip on 33/11kV Transformer at YASO results in **interruption>3 hours in duration** and disrupts 300 customers.	Customer	*(Original)* *2* (Mitigated) 2 *(1,000 customers for > 3 hours)*	 *4* 1 *(Almost no likelihood to occur)*	 ***8*** **2** **(Very low risk)**	 2019 2019

Risk Scenario	Risk Type	Consequence (C)	Likelihood (L)	Risk Score	Risk Year
Fault or Non-Spurious Trip on 33/11kV Transformer at BROX results in **interruption >24 hours**.	Customer	*(Original)* *4* (Mitigated) 4 *(15,000 customers for > 1 day)*	*4* 1 *(Almost no likelihood to occur)*	***16*** **4** **(Very low risk)**	2019 2019
Catastrophic failure of a 33/11kV transformer at BROX results in an **oil spill of >1000 litres** that extends beyond the property boundary (transformers not bunded).	Environment	*(Original)* *4* (Mitigated) 4 *(Material environmental harm and remediation/ rectification costs <$500,000 and >$50,000)*	*3* 1 *(Almost no likelihood to occur)*	***12*** **4** **(Very low risk)**	2019 2019
Catastrophic failure of a 33/11kV transformer at YASO results in an **oil spill of >1000 litres** that enters a water course (transformers not bunded).	Environment	*(Original)* *5* (Mitigated) 5 *(Extensive serious environmental harm and remediation/ rectification costs <$5,000,000 and >$500,000)*	*3* 1 *(Almost no likelihood to occur)*	***15*** **5** **(Very low risk)**	2019 2019
Catastrophic failure of 33kV isolator at YASO results in **serious injuries to multiple field workers or members of the public**.	Safety	*(Original)* *4* (Mitigated) 4 *(Multiple serious injuries/ illnesses)*	*2* 1 *(Almost no likelihood to occur)*	***8*** **4** **(Very low risk)**	2019 2019
Catastrophic failure of 33kV isolator at BROX results in **serious injuries to multiple field workers or members of the public**.	Safety	*(Original)* *4* (Mitigated) 4 *(Multiple serious injuries/ illnesses)*	*2* 1 *(Almost no likelihood to occur)*	***8*** **4** **(Very low risk)**	2019 2019
Catastrophic failure of 33/11kV transformer at BROX results in **serious injuries to multiple field workers or members of the public**. Likelihood based on condition, loading and history.	Safety	*(Original)* *4* (Mitigated) 4 *(Multiple serious injuries/ illnesses)*	*4* 1 *(Almost no likelihood to occur)*	***16*** **4** **(Very low risk)**	2019 2019

Risk Scenario	Risk Type	Consequence (C)	Likelihood (L)	Risk Score	Risk Year
Catastrophic failure of 33/11kV transformer at YASO results in **serious injuries to multiple field workers or members of the public**.	Safety	*(Original)*			
		4	*3*	***12***	2019
		(Mitigated)			
		4 *(Multiple serious injuries/ illnesses)*	1 *(Almost no likelihood to occur)*	**4 (Very low risk)**	2019

4 Recommendation

4.1 Preferred option

Economic analysis shows that Option A is economically more favourable than Option B and Option C. Option A also provided the greatest option value by maintaining the greatest flexibility in the timing of future investments and addresses the significant environmental risk at YASO by 2025.

The option analysis showed that each of the three options considered would be technically adequate to meet Safety Net and network capacity requirements.

Option A mitigates the loading risk at Broxburn substation where the loading is forecast to exceed the total substation emergency cyclic capacity in 2022 and the transformer is also requiring replacement based on condition. Without addressing this emerging constraint proactively, during peak load times this may result in forced load shedding as well as the prevent the connection of new customers.

Option A economically mitigates the safety and customer impact risk by removing a poor conditioned 50-year old power transformer and all ten 11kV isolators at Broxburn substation. Option A also mitigates the elevated risk of failure of a transformer failure at Yarranlea South and the possibility of an oil spill and resulting environmental damage.

4.2 Scope of preferred option

OPTION A – 10MVA skid at BROX (in 2021) and 10MVA skid at YASO (in 2025)

Scope

- Stage 1: Install a 10MVA 33/11kV skid transformer adjacent to BROX by 2021 to supply Springside, Pittsworth, and Copps Hill feeders. Retain BROX T1 &T3 (T1 & T3 to operate as hot-stand-by) to meet Safety Net and reduce environment risk associated with high loading and through faults.
- Stage 2: Install a 10MVA 33/11kV skid transformer adjacent to YASO by 2025, decommission YASO and remove aged assets. Recover BROX T1. Reconductor 10km of 7/.104 HDBC with Iodine 7/4.75 AAAC and install 3 x 200A 11kV voltage regulator delta connection to create a tie-feeder for providing load transfer capability during contingency to meet Safety Net.
- Stage 3: Install second 10MVA skid adjacent to BROX by 2029. Recover BROX T3 and remove associated aged assets.

The total Capital Cost of the project is $10.8M, and the total capital cost in 2020-25 AER regulatory control period is $7.8M.

Appendix A. References

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

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

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

Energy Queensland, *Asset Management Plan, Substation Transformers [7.041]*, (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, *Network Risk Framework*, (October 2018).

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

Appendix B. Acronyms and Abbreviations

The following abbreviations and acronyms appear in this business case.

Abbreviation or acronym	Definition
$M	Millions of dollars
$ 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
ALARP	As Low as Reasonably Practicable
AMP	Asset Management Plan
Augex	Augmentation Capital Expenditure
BAU	Business as Usual
BROX	Broxburn Substation
CAPEX	Capital expenditure
CBRM	Condition Based Risk Management
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
ECC	Emergency cyclic capacity
EQL	Energy Queensland Ltd
IT	Information Technology
kV	Kilovolt
kVA	Kilovolt ampere
kW	Kilowatt
kWh	kilowatt hour
MSS	Minimum Service Standard
MVA	Megavolt Ampere
NCC	Normal cyclic capacity
NECF	National Energy Customer Framework
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

Abbreviation or acronym	Definition
ONAN	Oil Natural Air Natural
OPEX	Operating and Maintenance Expenditure
PCBU	Person in Control of a Business or Undertaking
POE	Probability of exceedance
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
SCADA	Supervisory Control and Data Acquisition
SFAIRP	So Far as Is Reasonably Practicable
TX	Transformer
VCR	Value of customer reliability
WACC	Weighted average cost of capital
YARA	Yarranlea Bulk Supply Point
YASO	Yarranlea South
YOM	Year of Manufacture
ZS	Zone Substation

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

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

Table 10: Alignment with NER

Capital Expenditure Requirements	Rationale
6.5.7 (a) (1) **The forecast capital expenditure is required in order to meet or manage the expected demand for standard control services.**	This project is required to meet the forecast demand growth in the Pittsworth area.
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**	Our alignment to regulatory obligations or requirements is demonstrated in this proposal, whereby CAPEX is required in order to maintain compliance and electrical safety through alignment with the QLD Electrical Safety Act 2002 and the QLD Electrical Safety Regulation 2006. In particular, this proposal refers to the Ergon Energy Safety Net targets, which are set to meet threshold criteria following an N-1 event on the sub-transmission network. This proposal maintains operations within the Safety Net targets so that Ergon remains compliant and in alignment with the NER.
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**	This proposal seeks to ensure we adhere to our Safety Net targets. These targets are set such that any disruption to supply is minimised in terms of the outage time and number of customers affected. This proposal will utilise CAPEX to maintain reliability and security of supply for those customers in the above-mentioned regions.
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.**	This proposal has employed a standard risk analysis to highlight the safety risks that exist for staff, contractors and the community. That risk analysis has identified safety concerns that require capital expenditure to be addressed and mitigated.
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).

Capital Expenditure Requirements	Rationale
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).
6.5.7 (c) (1) (iii) **The forecast capital expenditure reasonably reflects a realistic expectation of the demand forecast and cost inputs required to achieve the capital expenditure objective**	Our peak demand forecasting methodology employs a bottom-up approach reconciled to a top-down evaluation, to develop the ten-year zone substation peak demand forecasts. Our forecasts use validated historical peak demands and expected load growth based on demographic and appliance information in small area grids. Demand reductions, delivered via load control tariffs, are included in these forecasts. This provides us with accurate forecasts on which to plan.

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 11: 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

<table>
<tr><th colspan="5">Network Risks - Risk Tolerability Criteria and Action Requirements</th><th></th></tr>
<tr><th>Risk Score</th><th>Risk Descriptor</th><th colspan="3">Risk Tolerability Criteria and Action Requirements</th><th></th></tr>
<tr><td>30 – 36</td><td colspan="4">Intolerable
(stop exposure immediately)</td><td></td></tr>
<tr><td>24 – 29</td><td>Very High Risk</td><td rowspan="5">*ALARP
Risk in this range managed to As Low As Reasonably Practicable</td><td>Executive Approval
(required for continued risk exposure at this level)</td><td>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</td><td rowspan="5">SFAIRP
Risks in this area to be mitigated So Far as is Reasonably Practicable</td></tr>
<tr><td>18 – 23</td><td>High Risk</td><td>Divisional Manager Approval
(required for continued risk exposure at this level)</td><td>Introduce new or changed risk treatments to reduce level of risk
Periodic review of the risk and effectiveness of the existing risk treatments</td></tr>
<tr><td>11 – 17</td><td>Moderate Risk</td><td rowspan="2">Group Manager / Process Owner Approval
(required for continued risk exposure at this level)</td><td rowspan="2">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</td></tr>
<tr><td>6 – 10</td><td>Low Risk</td></tr>
<tr><td>1 to 5</td><td>Very Low Risk</td><td>No direct approval required but evidence of ongoing monitoring and management is required</td><td>Periodic review of the risk and effectiveness of the existing risk treatments</td></tr>
</table>

Figure 3: A Risk Tolerability Scale for evaluating Semi-Quantitative risk score

Appendix F. Safety Net Obligations

Safety Net Criteria

Network planning criteria is a set of rules that guide how future network risk is to be managed for and under what conditions network augmentation or other related expenditure should be undertaken.

Ergon

Ergon Energy is required under Distribution Authority No. D01/99 to adhere to the probabilistic planning approach where full consideration is given to the network risk at each location, including operational capability, plant condition and network meshing with load transfers.

The Safety Net requirements provide a backstop set of 'security criteria' that set an upper limit to the customer consequence (in terms of unsupplied load) for a credible contingency event on our network. Ergon Energy is required to meet the restoration targets defined in Schedule 4 of Ergon Energy's Distribution Authority "…*to the extent reasonably practicable."*

The safety net criteria are classified into Regional Centre and Rural Area, each with a different timeline as follows:

Table 12: Safety Net – Load not supplied and maximum restoration times following a credible contingency

Area	Targets
Regional Centre	Following an N-1 Event, load not supplied must be: • Less than 20 MVA (5,000 customers) after 1 hour; • Less than 15 MVA (3,600 customers) after 6 hours; • Less than 5 MVA (1,200 customers) after 12 hours and • Fully restored within 24 hours.
Rural Areas	Following an N-1 Event, load not supplied must be: • Less than 20 MVA (7,700 customers) after 1 hour; • Less than 15 MVA (5,800 customers) after 8 hours; • Less than 5 MVA (2,000 customers) after 18 hours and • Fully restored within 48 hours.

It is noted that each of the zone substations supplied from M028 and M049 are classified Rural Area for Safety Net purposes, therefore requiring full supply to all customers to be completed within 48 hours.

Safety Net Analysis – BROX

The Safety Net Contingency Management Plan for BROX shows that during a contingency to the incoming sub-transmission feeder, Broxburn 33kV Feeder, supply can be restored by changing open points and supplying via Broxburn-Purrawunda 33kV Feeder within Safety Net restoration timeframes.

For a transformer failure at BROX the contingency management plan states that 11kV transfer is limited but the unsupplied load, which is the load at risk (LAR), will be restored with a NOMAD (10MVA mobile substation) within 48 hours. This will allow Safety Net compliance to be achieved as shown in Figure 4.

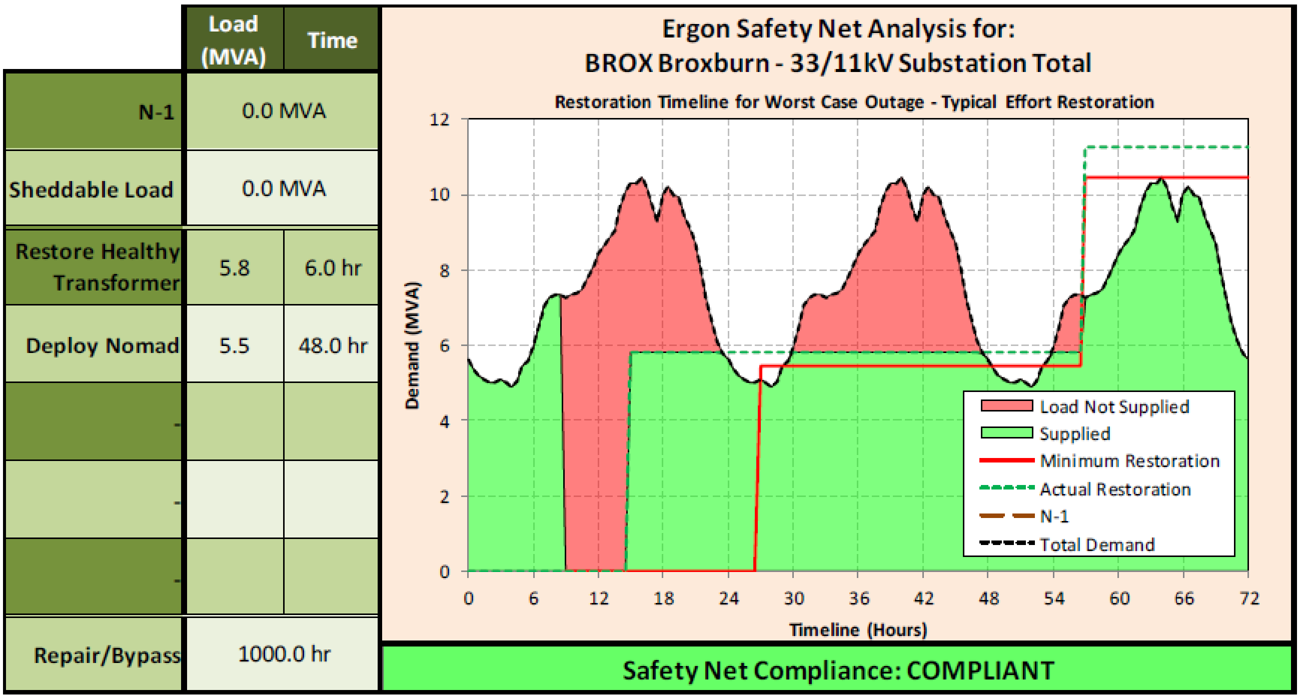

Figure 4: BROX Safety Net analysis

Safety Net Analysis – YASO

A failure of the incoming 33kV supply to YASO (Broxburn 33kV Feeder) can be expected to be repaired within the Safety Net restoration timeframe of 48 hours.

For a transformer failure at YASO, the Contingency Management Plan states no 11kV transfers are available during peak load times. A Pegasus (1MVA mobile generation unit) can be deployed and connected to supply the lost load within 48 hours thus allowing Safety Net to be met as detailed in Figure 5.

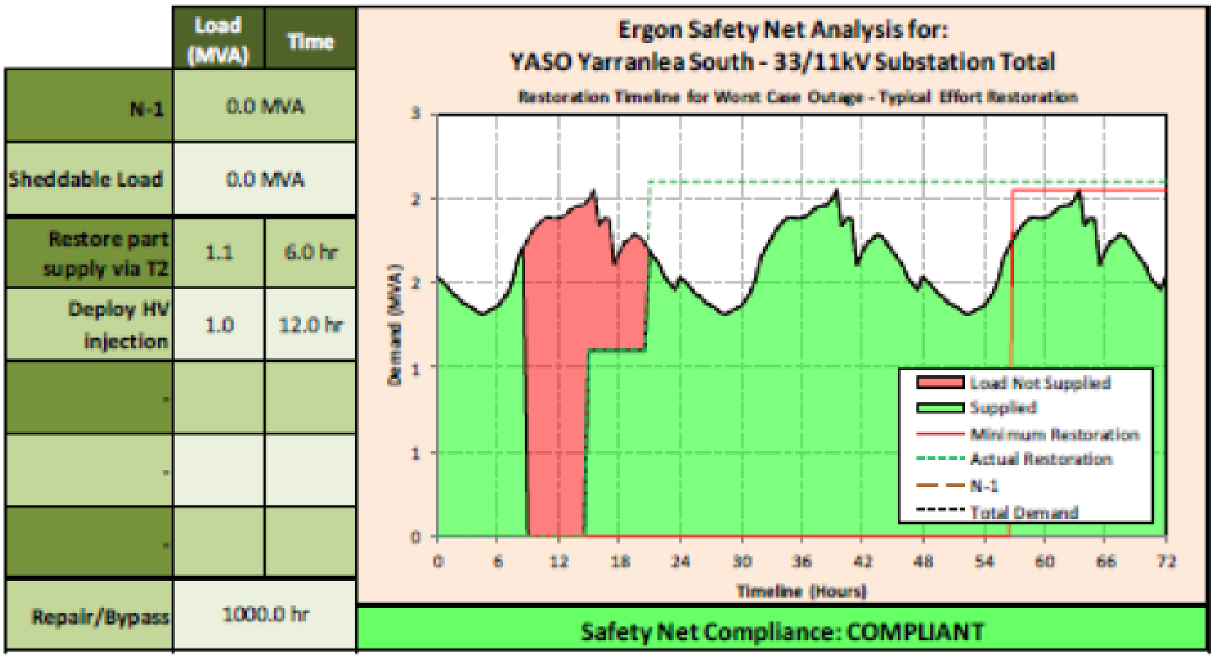

Figure 5: YASO Safety Net analysis

Appendix G. Reconciliation Table

Reconciliation Table Conversion from $18/19 to $2020	
Business Case Value	
(M$18/19)	$7.80
Business Case Value	
(M$2020)	$8.07

Appendix H. Additional information

The following sections contain additional information used to support the development of this business case.

Schematic diagram of the Pittsworth supply

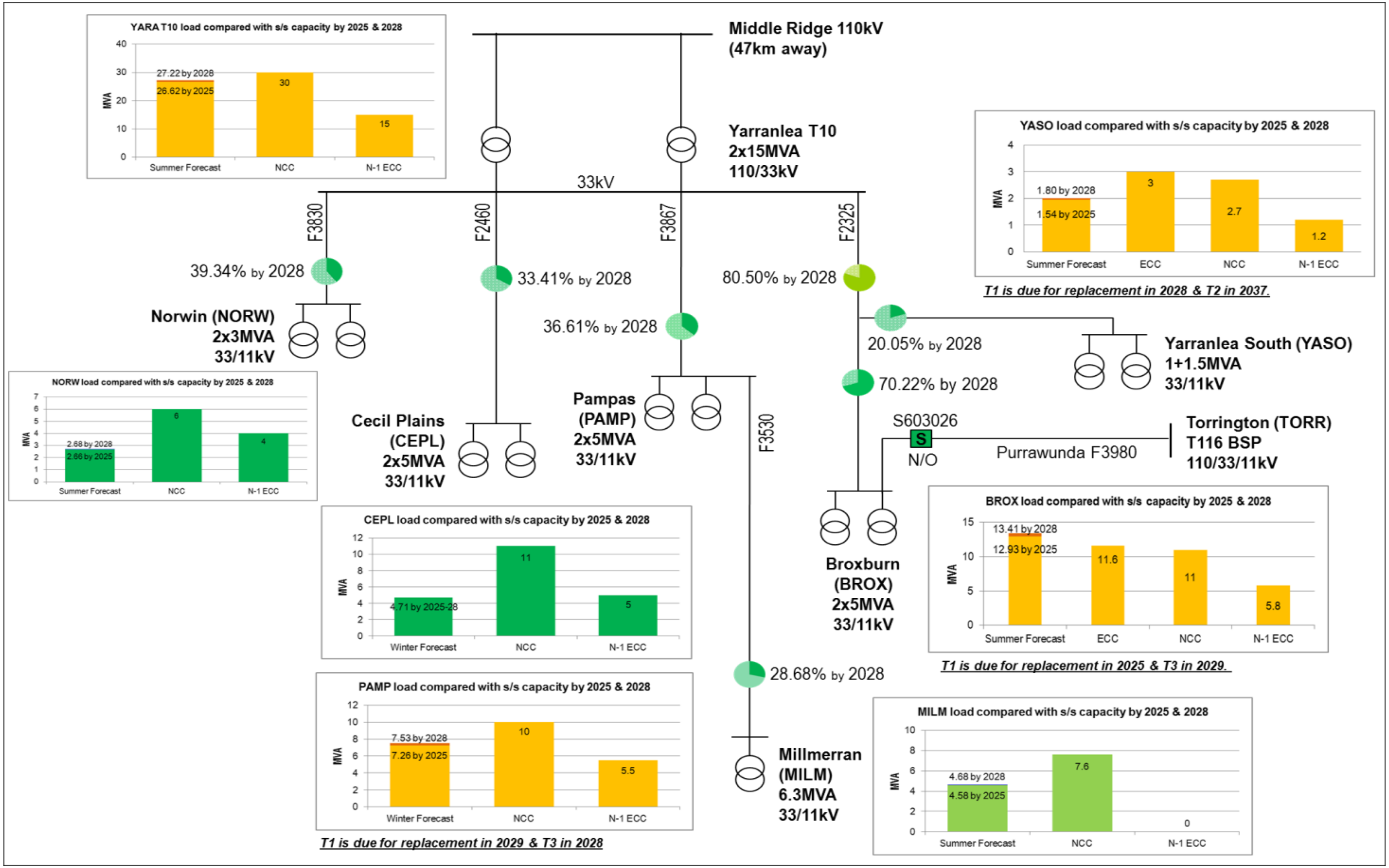

Figure 6: Overview of the 33kV sub-transmission from Yarranlea T10 which supplies BROX and YASO with business-as-usual replacement dates.

BROX historic and future load

Table 13: BROX Transformers' Details

ZS	Tx №	Nameplate Rating (MVA)	kV	YOM	Cooling	NCC	ECC
BROX	1	5	33/11	1962	ONAN	5.5	5.8
BROX	3	5	33/11	1966	ONAN	5.5	5.8

Table 13 gives nameplate, NCC and ECC ratings for the transformers at BROX.

The annual load duration curve for BROX shown in Figure 7 illustrates that currently when either transformer is out of service, substation load exceeds the N-1 ECC rating 7.5% of the time. This is equivalent to 657 hours annually.

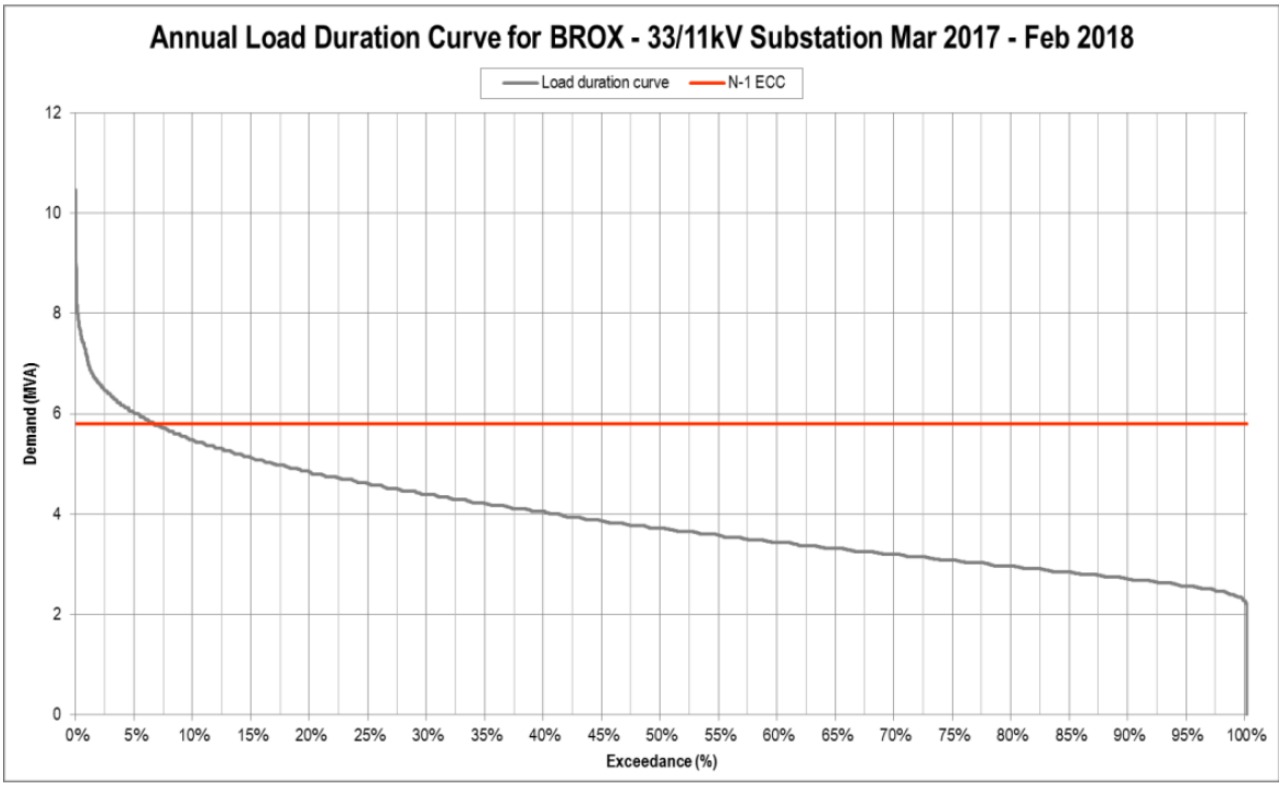

Figure 7: BROX load duration curve

As shown in Figure 8, BROX load is currently breaching the N-1 ECC and is approaching substation NCC and ECC. Peak demand was 10.46MVA in February 2018, higher than the Broxburn ZS nameplate rating.

Figure 9 is the substation 10POE (10% probability of exceedance) forecast at BROX showing an increase in demand in 2019 and 2022 due to two customer connection applications, Alpair Micro Grid for 1.5MVA and LRDM PTY LTD for 2MVA respectively. Agreements have been signed with both customers with the Alpair Micro Grid connect design finalised and the LRDM Pty Ltd design nearing completion. It can be seen that the N-1 ECC rating of the substation is currently being exceeded and that by year 2022, both the NCC and ECC (with both transformers in service) ratings will also be exceeded.

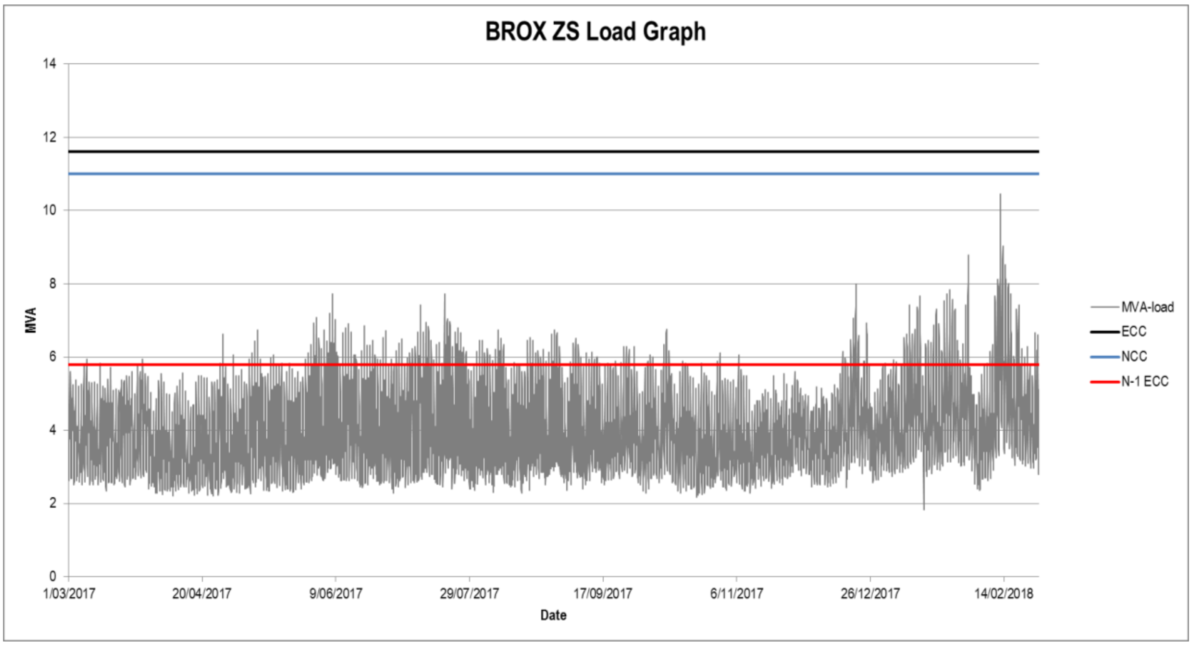

Figure 8: BROX substation historic load

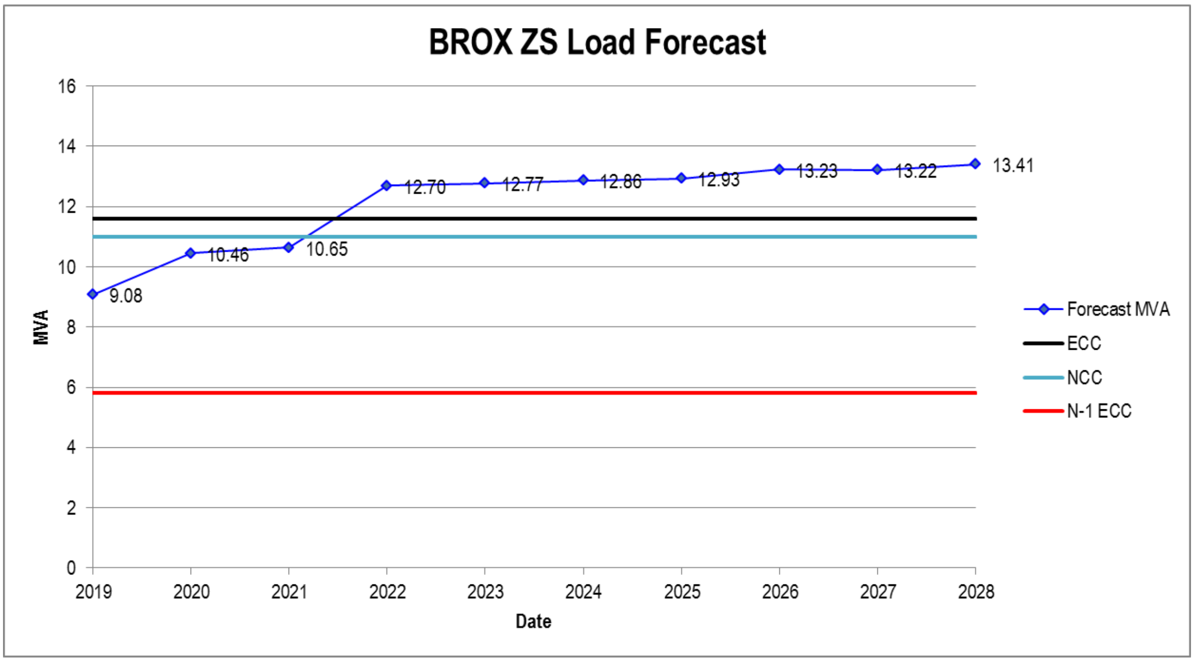

Figure 9: BROX 10POE substation forecast

YASO historic and future load

Table 14: YASO Transformer's nameplate, NCC and ECC ratings

ZS	TX No.	Nameplate Rating (MVA)	kV	YOM	Cooling	NCC	ECC
YASO	1	1.5	33/11	1962	ONAN	1.6	1.8
YASO	2	1	33/11	1967	ONAN	1.1	1.2

The annual load duration curve for YASO shown in Figure 10 shows that load exceeds the N-1 ECC 5% of the time (equivalent to 438 hours per annum).

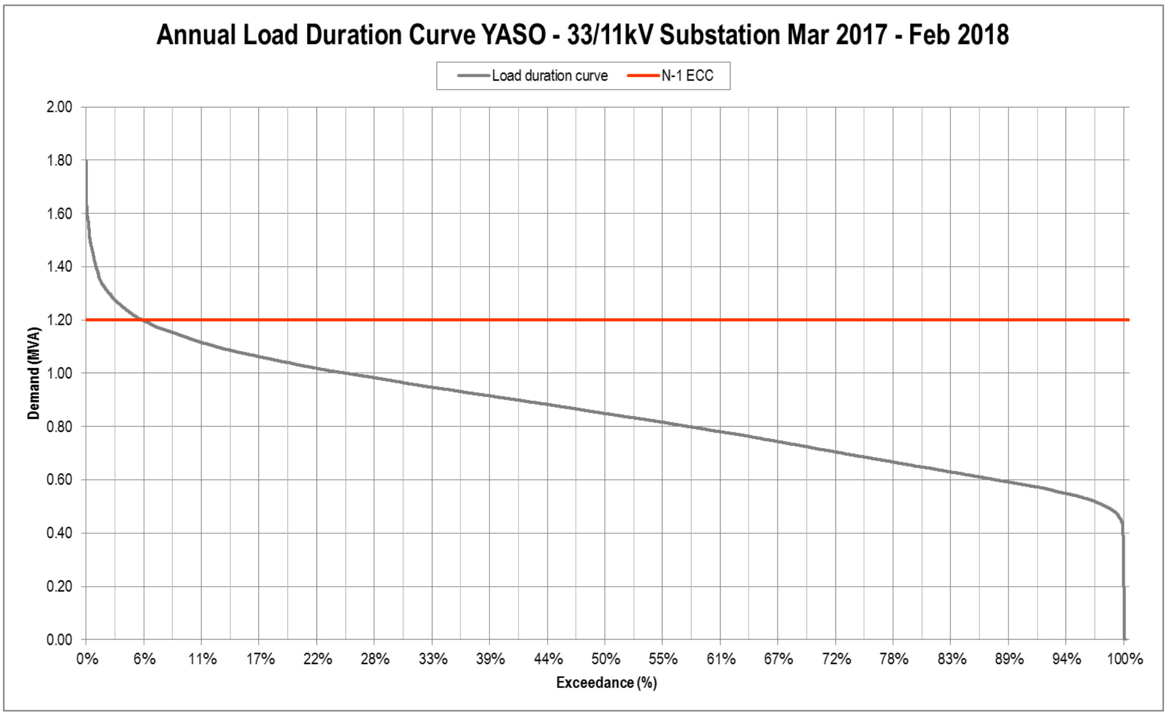

Figure 10: YASO T1 load duration curve

Transformer 2 is fixed-tap which means the two transformers are not able to be tied together to share load. For this reason, the two transformers will be considered separately for load limitations.

Figure 11 shows historic loading of Transformer 1. Peak demand was 1.5MVA in February 2018.

Figure 12 shows historic loading of Transformer 2. Peak demand was 0.58MVA in February 2018.

Figure 13 shows that the substation 10POE forecast at YASO exceeds the N-1 ECC rating over the entire forecast period (2019 – 2028).

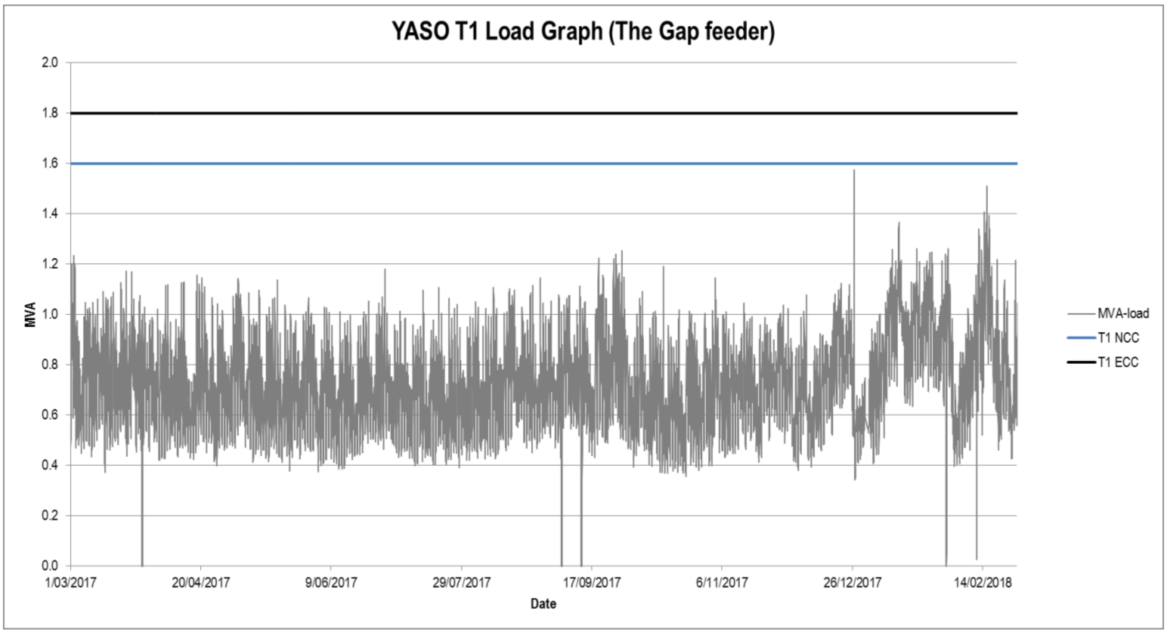

Figure 11: YASO Transformer 1 historic load

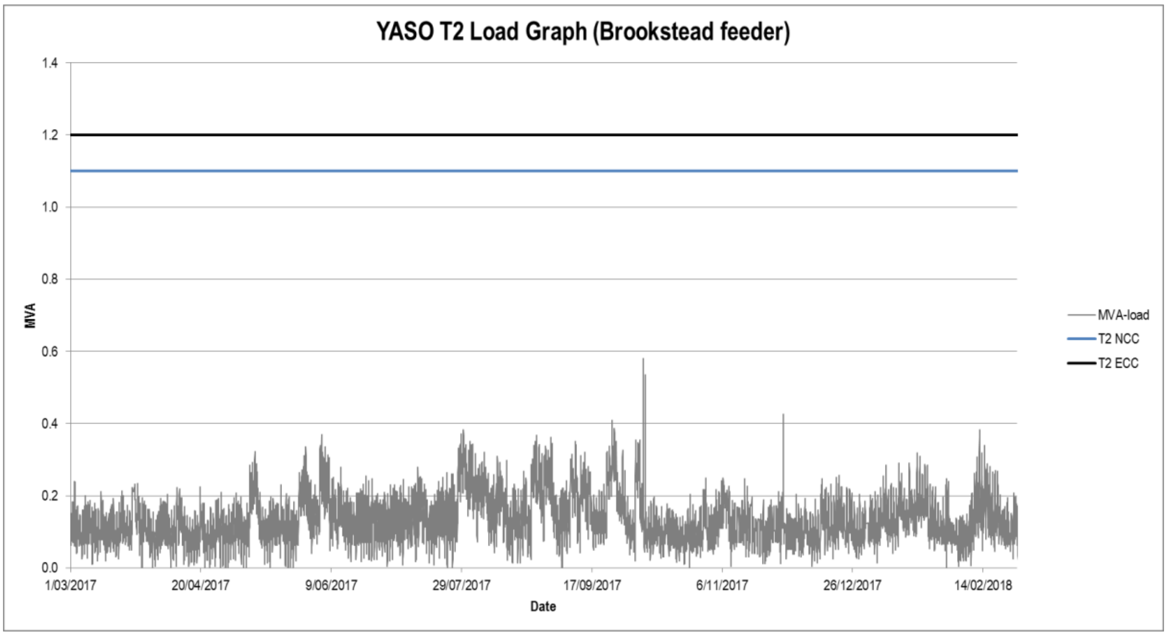

Figure 12: YASO Transformer 2 historic load

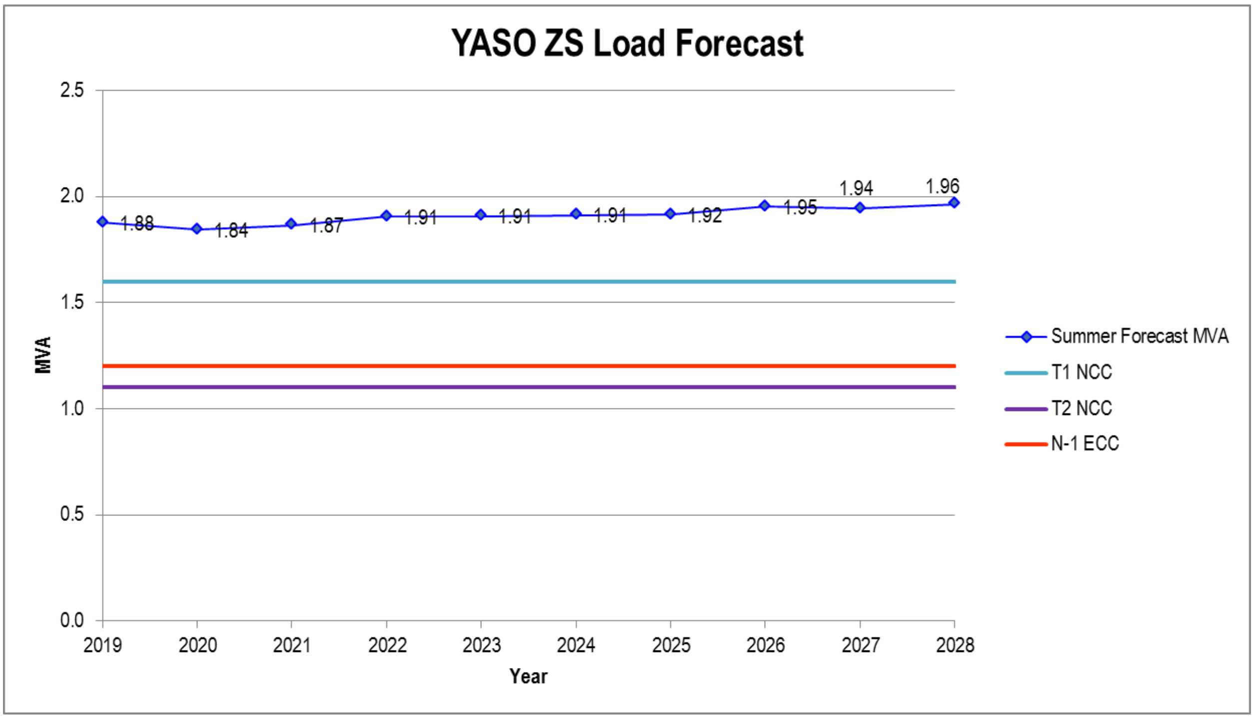

Figure 13: YASO 10POE substation forecast

Value of Customer Reliability

Energy Queensland utilises the AEMO 2014 Value of Customer Reliability (VCR) values as part of its investment and project planning process. VCR is an economic value applied to customers' unserved energy for any particular year and is intended to represent customers' willingness to pay for their reliability of electricity supply. Calculated VCR figures help to determine the augmentation option that most efficiently reduces lengthy service interruptions. VCR is considered as an Indirect Benefit for the purposes of NPV comparison of options. A VCR value of $26.57/kWh is used in this report, derived from the customer mix within the study area.

The expected interruption cost for the existing system was calculated based on three years of metered half-hourly system load data (Dec 2015 – Dec 2018). This load data was scaled to incorporate the two new block loads at BROX described above. The estimated outage cost to customers was found to be $19,384/annum. Note that this calculation only considered contingency scenarios based on sub-transmission and substation faults. This was done to allow comparison of VCR benefits in the Options Analysis. Based on the scopes of the various options considered, (predominately substation works) the differences in distribution network VCR was considered to be immaterial.

Asset Life Cycle Summary

Table 7 details the assets for both BROX and YASO that are proposed to be retired. Their retirement is based on a combination of Condition Based Risk Management (CBRM) modelling, age, known problematic operational and maintenance issues and the need to manage safety and network risk associated with unplanned failure.

CBRM is a structured process that combines asset information, engineering knowledge and practical experience to define the current and future condition, performance and risk for network assets. The process has been progressively applied for those asset classes where sufficient information is available to produce a health index and probability of failure for an individual asset.

Energy Queensland uses CBRM, in conjunction with the Network Risk Framework, to enable the delivery of optimised investment plans to replace and refurbish our existing assets, and proactively manage asset condition.

Appendix I. Condition Report Attachments

Recent SCAR for BROX	Minor Works SCAR_Broxburn_v1.0.
Condition Based Risk Management BROX and YASO	CBRM BROX & YASO
BROX T1 Insulating Oil Test Result	BROX T1 oil test
BROX T3 Insulating Oil Test Result	BROX T3 oil test
YASO T1 Insulating Oil Test Result	YASO T1 oil test
YASO T2 Insulating Oil Test Result	YASO T2 oil test

Supporting Photographs

Broxburn (BROX) Photographs	BROX photos
Yarranlea South (YASO) Photographs	YASO photos