Final Project Assessment Report

East Bundaberg Substation Refurbishment

This document describes the *identified need* for investment at East Bundaberg substation and the preferred option for addressing the identified need.

Publication Date: 12 January 2021

Executive Summary

ABOUT ERGON ENERGY

Ergon Energy Corporation Limited (Ergon Energy) is part of the Energy Queensland Group and manages an electricity distribution network which supplies electricity to more than 740,000 customers. Our vast operating area covers over one million square kilometres – around 97% of the state of Queensland – from the expanding coastal and rural population centres to the remote communities of outback Queensland and the Torres Strait.

Our electricity network consists of approximately 160,000 kilometres of powerlines and one million power poles, along with associated infrastructure such as major substations and power transformers.

We also own and operate 33 stand-alone power stations that provide supply to isolated communities across Queensland which are not connected to the main electricity grid.

IDENTIFIED NEED

East Bundaberg substation (EABU) is located on the eastern edge of Bundaberg city. EABU has two 12/16MVA 66/11kV transformers that supplies industrial, residential, and agricultural loads. The 11kV feeder network supplies a predominantly urban area extending further east and north to the coastal towns of Bargara and Burnett Heads. Peak demand was 18.85MVA[1] in 2019. For a loss of one transformer (N-1), the substation capacity is limited to the rating of the 11kV bushings which is 850A (16.2MVA). When this happens, the demand at the time could exceed 16.2MVA. Demand forecast will continue to exceed the N-1 capacity at EABU for the next 10 years reaching 24.59MVA[2] in 2030.

The substation condition assessment report identified the assets nearing the end of their useful life. As such, replacement of these assets is in stages that include 66kV circuit breakers, transformers T1 and T2, 11kV voltage transformers, 66kV surge arresters and protection relays. The condition of these assets is safety-critical that the risk score is moderately high and does not satisfy as low as reasonably practicable (ALARP). Safety-critical is a system failure or malfunction resulting in serious injury or fatality, loss or damage to equipment and property, and environmental harm.

The transformers T1 and T2 were manufactured in 1979. Oil test results of transformer T1 show elevated furan levels of 4ppm in the dissolved gas analysis (DGA), indicating advanced degradation of the paper insulation. Both transformers have no bunding and present an environmental risk in the event of a failure resulting in an oil spill.

The 66kV Delle circuit breakers are prone to slow opening times that is known to cause erroneous tripping of the upstream protection. The 66kV bus is galvanised pipe showing signs of corrosion and the bus arrangement itself increases the risk of a full substation outage. For a credible contingency where there is a fault on a single 66kV bus or single transformer there is a total loss of supply to the entire substation. This is due to the bus and circuit breaker (CB) arrangement that requires a total outage to isolate the faulted plant[3]. With demand forecast expected to exceed the N-1 capacity, there is a high risk that Safety Net restoration timeframes cannot be met.

[1] SIFT 47-2020 Base Forecast, 2019 SN 18.85MVA as per data 14 Oct 2020.
[2] SIFT 47-2020 Base Forecast, 2030 SN 24.59MVA as per data 14 Oct 2020.
[3] Planning Proposal EABU Refurbishment, *Safety Net Assessment - 66kV Bus Zone or Transformer Bay Fault*, page 26.

APPROACH

The National Electricity Rules (NER) require that, subject to certain exclusion criteria, network business investments for meeting service standards for a distribution business are subject to a Regulatory Investment Test for Distribution (RIT-D). Ergon Energy has determined that network investment is essential in this case for it to continue to provide electricity to the consumers in the East Bundaberg supply area in a reliable, safe and cost-effective manner. Accordingly, this investment is subject to a RIT-D.

Ergon Energy published a Notice of no non-network options for the above-mentioned identified needs on 22 June 2020.

The following three credible feasible options have been investigated in this report. The costs are indicative estimates at the time when a feasible option was being determined. There will be further stages to the following options in the future as mandated by the recommended replacement of assets.

1. **Option 1** – Rebuild 66kV yard in situ ($13.175M)
   This will require the rebuild of the 66kV bus in the same place, installation of a new 66kV bus tie circuit breaker, decommissioning and removing two 66kV circuit breakers, installation of two 66kV feeder circuit breakers, replacement of transformers T1 and T2 with 15/20MVA transformers and upgrade the protection scheme.

2. **Option 2** – Build 66kV yard on adjacent land ($12.561M)
   This will require the build of a new 66kV bus on the adjacent land, build two new 66kV feeder bays and transformer bays, decommission and remove two 66kV circuit breakers, replace transformers T1 and T2 with 15/20MVA transformers and upgrade the protection scheme.

3. **Option 3** – Rebuild 66kV yard as indoor gas-insulated switchgear (GIS) on adjacent land ($16.451M)
   This option will involve building an indoor GIS switchgear. The building will also house the future 11kV switchgear as well as protection and control panels.

This is now a Final Project Assessment Report, where Ergon Energy presents the technical and financial analysis of the above options and identifies the preferred solution in accordance with the requirements of clause 5.17.4(o) of the NER. Ergon Energy's preferred solution to address the identified need is Option 2 – Build 66kV yard on adjacent land.

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1. Introduction

This FPAR has been prepared by Ergon Energy in accordance with the requirements of clause 5.17.4(o) of the National Electricity Rules (NER).

This report represents the final stage of the consultation process in relation to the application of the Regulatory Investment Test for Distribution (RIT-D) on potential credible options to address the identified need for EABU.

In preparing this RIT-D, Ergon Energy is required to consider reasonable future scenarios. With respect to major customer loads and generation, Ergon Energy has, in good faith, included as much detail as possible while maintaining necessary customer confidentiality. Potential large future connections that Ergon Energy is aware of are in different stages of progress and are subject to change (including outcomes where none or all proceed). These and other customer activity can occur over the consultation period and may change the timing and/or scope of any proposed solutions.

1.1. Structure of the report

This report:

- Provides background information of the capability limitations of the distribution network supplying the East Bundaberg area.
- Identifies the need which Ergon Energy is seeking to address, together with the assumptions used in identifying and quantifying that need.
- Describes the credible options that Ergon Energy currently considers may address the identified need, including for each:
    - Its technical definitions;
    - The estimated commissioning date; and
    - The total indicative cost (including capital and operating costs)
- Quantifies costs and classes of material market benefits for each of the credible options.
- Provides the results of Net Present Value (NPV) analysis of each credible option and accompanying explanatory statements regarding the results.

1.2. Dispute resolution process

In accordance with the provisions set out in clause 5.17.5(a) of the NER, Registered Participants or Interested Parties may, within 30 days after the publication of this report, dispute the conclusions made by Ergon Energy in this report with the Australian Energy Regulator. Accordingly, Registered Participants and Interested Parties who wish to dispute the conclusions outlined in this report based on a manifest error in the calculations or application of the RIT-D must do so within 30 days of the publication date of this report. Any parties raising a dispute are also required to notify Ergon Energy. Dispute notifications should be sent to demandmanagement@ergon.com.au

If no formal dispute is raised, Ergon Energy will proceed with the preferred option to rebuild the 66kV yard.

1.3. Contact details

Inquiries about this RIT-D may be sent to:

E: demandmanagement@ergon.com.au

P: 13 74 66

2. Background

Bundaberg is a regional city 360km north of Brisbane with a population of approximately 93,000 people. EABU is located on the eastern edge of Bundaberg city and supplies a diverse mix of industrial, residential, and agricultural zones. The 11kV network supplies a predominantly urban area near the substation and extends further east and north to the growing coastal towns of Bargara and Burnett Heads (**Figure 1**).

The Burnett Heads area is 16km north east of Bundaberg at the mouth of the Burnett River and contains a mix of coastal residential developments, large parcels of agricultural land, and the strategically important Port of Bundaberg. Bargara is 13km east of Bundaberg and is mostly residential with growth driven by an expanding tourism sector. **Figure 2** shows the East Bundaberg 11kV distribution network highlighted in blue.

The State Development Area (SDA) plan has identified Burnett Heads to have the potential for development as a port industry precinct.

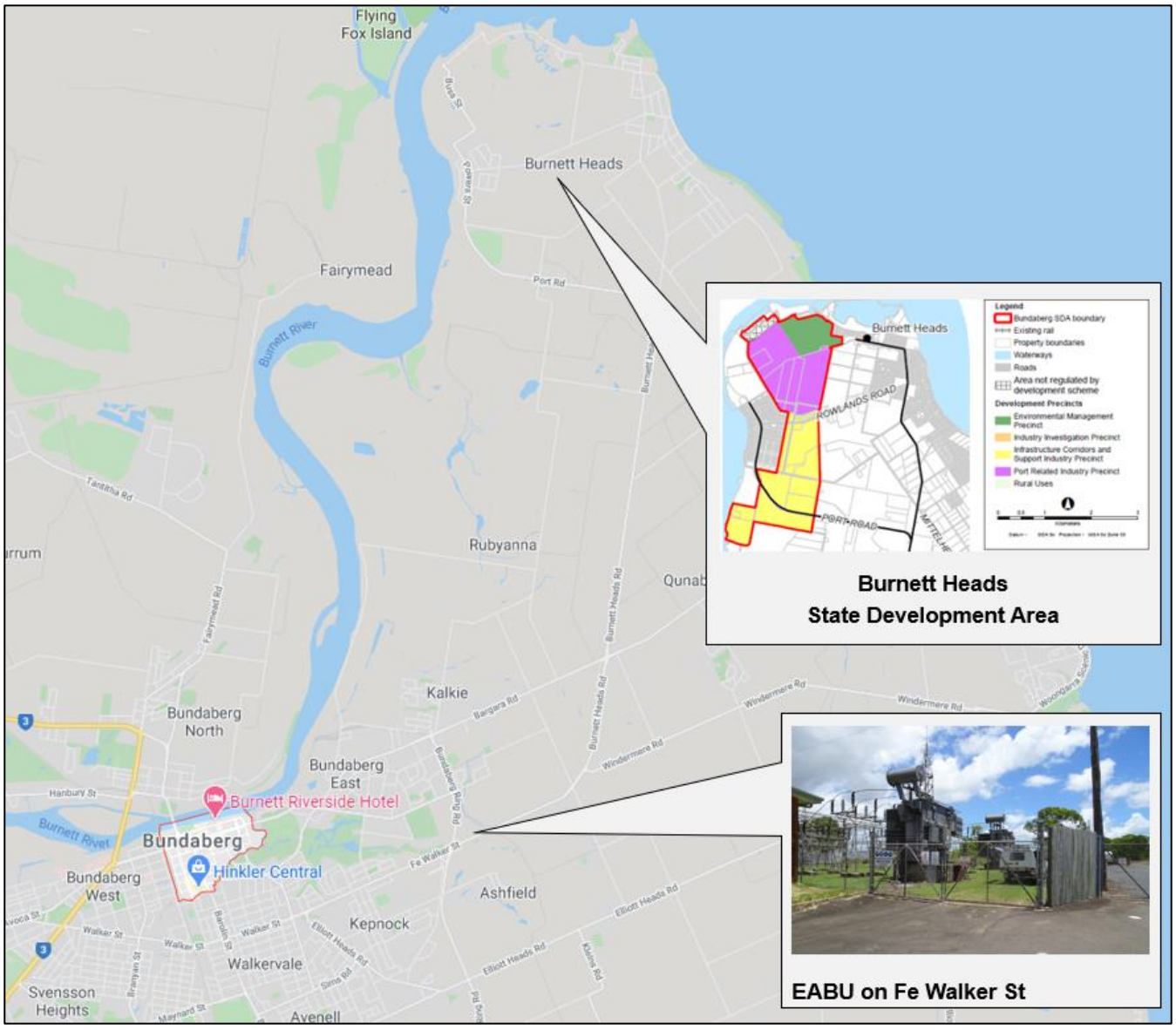


Figure 1: EABU substation to the east of Bundaberg City

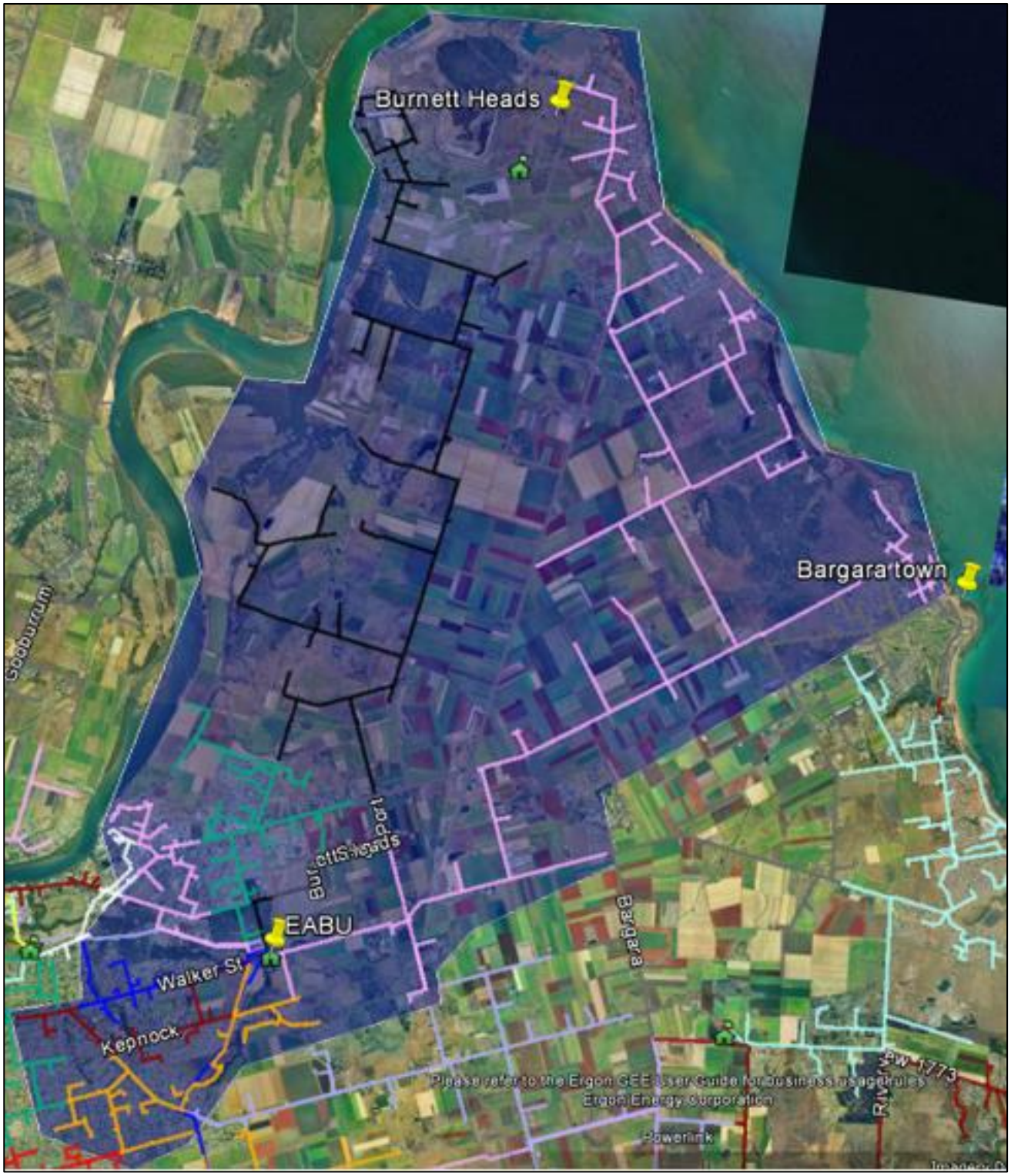


Figure 2: East Bundaberg 11kV distribution network

2.1 Existing Supply System

EABU is equipped with two 12/16MVA 66/11kV transformers, 66kV outdoor bus, two 66kV feeder bays, two 66kV transformer bays, and an indoor 11kV switchboard. The 11kV switchboard consists of two buses with one bus tie circuit breaker (normally closed) and eight 11kV distribution feeder bays. There are two 11kV 2.5MVAr capacitor banks (2.5MVAr each) connected to each 11kV bus via distribution feeder bays (Walker St and Steptoe Rd). See **Figure 3** below for the single line representation of EABU substation.

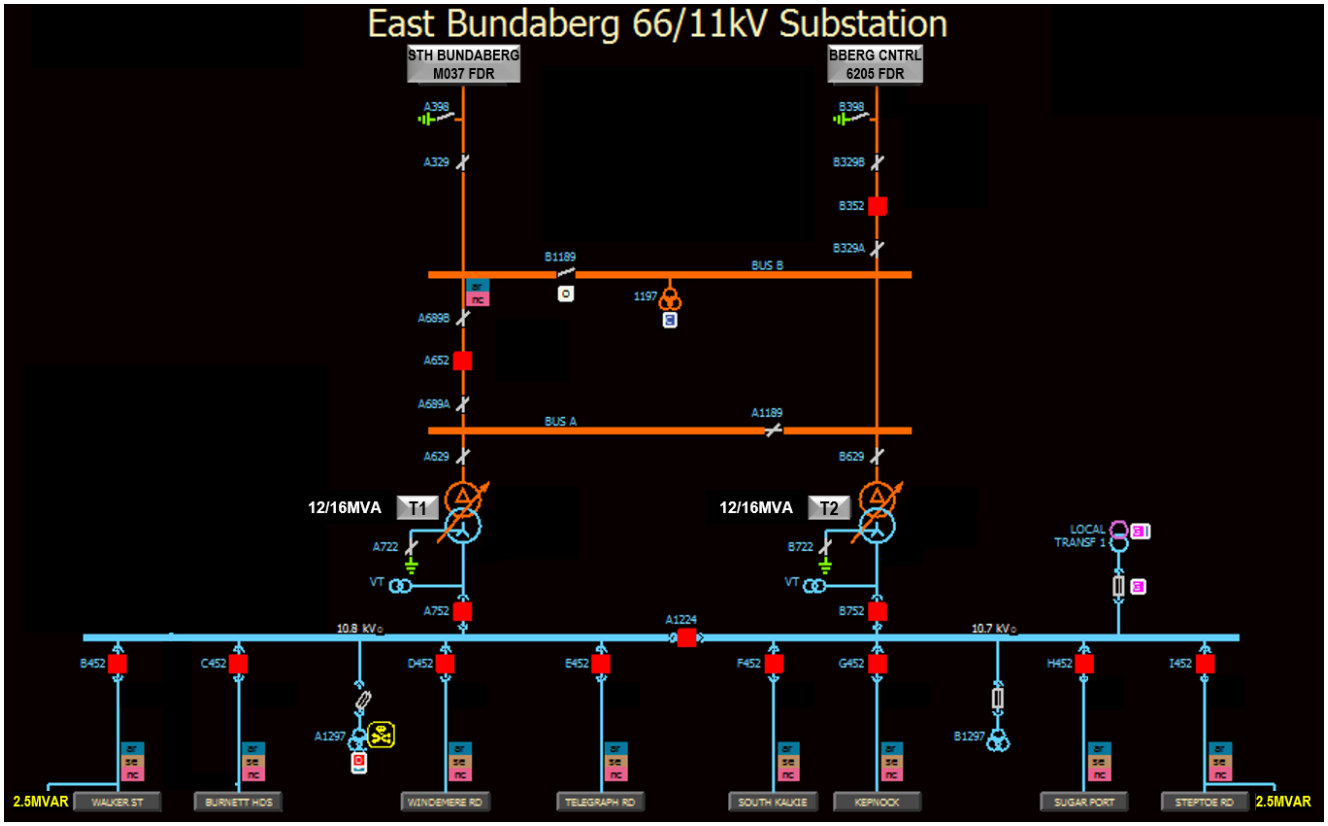


Figure 3: Single line diagram of EABU

2.2 Load profile and demand forecast

EABU is historically Summer Evening peak with a typical residential load profile. The 2019 peak demand was 18.85MVA[4].

Table 1 below shows the transformer ratings at EABU substation. The load can be supplied by the substation with both transformers T1 and T2 operating in parallel. However, the load breached the N-1 capacity in September 2019. Refer to Figure 4. As seen in Figure 4, if either transformer is out of service the load exceeds the rating of the 11kV transformer bushings.

Table 1: EABU transformer ratings

ZS	Tx	Nameplate Rating (MVA)	kV	YOM	Cooling	NCC	ECC	11kV bushing A (MVA)
EABU	1	12/16	66/11	1979	ONAN/ONAF	17.3	20.4	850A (16.2MVA)
EABU	3	12/16	66/11	1979	ONAN/ONAF	17.3	20.4	850A (16.2MVA)

[4] SIFT 47-2020 Base Forecast, 2019 SN 18.85MVA as per data 14 Oct 2020.

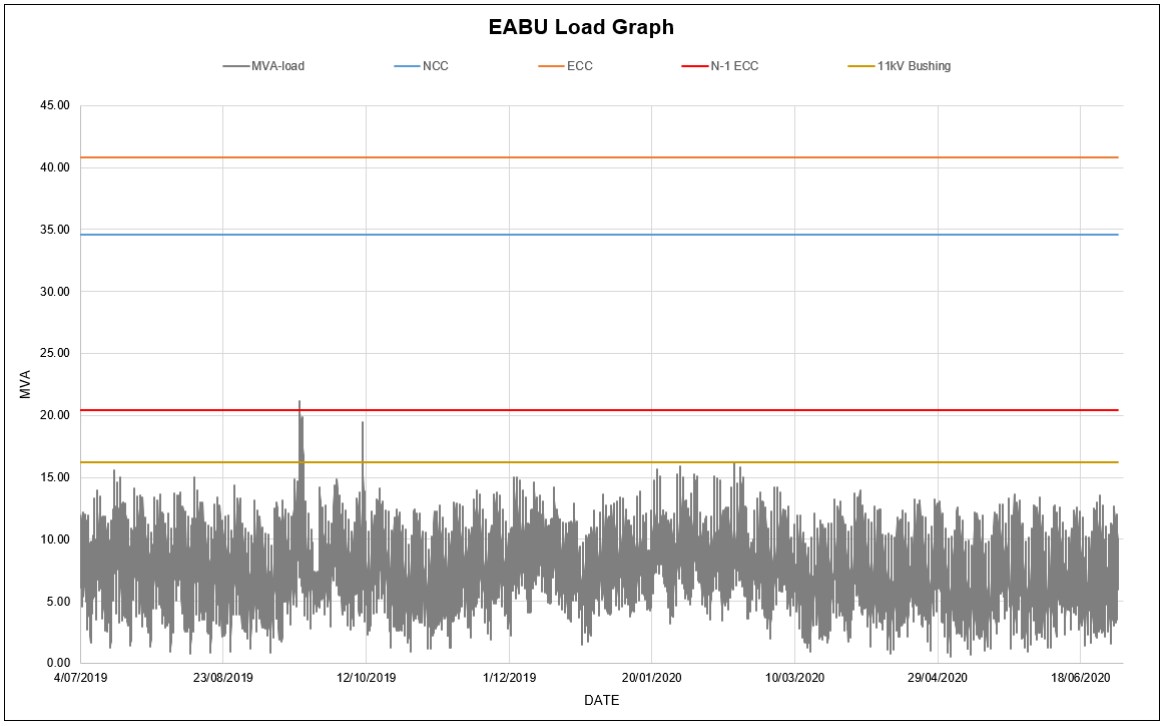
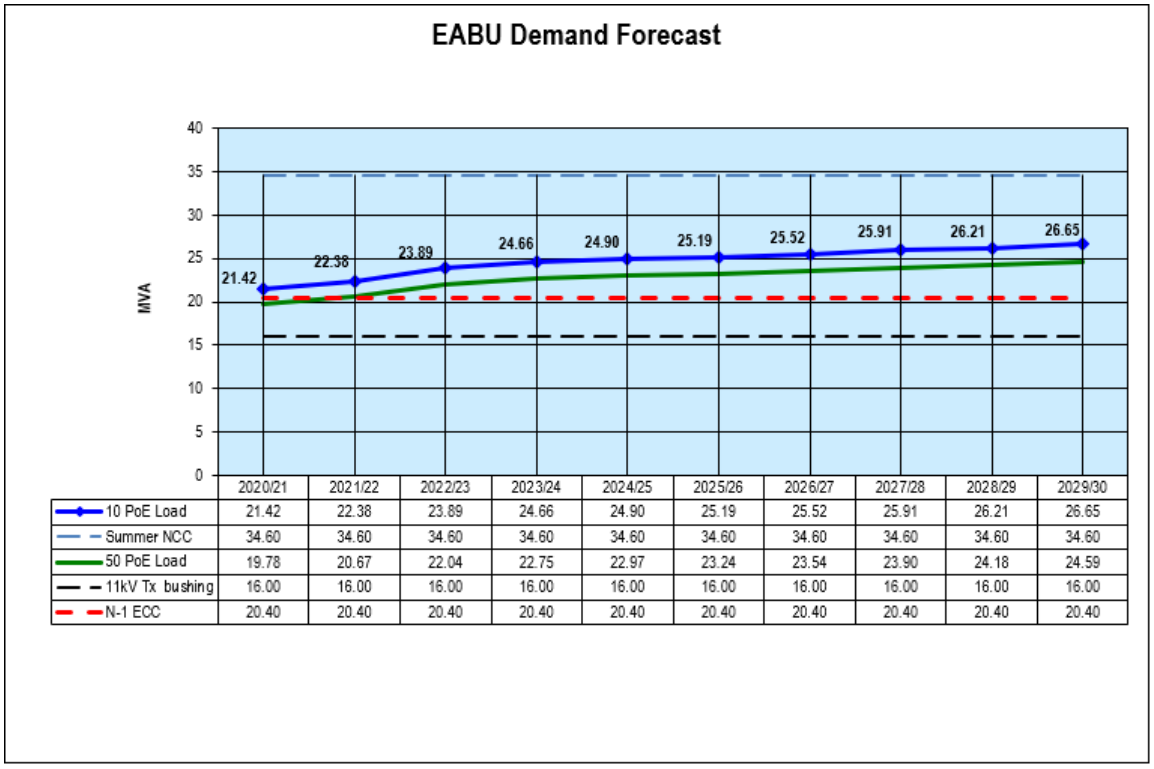


Figure 4: EABU substation historical load for the year 2019

Bundaberg Regional Council (BRC) has previously advised Ergon Energy that they consider the East Bundaberg and coastal areas as key zones for growth. There are a number of block loads already connected to the East Bundaberg distribution network with a number of pending loads in various stages of the connection process. The demand forecast[5] in **Figure 5** shows it will continue to exceed the N-1 ECC and the rating of the 11kV transformer bushings for the next 10 years.



	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30
10 PoE Load	21.42	22.38	23.89	24.66	24.90	25.19	25.52	25.91	26.21	26.65
Summer NCC	34.60	34.60	34.60	34.60	34.60	34.60	34.60	34.60	34.60	34.60
50 PoE Load	19.78	20.67	22.04	22.75	22.97	23.24	23.54	23.90	24.18	24.59
11kV Tx bushing	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
N-1 ECC	20.40	20.40	20.40	20.40	20.40	20.40	20.40	20.40	20.40	20.40

Figure 5: EABU substation forecast

[5] Substation Information Forecast Tool (SIFT) @ 10POE 47-2020 Base Forecast

3. Identified Need

3.1 Description of the Identified Need

The identified need for investment is to address the risk of non-compliance with Safety Net targets as a result of assets approaching their end of life in order to maintain the reliable and safe supply of electricity in the East Bundaberg area.

3.1.1 Safety Net non-compliant

The Safety Net targets applicable to Ergon Energy are shown in Table 2. EABU is classed regional centre.

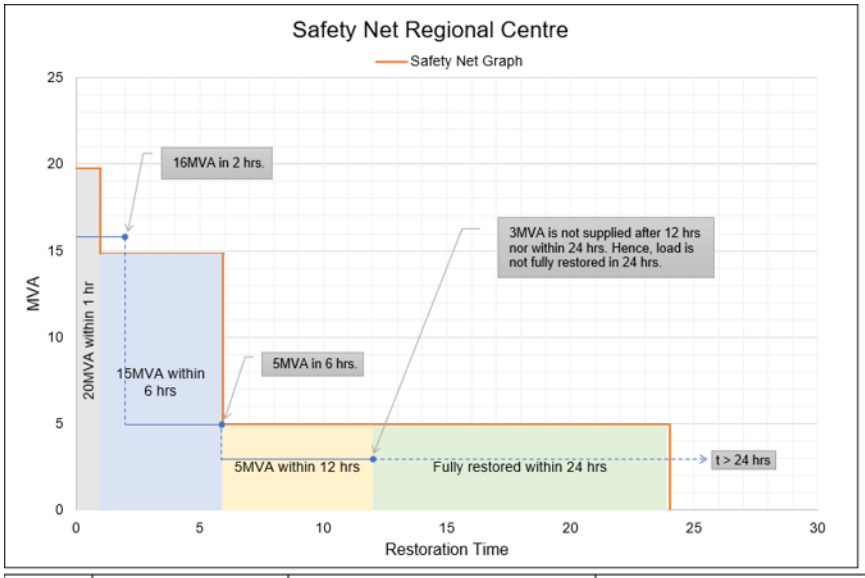
Ergon Energy has determined that EABU is not compliant with Safety Net for a credible contingency of the loss of either a 66kV transformer bay or the bus zone. Refer to Appendix 9.1.

Table 2: Safety Net restoration timeframe.

Safety Net targets for restoration of supply following a credible contingency event	
Regional Centre	**Rural Area**
Less than 20MVA (5000 customers) after 1 hour;	Less than 20MVA (7700 customers) after 1 hour;
Less than 15MVA (3600 customers) after 6 hours;	Less than 15MVA (5800 customers) after 8 hours;
Less than 5MVA (1200 customers) after 12 hours; &	Less than 5MVA (2000 customers) after 18 hours; &
Fully restored within 24 hours.	Fully restored within 48 hours.

Using the demand forecast to date, a Safety Net review at EABU shows that it is not compliant. For a fault either on the 66kV bus or on one of the transformers, a total loss of supply will occur to the entire substation. This is due to the bus and circuit breaker arrangement that requires a total outage to isolate the faulted plant.

The load that can be supplied under fault conditions is limited to 16.2MVA due to the rating of the 11kV transformer bushings. This will result in a Safety Net breach as restoration cannot be achieved within the 1-hour timeframe due to manual switching. The absence of the bus section breaker adds to the limitation of not being able to isolate the fault and energise half of the bus.



	MVA	Time (hr)	SN Compliant?
N-1 capacity	16		
Load supplied by T1 or T2	16	2	
Load transfer	5	6	

Say by 2023 forecast, i.e. 24MVA:			
Load supplied by T1 or T2	16	2	No
Load transfer	5	6	Yes
Load not supplied	3	>24	No
Fully restored in 24 hrs?			No
Temporary generation is required to supply 3MVA and it would take >24 hours to get it up and running on-site.			

Safety Net compliance: NOT COMPLIANT

Max Demand	Contingency	Consequence	Actions	MVA Supplied	SN Restoration Time	Typical Time	SN Compliant?
24MVA by 2023	Fault on either transformer 66/11kV.	Total loss of supply at EABU.	▪ Manual switching of disconnects to isolate faulty transformer. ▪ Close 66kV CB to restore supply through healthy transformer.	16	1 hr	2 hr	No
			▪ Transfer load via 11kV tie feeders.	5	6 hr	6	Yes
		MVA still to be supplied = 24-16-5 = 3	▪ Temporary generation is required to supply 3MVA but will take more than 12 hrs. Full restoration will take >24 hrs.	3	12	> 12 hr	No
			Full restoration:		24	> 24 hrs	No
	Fault on 66kV bus.	Total loss of supply at EABU.	▪ Manual switching of disconnects to isolate bus fault. ▪ Close 66kV CB to restore supply through healthy transformer.	16	1 hr	2	No
			▪ Transfer load via 11kV tie feeders.	5	6 hr	6	Yes
		MVA still to be supplied = 24-16-5 = 3	▪ Temporary generation is required to supply 3MVA but will take more than 12 hrs. Full restoration will take >24 hrs.	3	12	> 12 hr	No
			Full restoration:		24	> 24 hrs	No

Figure 6: Safety Net assessment of EABU to show it is not compliant based on 2023 forecast.

3.1.2 Asset near end of service life

A substation condition assessment report (SCAR) was completed on EABU in early 2019 which identified that several assets require replacement between 2022 and 2028**.**

- **Circuit breaker B352 66kV**

Asset Description	Replacement Reason	Age	Estimated Retirement Year
WB EABU B352 - CB92860234 1971 66kV - DELLE > HPGE 9-12E (109/850)	Problematic	48	2022

The Delle CB is problematic where the main issue is slow opening times or non-operation of the equipment resulting in the backup protection to clear the fault. This CB has had oil leaks and multiple corrective maintenance done in the past to remediate the problems with the CB.

This CB is recommended for replacement in the next five years.

- **Circuit breaker A652 66kV**

Asset Description	Replacement Reason	Age	Estimated Retirement Year
WB EABU A652 - CB93092786 1965 66kV - DELLE > HPGE 9-12E (109/392)	Problematic	54	2021

This is the same make as CB B352, i.e. Delle. It is notoriously slow to operate resulting in the backup protection to clear the fault. This CB has had oil leaks and has had oil changes and multiple corrective maintenance done on it in the past to remediate the problems with the CB.

This CB is recommended for replacement in the next five years.

- **Transformer T1**

Asset Description	Replacement Reason	Age	Estimated Retirement Year
WB EABU T1 - TR92482802 1979 66/11 kV 16MVA GEC (A32K3042/1)	Furfural	40	2022

Dissolved gas analysis (DGA) of T1 shows a high level of Furans indicating degradation in the paper insulation. Transformer T1 has a history of oil leaks, and extra corrective maintenance has been periodically undertaken to fix the leaks. Also, the 66kV T1 surge arresters are 1987 ASEA type which are nearing the end of service life.

The recommendation is to replace Transformer T1 and 66kV surge arresters altogether.

3.1.3 Lack of transformer oil containment

Transformers T1 and T2 are on plinths and do not have oil containment (or bunding) and this does not comply with AS2067[6]. Refer to **Figure 7**.

Figure 7: Transformers T1 and T2 on plinth with no bunding.

[6] AS2067:2016 Substations and High Voltage Installations, 6.8.1 Oil containment, "*transformer insulating oil shall have provision for containing the total volume of any possible leakage"*, page 91.

3.1.4 Insufficient protection scheme

Transformers T1 and T2 both have single transformer differential protection only and this does not comply with the current protection standard[7] of Ergon Energy which requires main and backup transformer differential protection. Similarly, there is only single 66kV bus zone protection.

3.1.5 66kV bus is corroded

The 66kV bus was constructed in the 1960s era with galvanised pipe and shows a significant amount of corrosion. Corrosion impacts on both electrical and structural integrity of the 66kV bus.

3.1.6 Insufficient rating of transformer bushing and 11kV cable

The 11kV transformer bushings have a rating of 850A (16.2MVA) and the 11kV transformer cables have a rating of 861A (16.4MVA) when ambient temperature reaches 30° C. These will be overloaded if one transformer becomes faulty as demonstrated in Figure 8. The load duration curve shows that the 11kV bushings and 11kV transformer cable are overloaded if one of the transformers is out of service due to a fault.

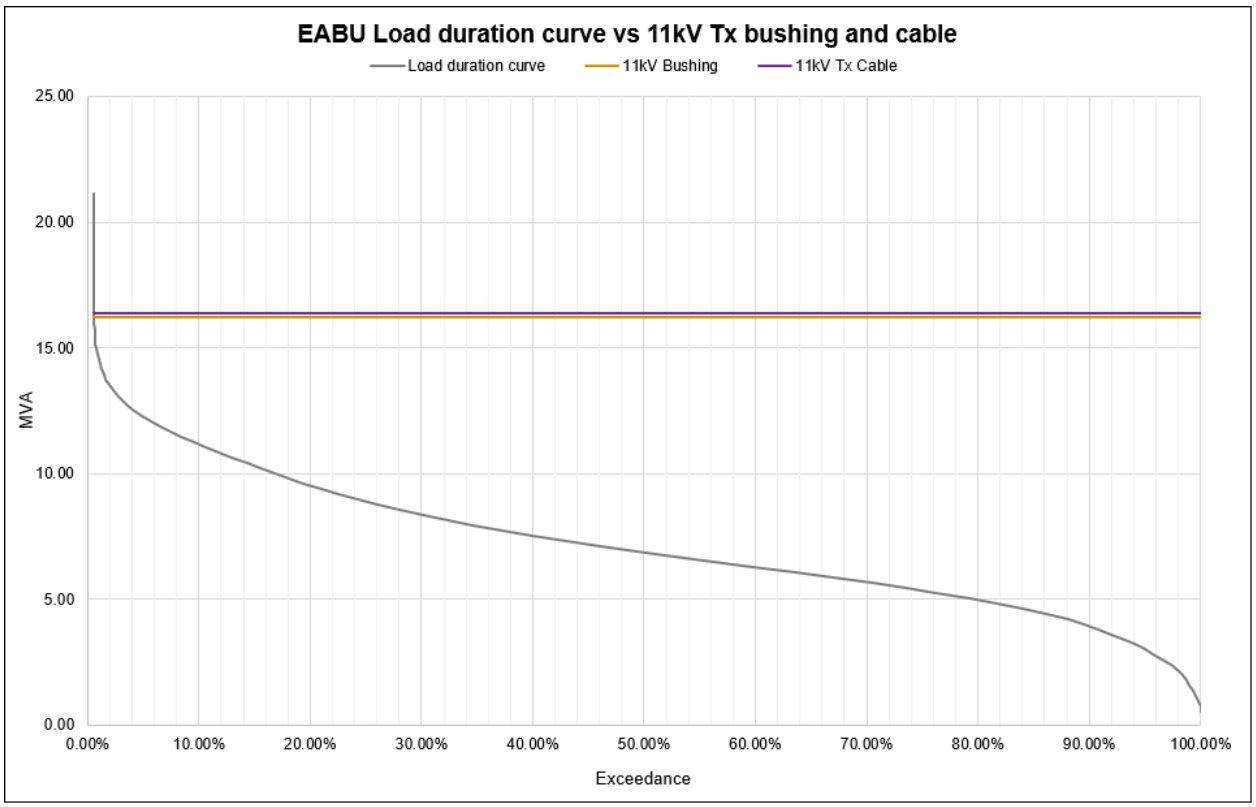


Figure 8: EABU load duration curve.

3.1.7 Substation security fence non-compliant to AS2067

A review of the existing substation security fence has indicated several shortcomings which are a high priority. A number of security measures need to be installed at this site and the substation fence needs to be replaced to comply with AS2067[8]. The existing fence is shown in Figure 9.

[7] STNW1002 Standard for Substation Protection, 7.6.6.2 Power transformers greater than 6.3MVA, "*power transformers with rating above 6.3MVA a duplicated differential protection scheme shall be employed*", page 16.
[8] AS2067:2016 Substations and High Voltage Installations, 5.2.8 External fences or walls and access doors, (…) *fence shall be at least 2500 mm*

Figure 9: EABU existing security fence.

3.2 Quantification of the Identified Need

- **Safety Net non-compliant**

The primary objective of this investment is to address the Safety Net non-compliance.

- **Ageing plant**

The second objective of this investment is to address the risk to the network, plant and personnel from operating such plant which is at the end of its lifecycle (lifecycle of an asset being the year of its manufacture, operational conditions and its condition assessment towards the recommended end of service life).

- **Environmental impact**

The third objective is to minimize oil contamination to the environment hence comply with AS2067[9]. The oil containment system is a bund wall that contains the unintentional escape of oil until a remedial action can occur.

high (…) top 500 mm of the fence shall be strands of barbed wire (…) at least 4 strands at a maximum of 150 mm apart. Access doors (…) shall be equipped with security locks, page 64.

[9] AS2067:2016, 6.7.4.3 Transformer fire damage control measures, (…) *minimize contamination and damage to the environment by provision of oil containment systems, bunding (…),* page 83.

- **Legislative requirement**

The fourth objective is to comply with the legislative framework for the Safety Net targets issued to Ergon Energy consistent with Clause 10 of the Distribution Authority.

- **Protection Duplication**

Another objective of this investment is to comply with the current protection standards by providing a main and backup transformer and 66kV bus zone protection.

- **Risk management**

The final objective of the investment in this part of the network is to mitigate all risks identified to ALARP. Refer to Appendix 9.1.

3.3 Assumptions in Relation to Identified Need

Below is a summary of key assumptions that have been made when the identified need has been analysed and quantified. It is recognised that the below assumptions may prove to have various levels of correctness, and they merely represent a 'best endeavours' approach to predict the future identified need.

- **Load Profile**

Characteristic peak day load profiles shown in section 2 are unlikely to change significantly from year to year, i.e. the shape of the load profile will remain virtually the same with increasing maximum demand.

- **Forecast Maximum Demand**

It has been assumed that peak demand at EABU will grow as per the base case load forecast.

Factors that have been considered when the demand forecast has been developed include the following:

- load history
- known future developments (new major customers, network augmentation, etc.)
- temperature corrected start values (historical peak demands)
- forecast growth rates for organic growth

- **System Capability – Transformer capacity**

Transformer ratings are normally specified by a continuous rating, supplied by the manufacturer on the nameplate. This corresponds to the load that will cause the oil and winding temperature rise to meet the specified limit, assuming a constant temperature and a constant rated load.

Cyclic ratings in excess of nameplate ratings are possible because the typical load cycle is not continuous, nor is the daily temperature cycle. Each transformer also has a typical thermal time constant of a few hours. All these factors are combined to enable cyclic loading of a transformer in excess of the nameplate rating before the temperature limits are reached.

Each transformer has two cyclic ratings for both summer and winter, based on the load profile and the ambient temperature for that transformer location.

- **System Capability – Transfer Capacity**

In times of contingency, for example when one transformer is faulty, load may be transferred to another substation via the distribution network. The distribution network transfer capability is largely determined by the capacity of the powerlines to carry the transferred load as well as their ability to maintain system voltages.

4. No Non-Network Alternatives

Ergon Energy has determined there is no non-network alternative that would be technically viable to address the network risk associated with the poor condition of the existing assets, i.e. Safety Net non-compliance, assets near end of service life, lack of transformer oil containment, insufficient protection scheme, and substation security fence non-compliant to AS2067.

The following non–network solutions have been assessed for either deferring or replacing the network investment required in the East Bundaberg supply area:

- Demand Management (Demand Reduction) such as power factor correction, energy efficiency, load control.
- Demand Response through customer embedded generation, call off load and load curtailment contracts.

The above have been assessed as not technically viable as they will not address the network risk associated with poor condition of the assets.

5. Internal Option Identified

Ergon Energy's preferred internal option is to build a 66kV bus on the adjacent vacant land, build two new 66kV feeder bays and transformer bays, decommission and remove two 66kV circuit breakers, replace transformers T1 and T2 with 15/20MVA transformers and upgrade the protection scheme. The completion of this is required by 2023. There will be further investments required in the following regulatory periods to replace other assets which will reach end of life in the future.

Operating expenses for new infrastructure are typically 1% - 2% of the capital cost. Table 3 provides the approximate anticipated capital cost for the preferred option. It is noted at the time of writing the RIT-D more detailed cost estimates are being performed which may cause some change to the below figures.

Table 3: Ergon Energy's internal cost for the preferred option.

Internal option	Build 66kV yard on adjacent land
ACP	$8,934,664

5.1 Scope of the Preferred Internal Option

The following works are proposed to be carried out as part of the preferred network solution at EABU.

Build 66kV yard on adjacent land by 2023

- Expand the yard to the north to allow a total of four 66kV feeder bays and install fence and earth grid as well as driveway inside (bitumen) and access track outside the new yard.
- Install 66kV bus as well as support structures, two 66kV feeder bays and two transformer bays without transformer circuit breakers in the new yard.
- Install a new bus section circuit breaker between the two new 66kV feeder bays with duplicated 3-terminal transformer differential protection scheme. Decommission the existing 66kV bus protection scheme.
- Install two new 15/20MVA 66/11kV transformers.
- Install new 11kV cables between the new transformers and the 11kV switchboard.
- Cut-in Bundaberg Central and South Bundaberg feeders to the new bays.
- Remove all plant including the 66kV bus in the former Bundaberg Central and South Bundaberg feeder bays as well as two transformer bays.
- Replace existing fence.
- Install electronic security system.

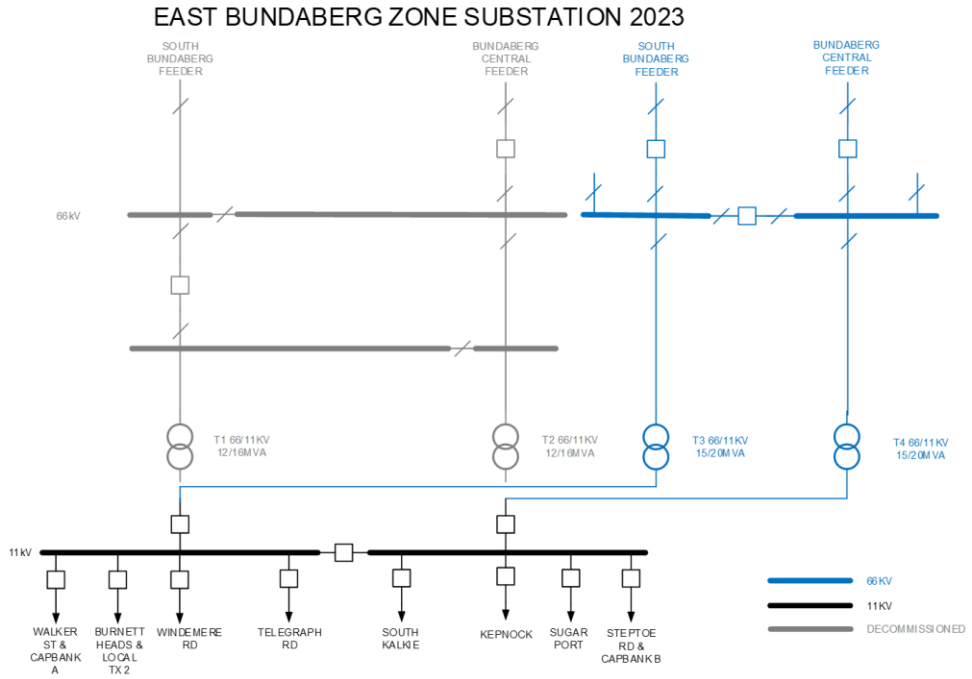


Figure 10: EABU single line diagram with the new 66kV bus on the adjacent land.

5.2 Options considered

- **Option 1 – Rebuild 66kV yard in situ**

This will require the rebuild of the 66kV bus in the same place, install a new 66kV bus tie circuit breaker, decommission and remove two 66kV circuit breakers, replace transformers T1 and T2 with

15/20MVA transformers and upgrade the protection scheme.

Table 4: Indicative cost of Option 1 at the time when a feasible option was being determined.

Option 1				$13,175,350
Year	Stage	Capex	Opex	Cost
2023	1	$3,943,000	$98,575	$4,041,575
2025	2	$600,000	$15,000	$615,000
2029	3	$2,096,000	$52,400	$2,148,400
2031	4	$1,500,000	$37,500	$1,537,500
2039	5	$1,415,000	$35,375	$1,450,375
2040	6	$3,300,000	$82,500	$3,382,500

- **Option 2 – Build 66kV yard on adjacent land**

This will require the build of a new 66kV bus on the adjacent land, build two new 66kV feeder bays and transformer bays, decommission and remove two 66kV circuit breakers, replace transformers T1 and T2 with 15/20MVA transformers and upgrade the protection scheme. **This option is preferred because it is practicably sound and economically optimal. Hence, a more detailed estimate of Option 2 has been performed which amounted to $8,934,664.**

Table 5: Indicative cost of Option 2 at the time when a feasible option was being determined.

Option 2				$12,561,375
Year	Stage	Capex	Opex	Cost
2023	1	$5,300,000	$132,500	$5,432,500
2029	2	$1,442,000	$36,050	$1,478,050
2031	3	$1,300,000	$32,500	$1,332,500
2039	4	$913,000	$22,825	$935,825
2040	5	$3,300,000	$82,500	$3,382,500

- **Option 3 – Rebuild 66kV yard as indoor GIS on adjacent land**

This will require building indoor GIS switchgear. The building will also house the future 11kV switchgear as well as protection and control panels.

Table 6: Indicative cost of Option 3 at the time when a feasible option was being determined.

Option 3				$16,451,250
Year	Stage	Capex	Opex	Cost
2023	1	$12,000,000	$300,000	$12,300,000
2029	2	$350,000	$8,750	$358,750
2031	3	$1,000,000	$25,000	$1,025,000
2039	4	$200,000	$5,000	$205,000
2040	5	$2,500,000	$62,500	$2,562,500

5.3 Financial Analysis

A net present value (NPV) calculation was completed to determine which option is most financially feasible. The NPV is for investment planning to analyse the financial gain of each option. Table 7 shows the result of the NPV across the three options. A positive NPV indicates it is a 'gain' and a negative NPV is a 'loss'. In this instance, the least negative option is the most feasible.

Table 8 shows the cash flow over the service life of the asset and the timing of every stage. The Monte Carlo analysis confirms that Option 2 is the most feasible option, Table 9.

Table 7: NPV results of the three options.

Results displayed in $000s					
WEIGHTED AVERAGE RESULT ACROSS ALL SCENARIOS					
AVERAGE Option	Option Name	Rank	Net NPV	Capex NPV	Opex NPV
1	Rebuild 66kV yard in situ	2	**-15,891**	-9,694	-6,197
2	Build 66kV yard on adjacent land	1	**-15,536**	-9,456	-6,080
3	Rebuild 66kV yard as indoor GIS on adjacent land	3	**-22,679**	-13,684	-8,995

Table 8: Cash flow over the service life of the asset and the timing of every stage.

Option	Option Name	Stage	Timing	Equipment &/or Asset	Life	CAPEX	OPEX	NPV Result in $000s			
								Rank	Net NPV	Capex NPV	Opex NPV
1	Rebuild 66kV yard in situ	1	2023	Transformer	45	$3,943,000	$98,575	2	-15,891	-9,694	-6,197
		2	2025	Isolator	45	$600,000	$15,000				
		3	2029	Feeder bay	45	$2,096,000	$52,400				
		4	2031	Protection	20	$1,500,000	$37,500				
		5	2039	Feeder bay	45	$1,415,000	$35,375				
		6	2040	Switchboard	45	$3,300,000	$82,500				
2	Build 66kV yard on adjacent land	1	2023	Transformer	45	$5,300,000	$132,500	1	-15,536	-9,456	-6,080
		2	2029	Feeder bay	45	$1,442,000	$36,050				
		3	2031	Protection	20	$1,300,000	$32,500				
		4	2039	Feeder bay	45	$913,000	$22,825				
		5	2040	Switchboard	45	$3,300,000	$82,500				
3	Rebuild 66kV yard as indoor GIS on adjacent land	1	2023	Transformer	45	$12,000,000	$300,000	3	-22,679	-13,684	-8,995
		2	2029	Feeder bay	45	$350,000	$8,750				
		3	2031	Protection	20	$1,000,000	$25,000				
		4	2039	Feeder bay	45	$200,000	$5,000				
		5	2040	Switchboard	45	$2,500,000	$62,500				

Table 9: Monte Carlo NPV results.

MONTE CARLO NPV ANALYSIS							
PROJECT:	East Bundaberg Asset Replacement						
Results displayed in $000s							
COMBINED RESULTS ACROSS ALL SCENARIOS							
COMBINED Option	Option Name	Rank	Average NPV	Maximum NPV	Minimum NPV	Best NPV	Worst NPV
1	Rebuild 66kV yard in situ	2	**-15,918**	-15,059	-16,811	17.2%	0.0%
2	Build 66kV yard on adjacent land	1	**-15,509**	-14,571	-16,521	82.8%	0.0%
3	Rebuild 66kV yard as indoor GIS on adjacent land	3	**-22,630**	-21,056	-24,662	0.0%	100.0%

6. Market Benefits

The purpose of the RIT-D is to identify the option that maximises the present value of net market benefits to all those who produce, consume and transport electricity in the National Electricity Market (NEM). Consistent with NER clause 5.17.1(c)(4), Ergon Energy has considered the following classes of market benefits:

- Changes in voluntary load curtailment;
- Changes in involuntary load shedding and customer interruptions caused by network outages using a reasonable forecast of the value of electricity to customers;
- Changes in costs for parties other than the RIT-D proponent due to differences in the timing of new plant, capital costs, and operating and maintenance costs;
- Differences in the timing of expenditure;
- Changes in load transfer capacity and the capacity of embedded generators to take up load;
- Any additional option value (where this value has not already been included in the other classes of market benefits) gained or foregone from implementing the credible option with respect to the likely future investment needs of the NEM;
- Changes in electrical energy losses.

6.1 Changes in Voluntary Load Curtailment

None of the options considered in this RIT-D include any voluntary load curtailment. There are no customers on such arrangements in the Bundaberg area at the moment. Any market benefits associated with changes in voluntary load curtailment have not been considered.

6.2 Changes in Involuntary Load Shedding

A reduction in involuntary load shedding is expected from all the credible options presented in this report. The fact is that the aged substation assets present an area wide level of risk to the supply network. The benefits from changes in involuntary load shedding have not been quantified and considered in this report because they are not so significant as to impact the financial ranking of feasible options.

6.3 Changes in costs to Other Parties

Ergon Energy does not anticipate that any of the credible options included in this RIT-D assessment will affect costs incurred by other parties.

6.4 Differences in Timing of Expenditure

None of the credible options included in this RIT-D assessment is expected to affect the timing of other distribution investments for unrelated identified needs.

6.5 Changes in Load Transfer Capacity

None of the options included in this RIT-D assessment are expected to affect the load transfer capacity in the East Bundaberg area.

6.6 Option Value

The AER's view is that option value is likely to arise where there is uncertainty regarding future outcomes, the information that is available in the future is likely to change, and the credible options considered by the RIT-D proponent are sufficiently flexible to respond to that change.

Ergon Energy does not consider that the identified need for the options included in this RIT-D would be affected by uncertain factors about which there may be more clarity in the future.

6.7 Changes in Network Losses

Ergon Energy does not anticipate that any of the credible options included in the RIT-D assessment will lead to any significant change in network losses.

7. Conclusion

This Final Project Assessment Report represents the final stage of the RIT-D process to address the identified need at EABU.

Ergon Energy intends to take steps to progress the recommended solution(s) to ensure any statutory non-compliance is addressed and undertake appropriately justified network reliability improvements as necessary.

7.1 Preferred Option

Ergon Energy's preferred internal solution is to build a new 66kV bus on the adjacent land, build two new 66kV feeder bays and transformer bays, decommission and remove two 66kV circuit breakers, replace transformers T1 and T2 with 15/20MVA transformers and upgrade the protection scheme. These works are required to be completed by 2023. The estimated total capital cost is $8.935M.

7.2 Satisfaction of the RIT-D

The proposed preferred option satisfies the RIT-D. This statement is made on the basis of the detailed analysis set out in this report. The proposed preferred option is the credible option that has the highest net economic benefit under the most likely reasonable scenarios.

8. Compliance Statement

This Final Project Assessment Report complies with the requirements of NER section 5.17.4(j) as demonstrated below:

Requirement	Report Section
(1) a description of the identified need for investment;	3.1
(2) the assumptions used in identifying the identified need (including, in the case of proposed reliability corrective action, why the RIT-D proponent considers reliability corrective action is necessary);	3.3
(3) if applicable, a summary of, and commentary on, the submissions received on the NNOR;	NA
(4) a description of each credible option assessed	5.2
(5) where a *Distribution Network Service Provider* has quantified market benefits in accordance with clause 5.17.1(d), a quantification of each applicable market benefit of each credible option	NA
(6) a quantification of each applicable cost for each credible option, including a breakdown of operating and capital expenditure	5.2, 0
(7) a detailed description of the methodologies used in quantifying each class of costs or market benefit	NA
(8) where relevant, the reasons why the RIT-D proponent has determined that a class or classes of market benefits or costs do not apply to a credible option	6
(9) the results of an NPV analysis of each credible option and accompanying explanatory statements regarding the results	0
(10) the identification of the proposed preferred option	5.2, 7.1
(11) or the proposed preferred option, the RIT-D proponent must provide: (i) details of the technical characteristics; (ii) the estimated construction timetable and commissioning date (where relevant); (iii) the indicative capital and operating costs (where relevant); (iv) a statement and accompanying analysis that the proposed preferred option satisfied the RIT-D; and (v) if the proposed preferred option is for reliability corrective option and that the option has a proponent, the name of the proponent	5.2 7.2
(12) contact details for a suitably qualified staff member of the RIT-D proponent to whom queries on the draft report may be directed.	1.3

9. Appendices

9.1 Safety Net Assessment

Table 10: EABU forecast and load at risk.

Year	50 POE load (MVA)	Block loads (MVA)	50 POE with block loads (MVA)	N-1 (MVA)	50 POE LAR (MVA)	Transfers (MVA)	Residual LAR (MVA)
2017/18 (Actual)	19.5	-	-	16.20	3.3	5	0
2018/19	19.59	0.64	20.23	16.20	4.03	5	0
2019/20	19.37	3.25	22.62	16.20	6.42	5	1.42
2020/21	19.74	4.25	23.99	16.20	7.79	5	2.29
2021/22	20.29	4.45	24.74	16.20	8.54	5	3.54
2022/23	20.45	7.66	28.11	16.20	11.91	5	6.91
2023/24	20.64	7.66	28.3	16.20	12.10	5	7.10
2024/25	20.79	7.66	28.44	16.20	12.24	5	7.24
2025/26	21.3	7.66	28.96	16.20	12.76	5	7.76
2026/27	21.34	7.66	29	16.20	12.80	5	7.80

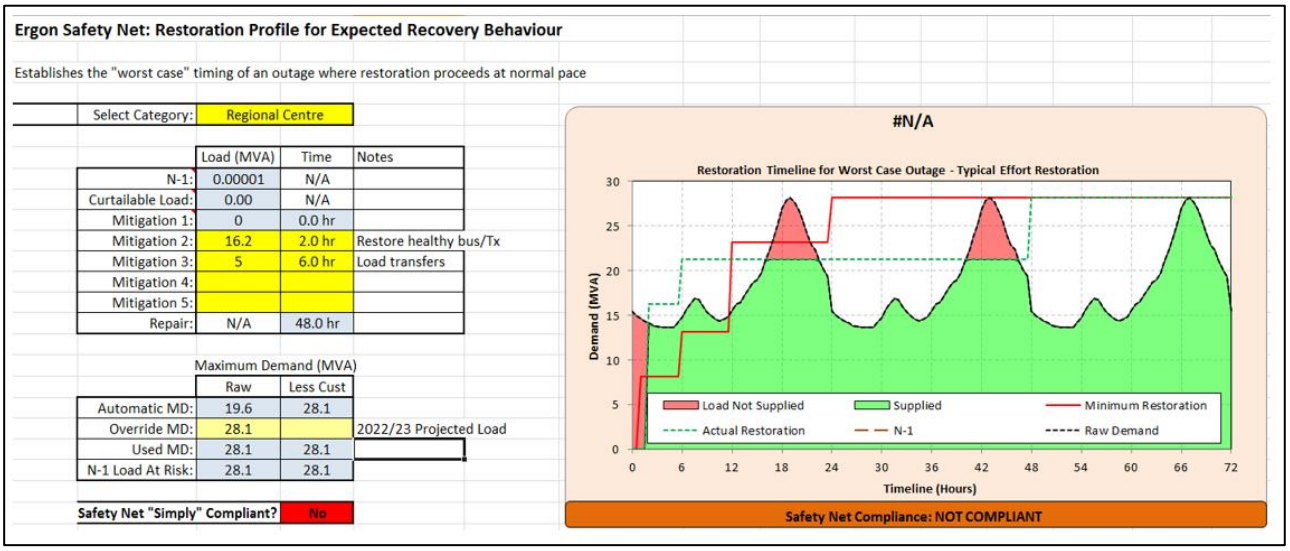


Figure 11: Safety Net assessment done in 2018/19.

9.2 Risk Assessment at EABU

Table 11: Risk assessment at EABU sourced from the project scope statement.

Risk Scenario (Untreated)	Risk Type	Inherent/Untreated Risk			Target (Residual)		Risk Year
		C	L	Risk Score	L	Risk Score	
Multiple serious injuries to staff as a result of explosive failure of the CB's, transformers and SD's ejecting porcelain debris due to insulation breakdown	Safety	4	2	8 (Low Risk)	1	4 (Very Low) ALARP	2022
Outage to ~8500 customers due to 66kV bus zone trip as a result of the slow operation of the Delle CB for a fault on 66kV Bundaberg Central or South Bundaberg feeder.	Customer Impact	3	3	9 (Low Risk)	1	3 (Very Low) ALARP	2022
Outage to multiple essential services due to 66kV bus zone trip as a result of the slow operation of the Delle CB for a fault on 66kV Bundaberg Central or South Bundaberg feeder.	Customer Impact	4	3	12 (Moderate Risk)	1	4 (Very Low) ALARP	2022
Outage to multiple essential services due to both transformers tripping off as a result of the transformer T1 fault and absence of the transformer 66kV CB or 66kV bus section CB.	Customer Impact	4	4	16 (Moderate Risk)	1	4 (Very Low) ALARP	2022
Inability to restore load above 20MVA within one hour as stipulated in the Safety Net requirement after a full substation outage as a result of the transformer T1 fault due to absence of the 66kV bus section CB.	Legislated Requirements	4	4	16 (Moderate Risk)	1	4 (Very Low) ALARP	2022
Oil spill of ~15000 litres as a result of transformer tank rupture due to absence of transformer bunding and oil containment system	Environment	5	2	10 (Low Risk)	1	5 (Very Low) ALARP	2020
Absence of adequate protection schemes of 66kV bus and 66/11kV transformers due to not containing a backup protection relay.	Legislated Requirements	4	3	12 (Moderate Risk)	1	4 (Very Low) ALARP	2020
Breach of Ergon protection standard that requires duplicate protection schemes on the subtransmission network due to protection schemes of 66kV bus and 66/11kV transformers not containing a backup protection relay.	Business Impact	3	5	15 (Moderate Risk)	1	3 (Very Low) ALARP	2020
Single fatality to a member of public as a result of presence in the vicinity of a line to ground fault on an 11kV feeder while the fault not being cleared in a timely manner due to the feeder protection relay being faulty of loss of DC supply and absence of adequate backup protection from the upstream network.	Safety	5	2	10 (Low Risk)	1	5 (Very Low) ALARP	2020
Single fatality to a member of public as a result of breaking into the substation yard and contacting live HV part due to inadequate fencing as well as security monitoring and detection system.	Safety	5	2	10 (Low Risk)	1	5 (Very Low) ALARP	2020
Ergon receiving improvement notice from authority as a result of a member of public breaking into the substation yard.	Legislated Requirements	4	3	12 (Moderate Risk)	1	4 (Very Low) ALARP	2020

9.3 Ergon Energy's Minimum Service

The legislated System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI) limits from Ergon Energy's Distribution Authority are detailed in **Table 12**.

Table 12: SAIDI (minutes per customer) and SAIFI (interruptions per customer) limits.

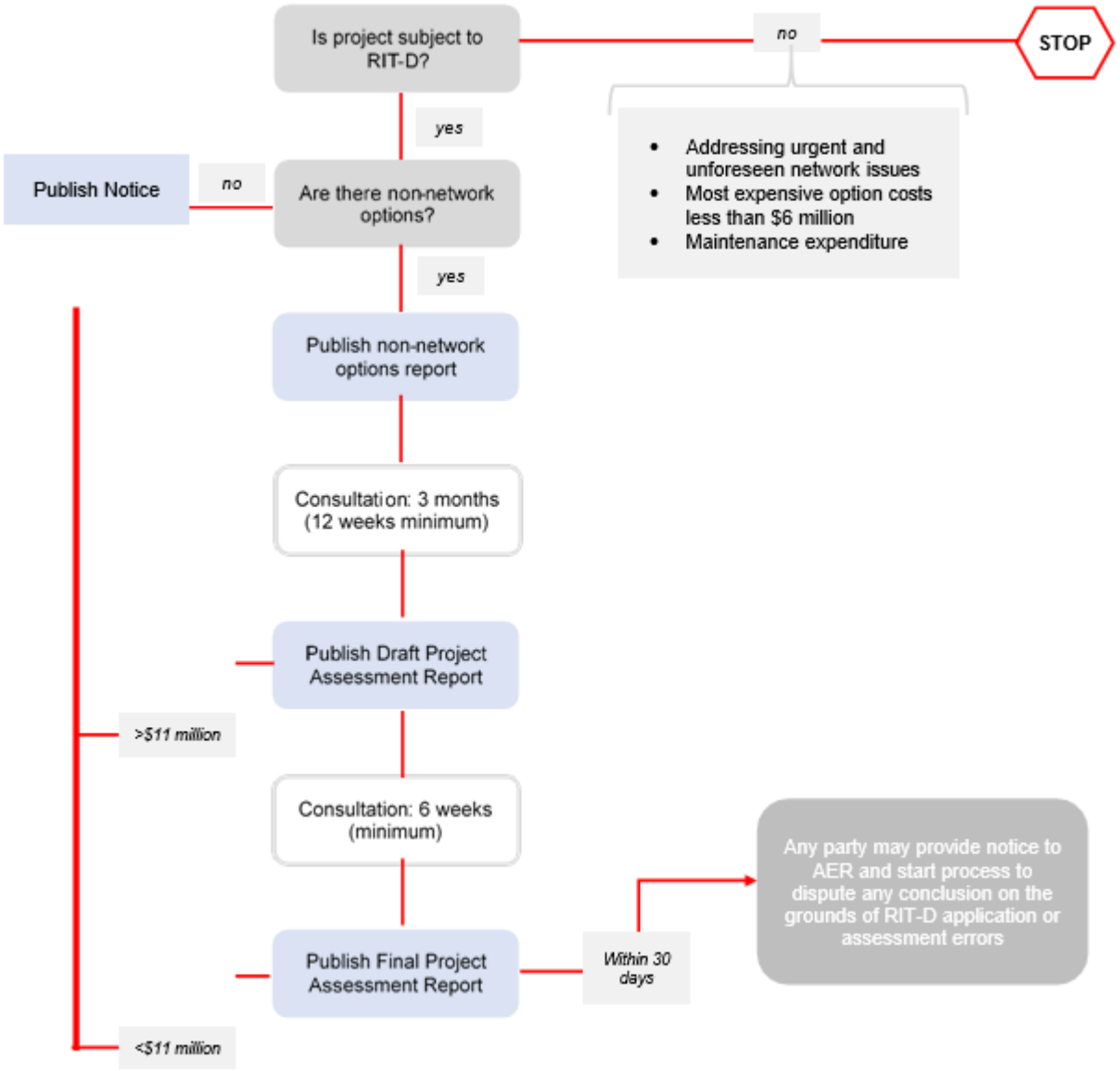
Feeder Category	SAIDI MSS Limit	SAIFI MSS Limit
Urban	149	1.98
Short Rural	424	3.95
Long Rural	964	7.40

The legislated Safety Net Targets from Ergon Energy's Distribution Authority are provided in Table 6. East Bundaberg is classified a 'Rural Area'.

Table 13: Ergon Energy Safety Net Targets

Area	Targets (for restoration of supply following an N-1 Event)
Regional Centre	Following an N-1 event, load not supplied must be: ○ Less than 20 MVA after 1 hour; ○ Less than 15 MVA after 6 hours; ○ Less than 5 MVA 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 after 1 hour; ○ Less than 15 MVA after 8 hours; ○ Less than 5 MVA after 18 hours; and ○ Fully restored within 48 hours.
Note: All modelling and analysis will be benchmarked against 50 POE loads and based on credible contingencies. 'Regional Centre' relates to larger centres with predominantly urban feeders. 'Rural Areas' relates to areas that are not Regional Centres.	

9.4 The RIT-D Process



9.5 Glossary of Terms

Abbreviation	Description
ACP	Approved Cost Plan
ALARP	As Low as Reasonably Practicable
ASEA	Allmänna Svenska Elektriska Aktiebolaget (or General Swedish Electrical Limited Company)
CB	Circuit Breaker
CBRM	Condition Based Risk Management
DGA	Dissolved Gas Analysis
EABU	East Bundaberg substation 66/11kV
ECC	Emergency cyclic capacity
kV	kilovolts
MVA	Megavolt-ampere
N-1 ECC	Capacity available when the largest transformer fails
NCC	Normal cyclic capacity
NEF	Neutral earth fault
NER	National Electricity Rules
ONAF	Oil natural air forced
ONAN	Oil natural air natural
POE	Probability of exceedance
ppm	Parts per million
REF	Restrictive earth fault
RIT-D	Regulatory Investment Test for Distribution
SCAR	Substation Condition Assessment Report
SEF	Sensitive earth fault
VT	Voltage transformer
YOM	Year of manufacture
ZS	Zone Substation (or simply substation)