Upgrade Chinchilla Zone Substation

Business Case

17 January 2024

Part of Energy Queensland

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DOCUMENT VERSION

Version Number	Change Detail	Date	Updated by
1.0	Review	08/12/2023	Principal Planning Engineer
2.0	Endorsed	08/12/2023	Manager Sub-Transmission Planning
3.0	Approved	13/12/2023	General Manager Grid Planning

1 SUMMARY

<table>
<tr><th>Title</th><th>Upgrade Chinchilla Zone Substation</th></tr>
<tr><td>DNSP</td><td>Ergon Energy</td></tr>
<tr><td>Expenditure category</td><td>☒ Replacement ☒ Augmentation ☐ Connections ☐ Tools and Equipment
☐ ICT ☐ Property ☐ Fleet</td></tr>
<tr><td>Identified need
(select all applicable)</td><td>☐ Legislation ☐ Regulatory compliance
☒ Reliability ☒ CECV ☒ Safety ☐ Environment ☐ Financial
☐ Other

Chinchilla Town (CHTW) and Chinchilla Skid (CHSK) 33/11kV substations are critical to the supply of the Chinchilla area, supplying 3,532 customers and 46.1GWh of energy annually combined. Condition Based Risk Management (CBRM) modelling and a detailed Substation Condition Assessment Report completed in 2019 identified a significant number of primary and secondary plant reaching or have already reached end of life at CHTW. The ongoing operation of these assets beyond their estimated retirement date presents a significant risk to customer reliability, financial (emergency replacement costs) and safety.

With expected load growth in the Chinchilla area, by 2031 it is forecast that there will be insufficient substation capacity to meet customer demand during system normal. By 2035, the single 33kV feeder supplying CHTW and CHSK will have insufficient capacity to meet demand during system normal.

For the contingency loss of a 33/11kV transformer at CHTW or CHSK, there is an existing exceedance of the Safety Net Constraint which is expected to greatly increase over the forecast period.

This investment (Chinchilla Township Reinforcement) addresses all asset limitations at CHTW and increases substation capacity to meet the forecast load growth at Chinchilla in a timely manner. The benefits have been assessed in comparison to the counterfactual resulting in a positive NPV of $35.704m.</td></tr>
<tr><td>Summary of preferred option</td><td>Replacing CHTW and CHSK with a new 2 x 32MVA 33/11kV substation built on the existing CHIN land parcel in 2030.</td></tr>
<tr><td>Expenditure</td><td>
<table>
<tr><th>Year</th><th>Previous period</th><th>2025-26</th><th>2026-27</th><th>2027-28</th><th>2028-29</th><th>2029-30</th><th>2025-30</th></tr>
<tr><td>$m, direct 2022-2023</td><td>-</td><td>$0.096</td><td>$0.632</td><td>$3.619</td><td>$7.456</td><td>$1.183</td><td>$12.986</td></tr>
</table>
</td></tr>
<tr><td>Benefits</td><td>This option results in over $53m of NPV benefits, largely due to the new substation having full ‘N-1’ security which greatly improves network reliability.</td></tr>
</table>

2 BACKGROUND

2.1 Network Arrangement

Chinchilla is a rural town in the Western Downs Region and an important service centre for the nearby agriculture and mining industries. The distribution network supplying the township of Chinchilla and surrounding rural properties is composed of three 11kV feeders coming out of Chinchilla Town (CHTW) and Chinchilla Skid (CHSK) 33/11kV zone substations. CHTW and CHSK supply approximately 3,532 customers combined and deliver 46.1GWh of energy annually, predominantly domestic (48%) and commercial (36%) load.

CHTW and CHSK are both supplied from Chinchilla Town 33kV feeder out of Chinchilla T013 132/33kV bulk supply point (CHIN), a joint Ergon / Powerlink QLD substation. CHTW can be alternatively supplied by changing to open points on Fairymeadow 33kV feeder (CHIN) or Rywung 33kV feeder (MILE). Note that the network configuration shown below, and assumed within this report, presumes that the project to remove all 110kV assets from CHIN has been completed as planned in 2027. Figure 1 shows the geographic layout and Figure 2 shows a line diagram of this network.

Figure 1 - Geographic of the Chinchilla Township 33kV existing network

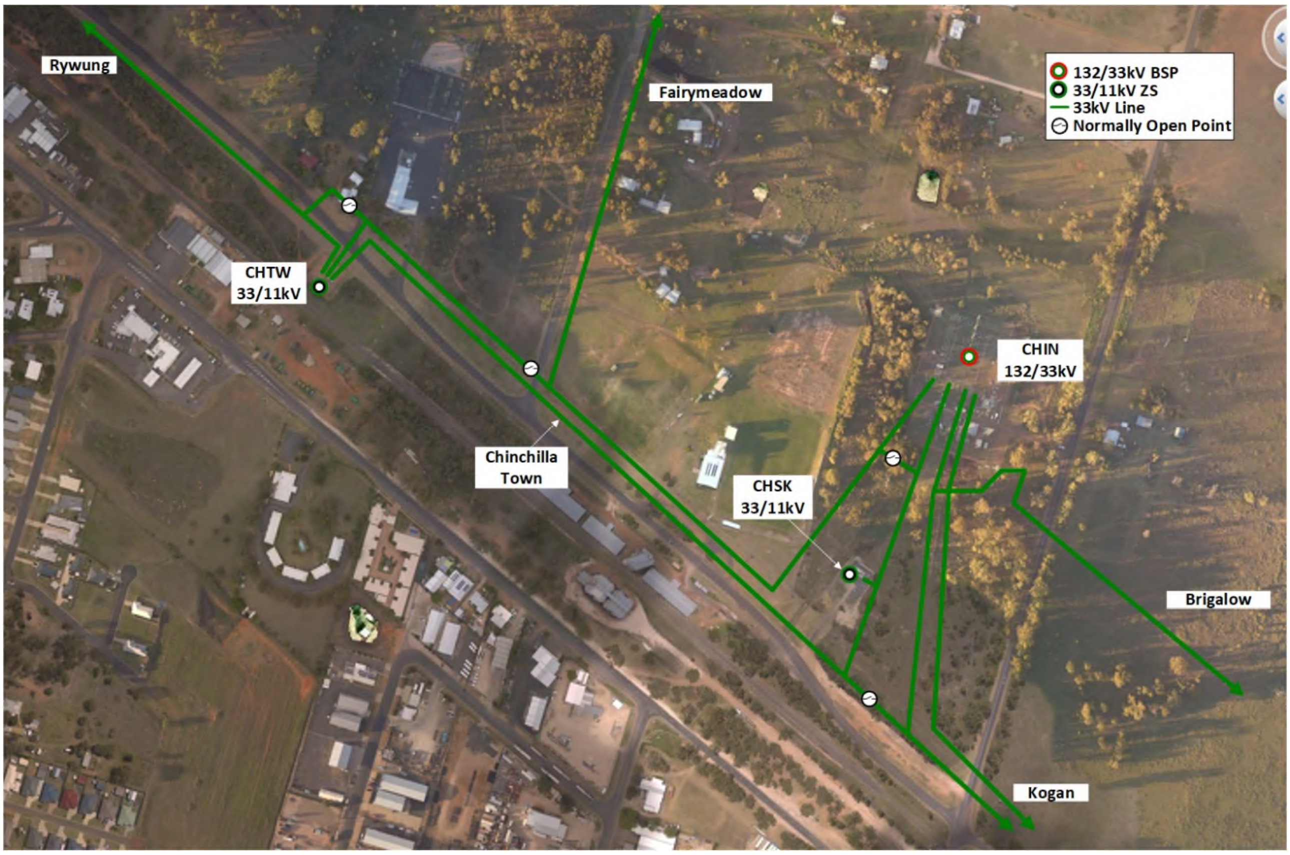
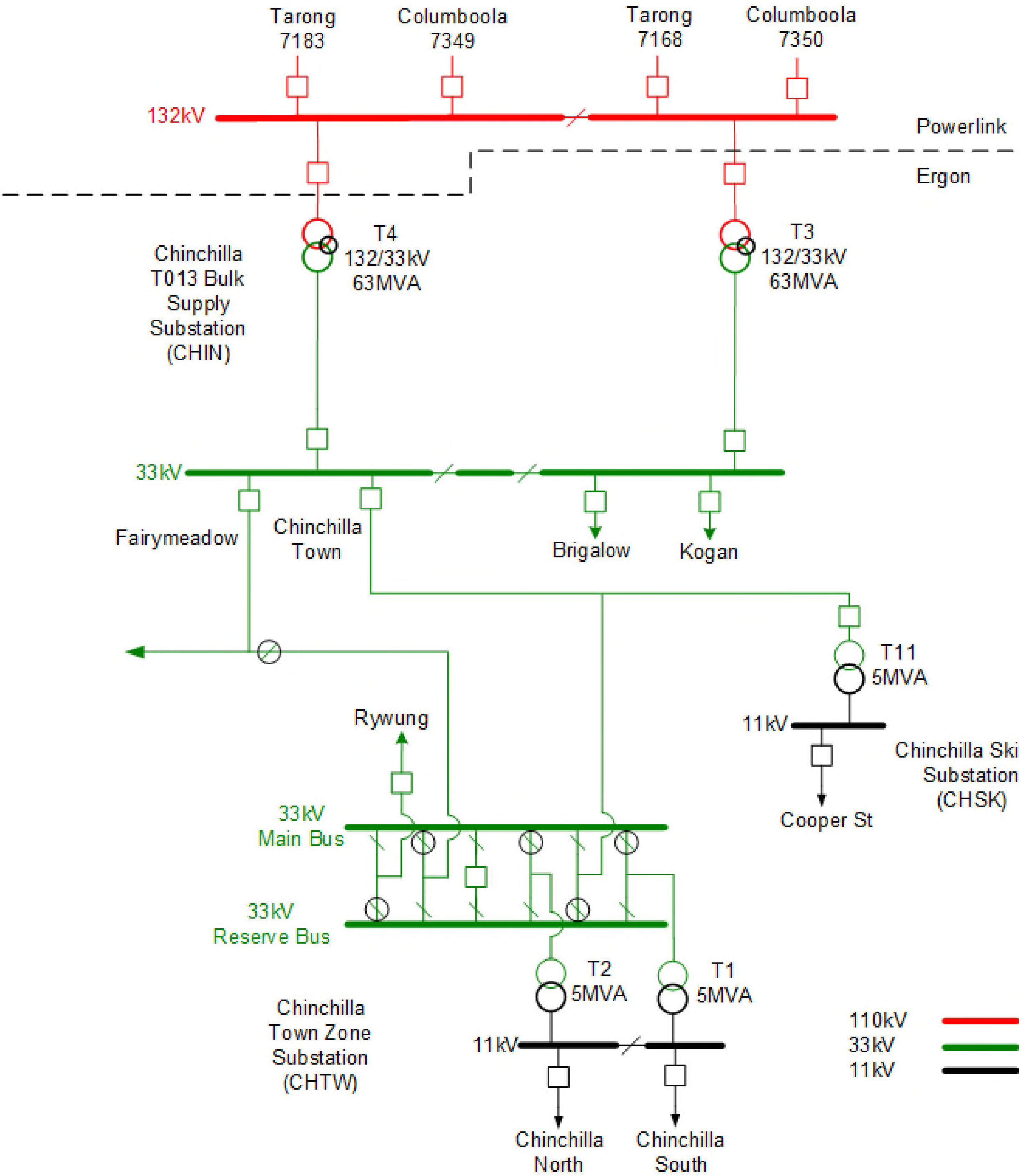


Figure 2 – Line diagram of the Chinchilla Township 33kV existing network



2.2 Substation Overview

CHTW is equipped with 2 x 5MVA 33/11kV transformers (not bunded), 11kV outdoor bus, 33kV main and reserve outdoor bus, 2 x 33/11kV transformer bays, two incoming and one outgoing 33kV feeder bays. It is noted that a single 33kV CB (CB2024) and associated protection scheme protects the main 33kV bus, reaches into both transformers and the 11kV bus and also provides back up protection to the 11kV feeder CBs for feeder faults. This arrangement results in only a minimal level of substation protection and customer reliability. Figure 3 shows the CHTW site general arrangement.

Figure 3 – CHTW site general arrangement

CHSK is a 5MVA 33/11kV skid mounted substation located on the same land parcel as CHIN, installed within a concrete bund. It is equipped with a single 33kV recloser on the incoming feeder and an 11kV recloser connecting to the single 11kV feeder. This type of skid substation was designed for easy transport and installation for contingency and temporary applications up to 4 years and it is noted that the skid was installed on site in 2009. There are 33kV and 11kV connection points to install a mobile substation in case of contingency loss of the skid transformer T11. Figure 4 shows the CHSK site general arrangement.

Figure 4 – CHSK site general arrangement

2.3 Asset Condition

Condition Based Risk Management (CBRM) modelling and a detailed Substation Condition Assessment Report completed in 2019 identified a significant number of primary and secondary plant reaching or have already reached end of life at CHTW. The ongoing operation of these assets beyond their estimated retirement date presents a significant risk to customer reliability, financial (emergency replacement costs) and safety.

These asset limitations are summarised below:

- CHTW 33kV CB2024 (estimated retirement year 2022)
- CHTW 15 x 11kV and 33kV bus isolators (estimated retirement year 2020-30)
- CHSK 3 x 11kV Nulec CAPM5 protection relays (estimated retirement year 2029)

2.4 Zone substation capacity

The 11kV distribution network at Chinchilla is limited by the 33/11kV transformer ratings at CHTW and CHSK as shown in Table 1. At CHTW, T1 and T2 are each limited by the HV/LV bushing ratings. This results in a system ‘N’ rating of 16.5MVA and ‘N-1’ of 11.0MVA in summer. During a contingency, there are no 11kV load transfers available outside of the CHSK and CHTW distribution area and up to 3MVA of mobile generation is available for network support. This results in a Safety Net Constraint of 14MVA for the Summer Night peak period.

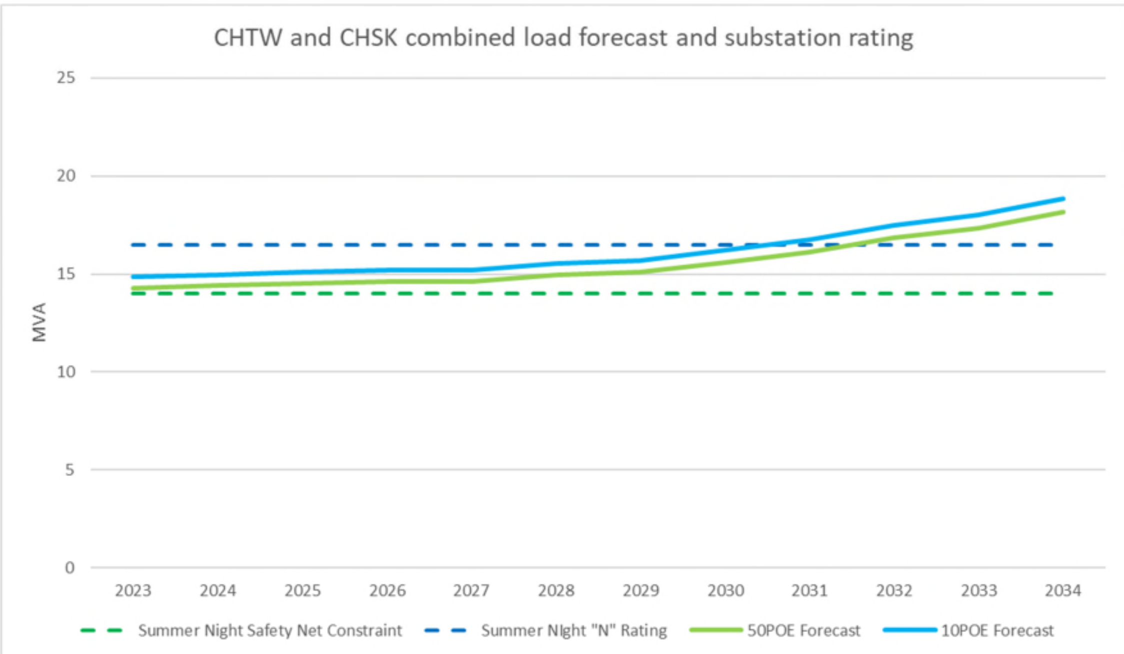
Table 1 – CHTW and CHSK transformer capacity

Transformer	Voltage	Normal Cyclic Rating		Long Term Emergency Cyclic Rating	
		Summer (MVA)	Winter (MVA)	Summer (MVA)	Winter (MVA)
CHTW T1	33/11kV	5.5	6.5	5.5	6.5
CHTW T2	33/11kV	5.5	6.5	5.5	6.5
CHSK T11	33/11kV	5.5	5.5	6.0	6.8

Figure 5 shows the combined CHTW and CHSK demand forecast and network constraints. It shows that there is a period of relatively low load growth from 2023 to 2029 and that during this period, the 50POE forecast slightly exceeds the Safety Net Constraint. Higher growth is predicted beyond 2029 leading to an increasing exceedance of this constraint.

The 10POE forecast is expected to exceed the ‘N’ rating by 2031 at which time there will be insufficient transformer capacity to meet demand during system normal.

Figure 5 – CHTW and CHSK combined load forecast and substation rating

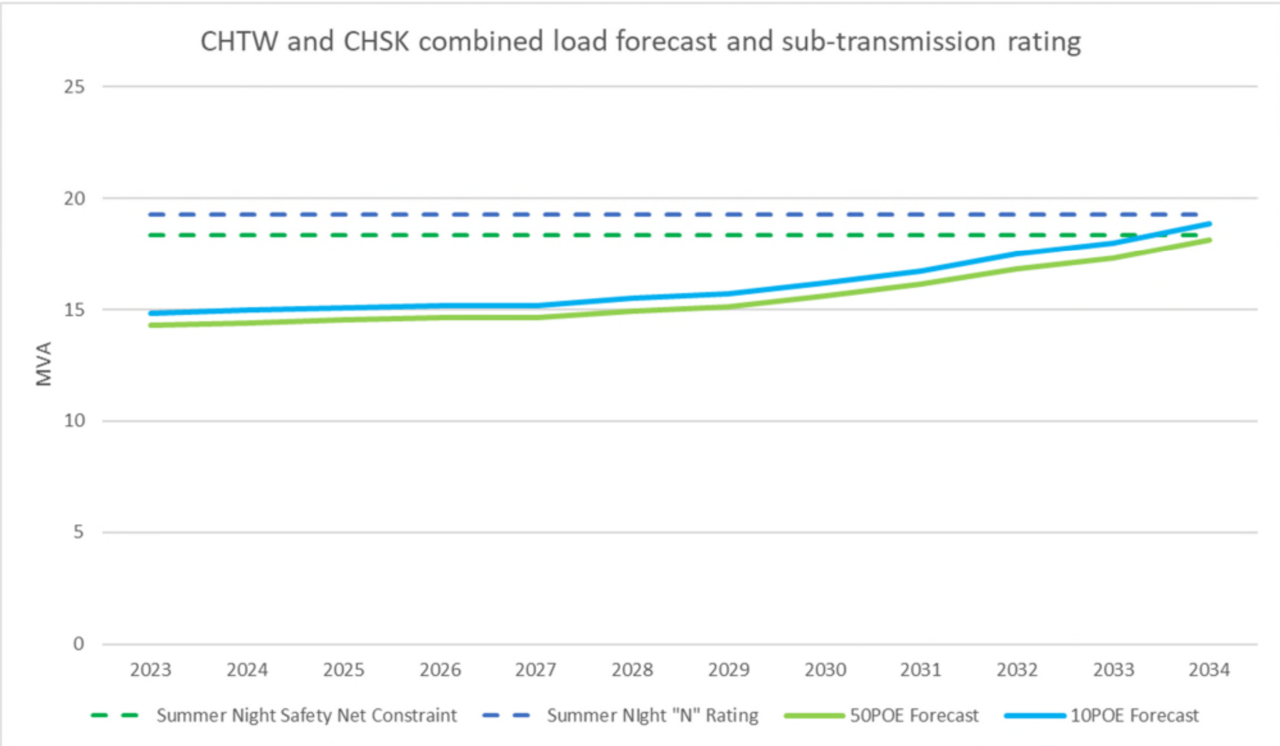


2.5 Sub-transmission Feeder Capacity

As shown in Figure 1, CHTW and CHSK are both supplied from Chinchilla Town 33kV feeder out of CHIN. The ‘N’ rating of this 33kV network is the Chinchilla Town feeder rating of 19.1MVA (Summer Day) and 19.3MVA (Summer Evening). During a contingency, CHTW can be supplied from Fairymeadow 33kV feeder (CHIN) by changing open points. In this scenario, the Safety Net constraint for the Summer Night peak is set by the Fairy Meadow feeder rating less any existing load on the feeder.

Figure 6 shows that the increasing 10POE forecast exceeds the ‘N’ rating by 2035 and that the 50POE forecast exceeds the Safety Net constraint in 2035 also.

Figure 6 - CHTW and CHSK combined load forecast and sub-transmission rating



3 REQUIREMENTS FOR CHINCHILLA TOWNSHIP REINFORCEMENT PROJECT

Section 3.1 outlines the identified need for a project at Chinchilla based on requirements for maintaining supply to customers in the CHSK and CHTW distribution areas. The counter factual analysis is included in Section 3.2 and provides a monetisation of the risks associated with continued operation of the network with existing assets. Credible options to address the identified need are then provided in Section 4 with comparison to the counter factual.

3.1 Identified Need

CHTW and CHSK are critical assets for supply of energy for domestic, industrial and commercial business located in and around Chinchilla. With the expected load growth in the Chinchilla area, by 2031, it is forecast that there will be insufficient substation transformer capacity to meet customer demand during system normal. By 2035, the single 33kV feeder supplying CHTW and CHSK will have insufficient capacity to meet demand during system normal.

For the contingency loss of a 33/11kV transformer at CHTW or CHSK, there is an existing exceedance of the Safety Net Constraint which is expected to greatly increase over the forecast period.

As described in Section 2.3, there are a number of assets at CHTW and CHSK which are nearing end of life. The ongoing operation of these assets results in increased exposure to safety, customer export and reliability consequences, due to the increased likelihood of asset failure.

The purpose of this project is to remove the elevated customer reliability, export and safety risks at CHTW and CHSK by replacing assets identified as having an increased likelihood of failure as well as increasing system capacity to meet forecast demand.

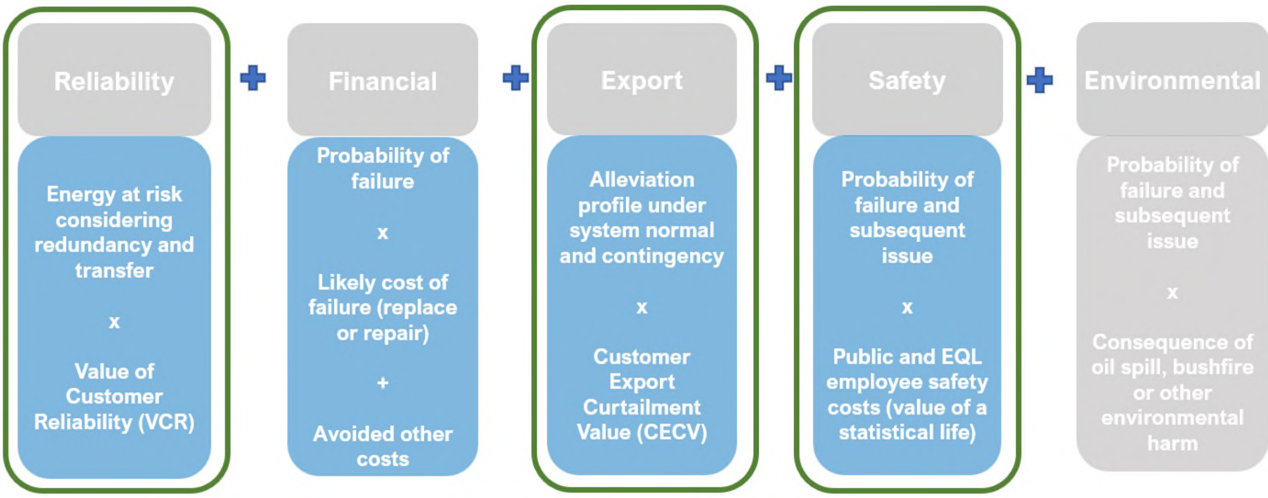
3.2 Counterfactual analysis

The monetised risk of the counterfactual is outlined below. The counter factual considers the risks associated with the identified need by proceeding with continued operation of the existing assets with current maintenance regimes and replacing assets on failure.

3.3 Risk Quantification Value Streams

Ergon Energy broadly considers five value streams for investment. Those pertinent to this project are *Reliability, Export* and *Safety* as shown in Figure 7.

Figure 7 – Value streams for investment



The three value streams that are relevant to this business case are *reliability*, *export* and *safety*. The counterfactual is to continue to operate the network as it is currently designed and has three primary elements for consideration:

- **Reliability:** There is potential unserved energy within the Chinchilla supply area following an outage at CHTW, CHSK or the 33kV sub-transmission network supplying these substations. For example, failure of any of the aged 33kV CBs or isolators at CHTW causing protection operating to clear the fault, would lead to full substation outages at CHTW and CHSK resulting in > 15MW of unsupplied customer load. Customers would remain without supply until such time as field crews attended the site and performed manual switching to isolate the fault and restore operation to the 33kV bus.
- **Export:** There is potential for export curtailment in the Chinchilla supply area following an outage at CHTW, CHSK or the 33kV sub-transmission network supplying these substations. For example, and outage to any of the 33/11kV transformers at CHTW or CHSK reduces the network export capacity from 16.5MVA to 11MVA. During this contingency scenario, if the amount of power flowing from the 11kV network into the 33kV network exceeded 11MVA then customer generation would be curtailed in order to prevent overloading the in-service transformers.
- **Safety:** Maintaining substation equipment beyond the recommended retirement year increases the safety risks to substation staff and to the public. E.g. there is an increased chance of catastrophic failure of oil insulated switchgear which could cause severe injuries or a fatality to workers within the substation. Mal-operation of protection relays can lead to unsafe conditions on the network which presents a risk to staff and the public.

3.3.1 Counterfactual Costs

The counterfactual is to continue to operate the network as it is currently designed. The existing maintenance regime will continue and equipment that fails in service will be replaced like for like through an urgent replacement project.

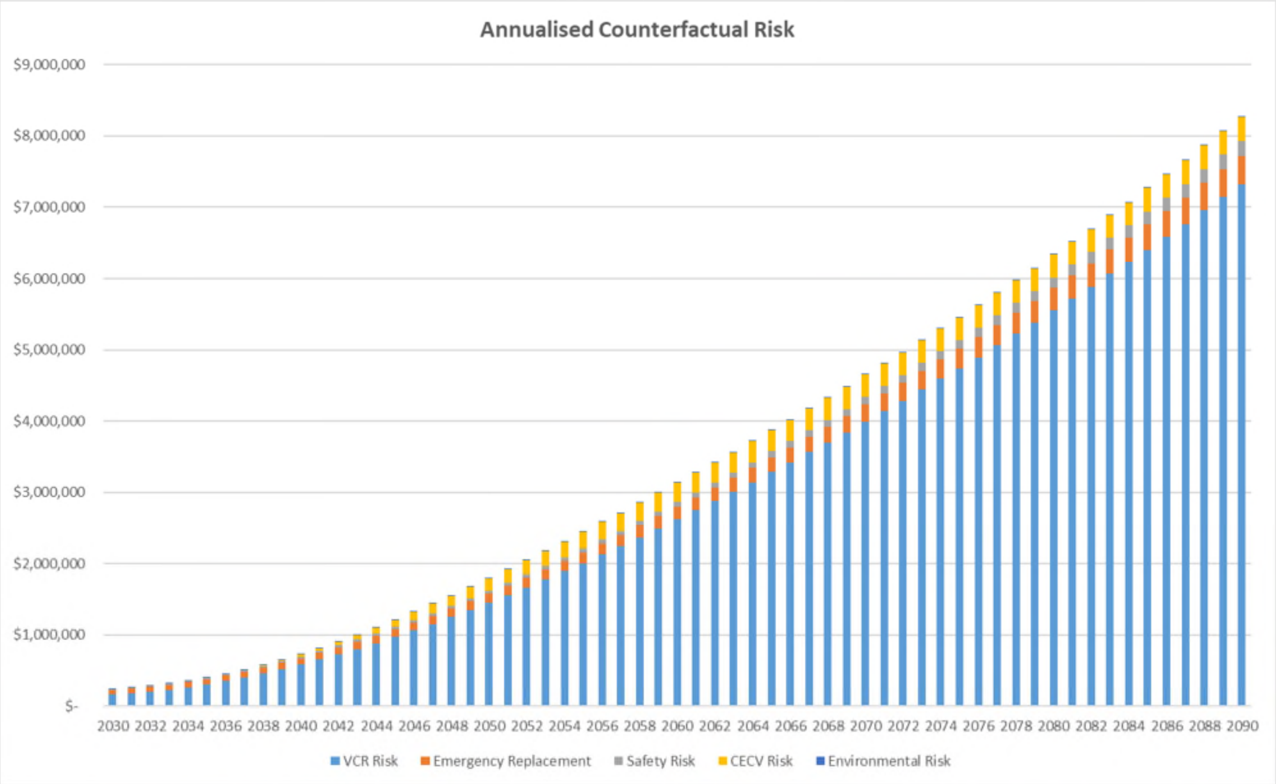
3.3.2 Counterfactual Risk Quantification Assumptions

The counterfactual risks are the expected reliability, emergency replacement, safety and export curtailment risks during an equipment failure and associated unplanned supply outage at CHTW or CHSK. Figure 8 shows the quantified risk per annum over the 60-year period calculated.

In calculating the value streams the following assumptions have been used:

- **HV Bus Forced Outage Rate** – 0.03 outages / year for the outdoor 33kV buses which is the standard outage rate used for buses of these construction and voltage level.
- **HV Circuit Breaker Forced Outage Rate** – The CB outage rate is predicted using a Weibull distribution with a Shape Parameter (β) of 4 and a Characteristic Life (η) of 75 for 11kV CBs, and a Characteristic Life (η) of 80 for 33kV CBs. A flat outage rate of 0.027 has been applied for the first 4 years to capture the increased risk of failure in the first years of a circuit breakers life.
- **Transformer Forced Outage Rate** – The zone transformer outage rate is predicted using a Weibull distribution with a Shape Parameter (β) of 3.6 and a Characteristic Life (η) of 79. A flat outage rate of 0.027 has been applied for the first 4 years to capture the increased risk of failure in the first years of transformers life.
- **Restoration** – it has been estimated that the average rectification time would be 48 hours for each outage type modelled.
- **Transfers** – during a contingency there are no 11kV load transfers available from CHTW or CHSK to another zone substation.
- **VCR** – a VCR of $37.91 / kWh has been used, with the mix of customers weighted towards domestic and commercial customers.
- **Emergency Replacement Cost** - On failure of assets the plant will be replaced like-for-like with an additional 30% cost in comparison to the planned project.
- **Safety quantification** – Considers forced outage rate of the asset with a conversion factor of 0.1% that a fatality to an employee and/or injury to an employee will occur.
- **Risk timeframe** – risks were calculated over a 60-year period, starting from 2030 to align with the investment year of Option 1 and Option 2 (see below).

Figure 8 – Counterfactual risk



4 OPTIONS ANALYSIS

This section describes the credible options to address the identified need with comparison to the counter factual.

4.1 Option Identification

In the process of determining the most cost-effective solution to address the identified network limitations, Ergon Energy has sought to identify a practicable range of technically feasible, alternative options that could satisfy the network requirements in a timely and efficient manner.

It was noted in Section 0 that there are no adjacent zone substations and no load transfers available from CHTW and CHSK, therefore it is not a feasible option to decommission CHTW or CHSK permanently. Also, assuming a single 33/11kV transformer configuration at Chinchilla, it would be impossible to meet Safety Net restoration targets for a contingency loss of the transformer and so a single transformer option does not meet legislative requirements.

Ergon Energy has identified two options that represent practical alternatives to address the network limitations in the required timeframe.

4.2 Option 1

Figure 9 shows the proposed network configuration after completion of Option 1. This option involves increasing network capacity by upgrading CHTW T1 and T2 and replacing the ageing asset identified in Section 2.3 in two stages:

2030 Stage 1:

- extend yard and earth grid to accommodate two new 33/11kV transformer bays
- replace T1 and T2 with 25MVA 33/11kV TXs on new bunds
- upgrade the existing substation earthing as necessary
- replace 2 x 33kV CBs
- build a new control building with space to accommodate six protection panels
- replace 6 x protection relays into the new building and upgrade substation protection schemes to current standards
- build 2 x new 11kV feeder bays
- reconfigure Cooper St 11kV feeder to be supplied from CHTW and,
- decommission CHSK

2055 Stage 2:

- build 3 x new 11kV feeder bays
- replace 2 x 11kV CBs
- replace 15 x 11kV and 33kV isolators

There are three key determinants in maximising the value to customers as part of this investment proposal:

- Maintaining continuity of supply to its customers in the Chinchilla distribution area.
- Maintaining network capability to allow customers export generation.
- Reducing the safety risks to Ergon staff and the public SFAIRP.

4.2.1 Costs

Option 1 has been estimated to have $12.8m of direct costs, which has been factored into the NPV as $10.6m incurred in 2030 and $2.2m in 2055.

4.2.2 Option 1 Benefits

Following completion of Option 1 asset replacements, it is expected to see a significant decrease in the forced outage rate of substation plant. This leads to a reduction in quantified risk compared to the counterfactual. These risk reductions form the Option 1 benefits as shown in Figure 10.

Figure 9 – Option 1 single line diagram

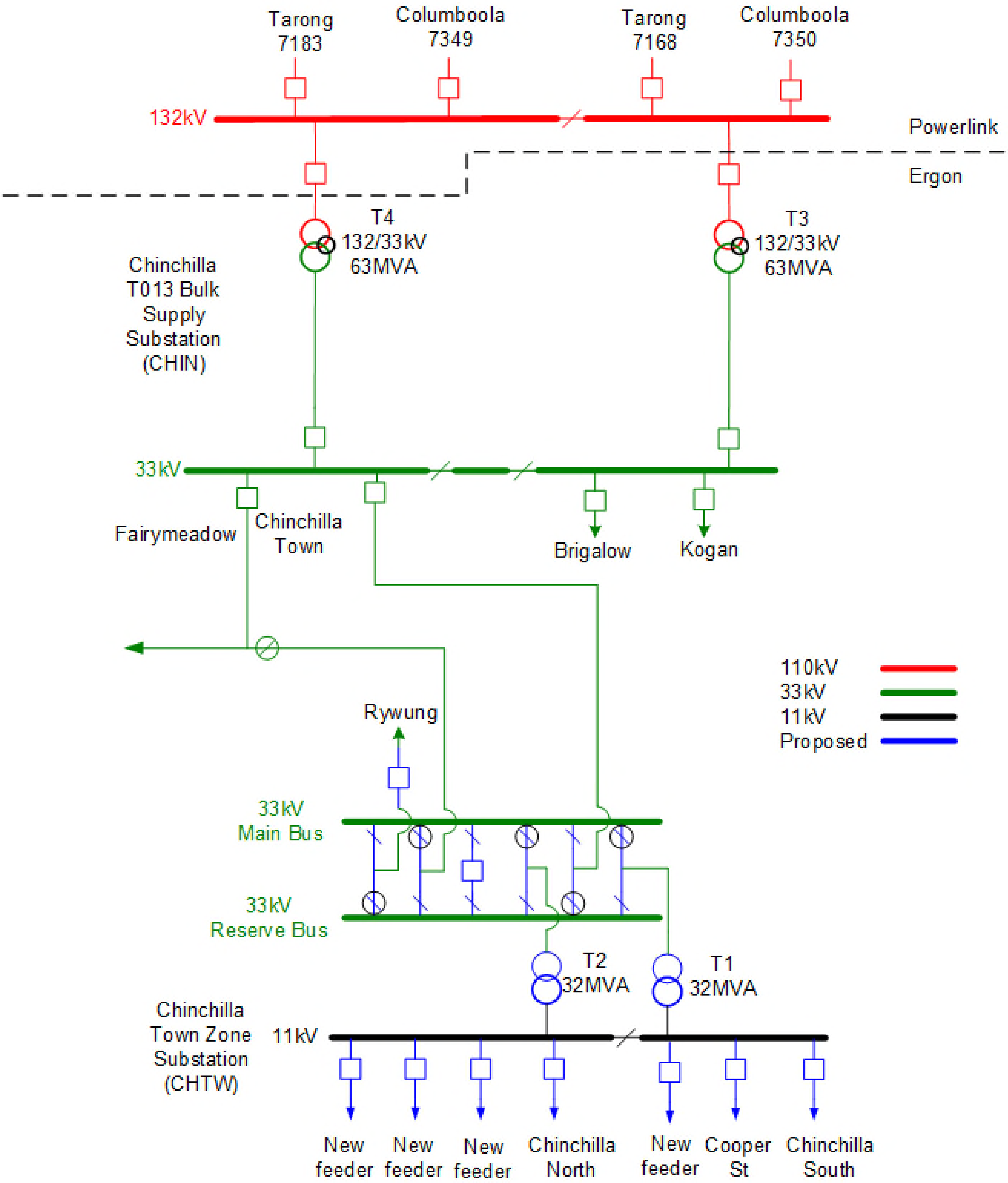
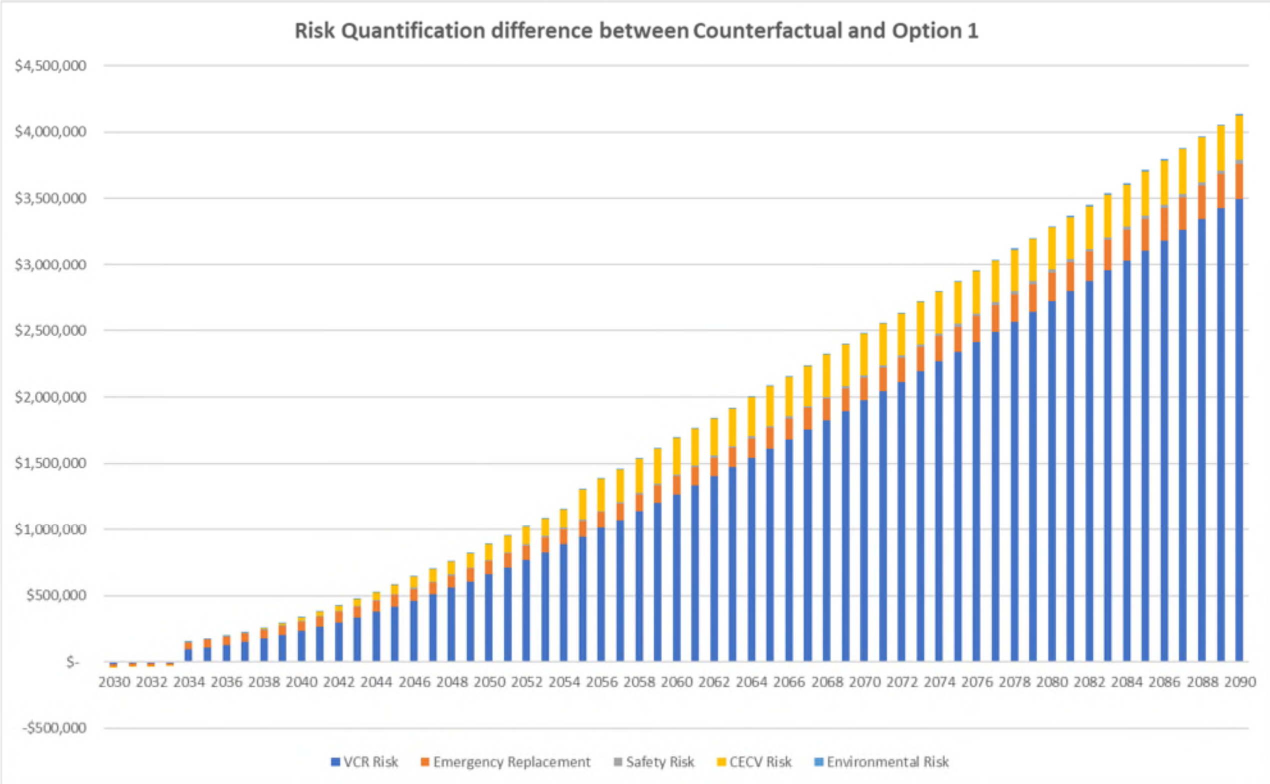


Figure 10 – Option 1 benefits



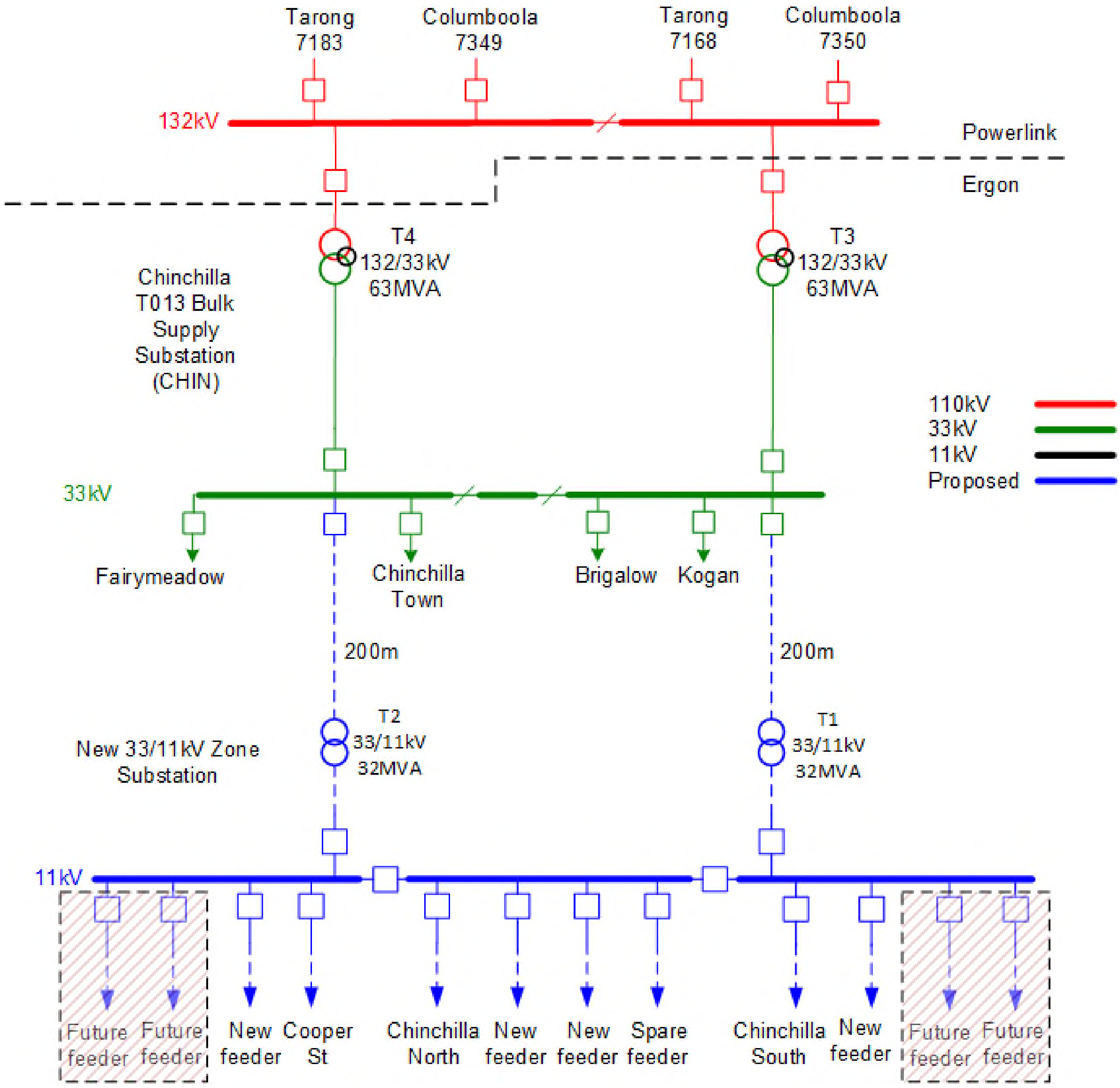
4.3 Option 2

Figure 11 shows the proposed network configuration after completion of Option 2. This option involves increasing network capacity and removing the asset limitations identified in Section 2.3 by replacing CHTW and CHSK with a new 2 x 32MVA Z7 standard design substation built on the existing CHIN land parcel in 2030.

There are three key determinants in maximising the value to customers as part of this investment proposal:

- Maintaining continuity of supply to its customers in the Chinchilla distribution area.
- Maintaining network capability to allow customers export generation.
- Reducing the safety risks to Ergon staff and the public SFAIRP.

Figure 11 – Option 2 single line diagram



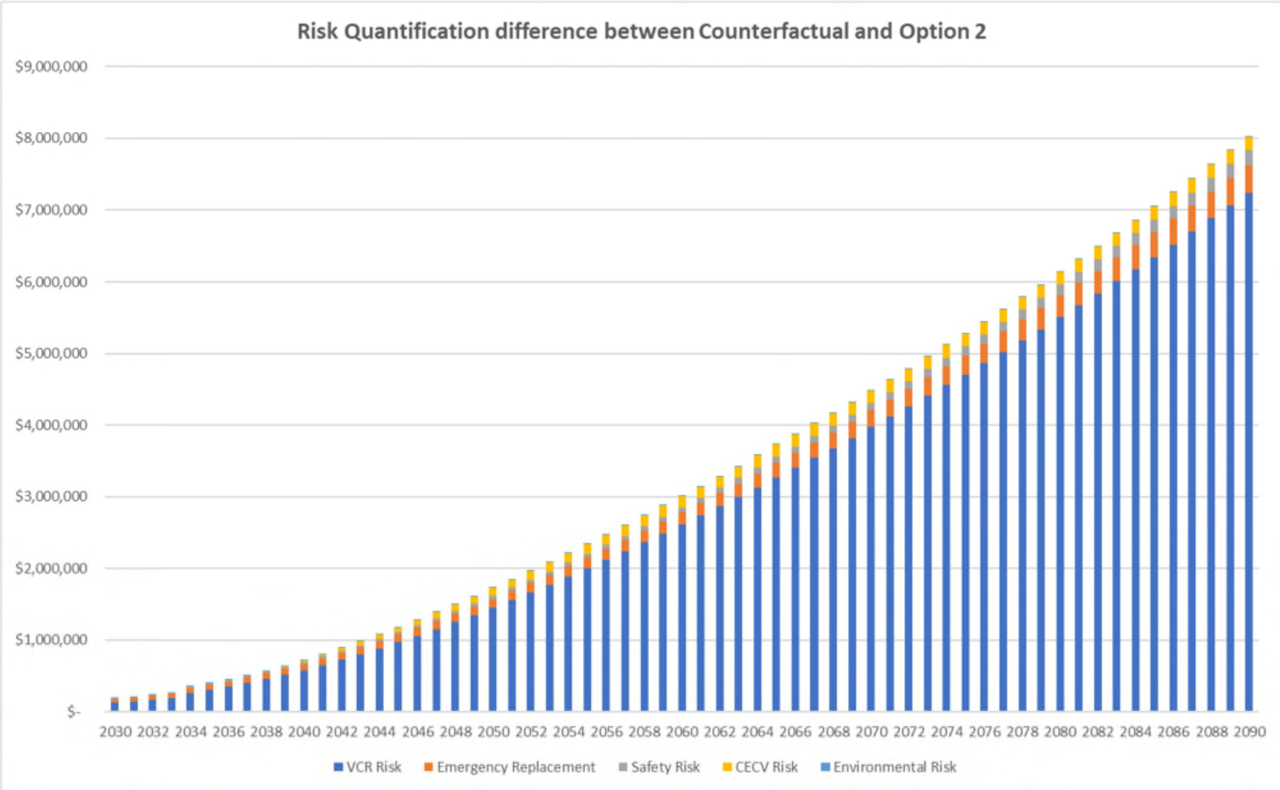
4.3.1 Costs

Option 2 has been estimated to have $13.0m of direct costs, which has been factored into the NPV to be incurred in 2030.

4.3.2 Option 2 Benefits

Following completion of the fully ‘N-1’ new zone substation in Option 2, as well as a reduced likelihood of forced outages, there is expected to be a large decrease in customer impacts associated with any outage. This leads to a reduction in quantified risk compared to the counterfactual. These risk reductions form the Option 2 benefits as shown in Figure 10.

Figure 12 – Option 2 benefits



In addition, this option reduces complex construction staging and eventual customer outages during the construction period - in comparison to Option 1 (in-situ replacement). The economic benefits associated with these have not been factored in the economic analysis.

4.4 Economic Analysis

4.4.1 Cost summary 2025-30

The preferred option, Option 2 has been estimated as $12.986m. The forecast expenditure by year is shown in Table 2.

Table 2 – Cost summary 2025-30

Option	2025-26	2026-27	2027-28	2028-29	2029-30	Total 2025-30
Option 2 – Replace CHTW and CHSK with new Z7-32	$0.096m	$0.632m	$3.619m	$7.456m	$1.183m	$12.986m

4.4.2 NPV analysis

Table 3 shows the NPV of Capex, Opex and Benefits for each option based on a regulated real pre-tax WACC of 3.5%. The most significant difference between the options is the greater amount of benefits expected for Option 2 compared to Option 1. This is attributed to the reliability improvement of the N-1 substation configuration proposed in Option 2 compared to maintaining the existing system configuration in Option 1. This leads to Option 2 having the greatest Net NPV and therefore is the preferred option.

Table 3 – Base Case NPV analysis

Option	Rank	Net NPV	Capex NPV	Opex NPV	Benefits NPV
Option 1 – Rebuild CHTW in stages	2	$12.251m	$-11.363m	$-4.378m	$27.992m
Option 2 – Replace CHTW and CHSK with new Z7-32	1	$35.704m	$-12.986m	$-5.029m	$53.719m

Table 4 shows the results over a range of parameters to test the sensitivity of the financial model. Based on Net NPV, Option 2 remains the preferred option across the entire range of scenarios tested.

Table 4 – Net NPV Sensitivity Analysis

Option	Discount rate		Failure rate		Benefits	
	2.5%	4.5%	75%	125%	75%	125%
Option 1 – Rebuild CHTW in stages	$23.159	$5.142	$6.289	$18.207	$5.253	$19.249
Option 2 – Replace CHTW and CHSK with new Z7-32	$57.182	$21.580	$23.293	$48.106	$22.274	$49.133

4.5 Optimal Timing

The forecast project completion date for this project is 2030. This date has been chosen to ensure that there will be adequate capacity to meet the forecast load growth in the Chinchilla area and to remove the asset limitations identified at CHTW (see Section 2.3). Completing the project by this date will maintain continuity of supply to customers and reduce the safety risks SFAIRP.

5 RECOMMENDATION

It is recommended to replace CHTW and CHSK with a new 2 x 32MVA 33/11kV zone substation built on the existing CHIN land parcel, as per Option 2 (the preferred option) of this report. The project is targeted be completed by 2030 which ensures adequate network capacity to meet demand and to address the asset limitations at CHTW in a timely manner. Table 5 summarises the option under consideration.

Table 5 – Options Analysis Scorecard

Criteria	Option 1 – Rebuild CHTW in stages	Option 2 – Replace CHTW and CHSK with new Z7-32
Net Present Value	$12.3m	$35.7m
Investment cost (TCO)	$12.8m	$13.0m
Investment Risk	Medium	Medium
Benefits	$28.0m	$53.7m
Delivery time	24 months	24 months
Detailed analysis – Benefits	This option results in $28.0m in NPV benefits largely due to asset replacements reducing the likelihood of unplanned outages compared to the counterfactual.	This option results in $53.7m in NPV benefits largely due to the new substation having full 'N-1' security which greatly improves network reliability.
Detailed analysis – Risks	This project has a net NPV of $12.3m. Sensitivity analysis showed that for some scenarios, the net NPV might be substantially less e.g. $5.3m if benefits were reduced to 75%.	There is a risk that the parameters used in the financial model might not match reality which results in inaccuracy in the calculated net NPV figure of $35.7m. However, sensitivity analysis showed that the net NPV remained positive over the range of scenarios which gives confidence in the result.
Detailed analysis - Advantages	This option increases network capacity and results in a secure and reliable network in the Chinchilla supply area. It provides 4 new 11kV feeder bays (which is the estimated number required to meet forecast growth) however any feeders additional to this would require additional works to extend the 11kV bus. The re-built CHTW retains the existing substation arrangement (lack of 33kV and 11kV bus section CBs) and although this meets Safety Net requirements initially, the increasing load forecast triggers non-compliance by 2036. Additional work would be required at this time to achieve compliance. By removing the asset limitations at CHTW and CHSK, safety risks are reduced SFAIRP.	This option increases network capacity and results in a secure and reliable network in the Chinchilla supply area. It also allows for additional 11kV feeders (1 spare and room for up to 4 future 11kV bays) to be established if required in the future. The new substation will have full 'N-1' which improves existing network security and ensures that Safety Net requirements are met now and into the future. By removing the asset limitations at CHTW and CHSK, safety risks are reduced SFAIRP.

Appendix 1 - Alignment with the National Electricity Rules

NER capital expenditure objectives	Rationale
A building block proposal must include the total forecast capital expenditure which the DNSP considers is required in order to achieve each of the following (the capital expenditure objectives):	
6.5.7 (a) (1) meet or manage the expected demand for standard control services over that period	Section 3, Section 4.3
6.5.7 (a) (2) comply with all applicable regulatory obligations or requirements associated with the provision of standard control services;	Section 3, Section 4.3
6.5.7 (a) (3) to the extent that there is no applicable regulatory obligation or requirement in relation to: (i) the quality, reliability or security of supply of standard control services; or (ii) the reliability or security of the distribution system through the supply of standard control services, to the relevant extent: (iii) maintain the quality, reliability and security of supply of standard control services; and (iv) maintain the reliability and security of the distribution system through the supply of standard control services	Section 3, Section 4.3
6.5.7 (a) (4) maintain the safety of the distribution system through the supply of standard control services.	Section 3, Section 4.3
NER capital expenditure criteria	**Rationale**
The AER must be satisfied that the forecast capital expenditure reflects each of the following:	
6.5.7 (c) (1) (i) the efficient costs of achieving the capital expenditure objectives	Section 4
6.5.7 (c) (1) (ii) the costs that a prudent operator would require to achieve the capital expenditure objectives	Section 4
6.5.7 (c) (1) (iii) a realistic expectation of the demand forecast and cost inputs required to achieve the capital expenditure objectives	Section 4

Appendix 2 - Reconciliation Table

Expenditure	2025-26	2026-27	2027-28	2028-29	2029-30	2025-30
Expenditure in business case $m, direct 2022/23	$0.096	$0.632	$3.619	$7.456	$1.183	$12.986