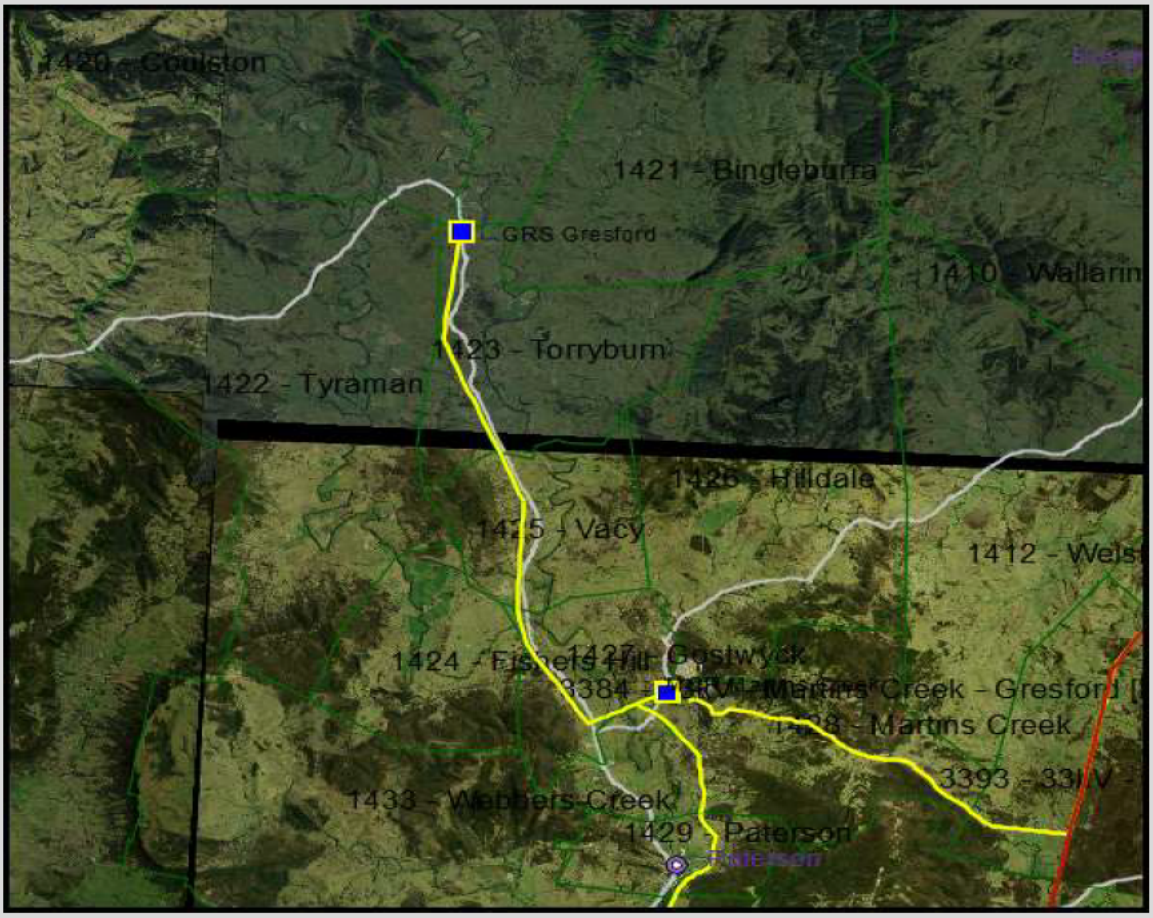
Essential Energy

10.06.09 Resilience Murrurundi Network Investment Case



November 2022

Network Resilience Project

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1.	[redacted]	Asset and Operations	Manager Network Planning	14/12/22

Revisions

Issue Number	Section	Details of Changes in this Revision
1.	All	Initial Issue
2.		
3.		
4.		
5.		

Table of Contents

1. Executive Summary

Major Project	10.06.09 Resilience Murrurundi Network Investment Case
Description	Establish back up supply to Murrurundi ZS
Drivers for Investment	Resilience: To improve the resilience of the network for customer on the Murrurundi Zone Substation as reliability is lower than required by applicable standards. Poor reliability performance is due to lightning and vegetation, coupled with access and distance from depot resulting in extended rectification timeframes. Climate change analysis is forecasting an increase in wind risk in this area. Following weather events there has been extended periods of power outages, including: 28/2/2022: 11 hours 15/12/2018: 10 hours 30/04/2022: 7 hours Reliability: To improve reliability for customers on the Murrurundi Zone Substation. This will also maintain the safety, quality, and security of supply of the network as per NER 6.5.7 capital objectives. Strong customer support for proactive resilience projects including microgrids (refer 4.02 How Engagement Informed our Proposal).
Investment Options	Options considered to improve customer reliabilty included: > Diesel Generation > Network solution > Battery backup > Market Non-network solution > Lightning protection (excessive capital costs, excluded from further analysis) Due to the scale of this project an Expression of Interest (EOI) for non-network solutions will be advertised prior to project initiation to enable the private sector to submit non-network options for evaluation. The following option was investigated in detail and evaluated using Net Present Value of cost and benefit: > Diesel Generation (NPV of $4.1M)
Estimated Expenditure FY24$	2024/25: $0; 2025/26: $0; 2026/27: [redacted]; 2027/28: [redacted]; 2028/29: $0

2024/25	2025/26	2026/27	2027/28	2028/29
$0	$0	[redacted]	[redacted]	$0

Note: All values are in middle of the year 2023-24 real dollar terms

2. Network

The radial Quirindi - Murrurundi 33kV 798 Feeder (Refer to Figure 1) supplies the Murrurundi 33/11kV substation and has a peak demand of approximately 3MVA and there is no increase in growth forecasted over the next 5 years. 1265 customers are connected to this ZS.

The Quirindi - Murrurundi 33kV 798 Radial Feeder is approximately 36km in length and was constructed in the 1940's. It's 377 structures are predominantly a delta pin configuration for the 33kV with an 11kV line underbuilt. The 798 feeder consists of 7/0.80 copper conductor.

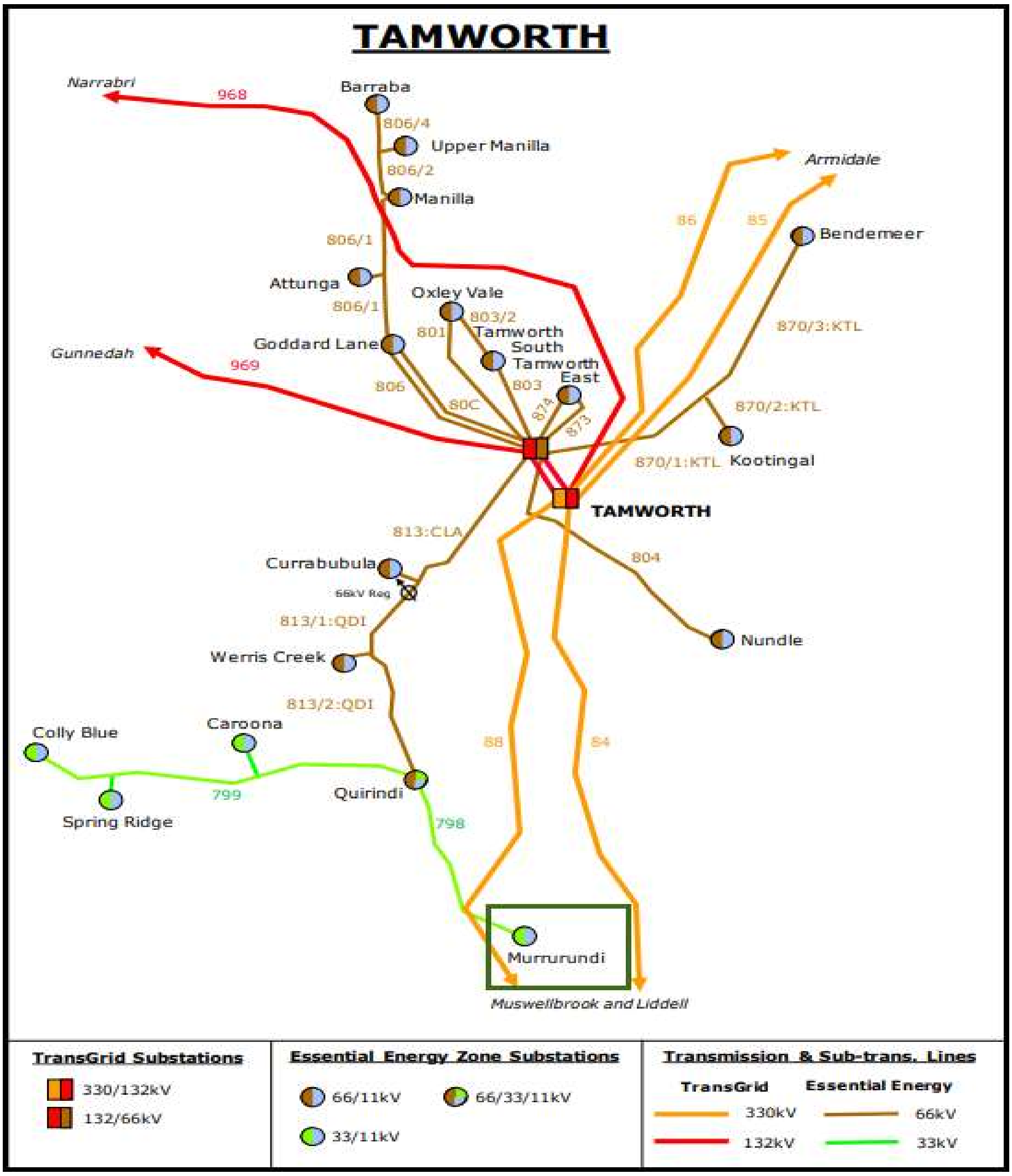

Figure 1 - Simplified Subtransmission Network

Asset inspection cycles include a ground inspection every five years and aerial photo inspections (drone), also every five years. To minimise customer outages, the feeders are mostly maintained live line.

3. Reliability

Reliability of the 33kV subtransmission network is mostly affected by weather. Storm activity and lightning, impact the unshielded feeders causing the network to trip via the 33kV circuit breaker at Quirindi zone substation.

For faults on this feeder, resources patrol the feeder visually via adjacent roads and other access. Depending on weather and night/daytime, patrols may take several hours. Once the fault is found, emergency repairs are usually completed straight away. Typical storm/lightning faults impact with the pole top; crossarm or insulators, conductor or pole faults are less common.

Historical outage data indicates there is an average of 2.6 unplanned outages per annum. Due to the conditions and patrol requirements the average outage timeframe is approximately four hours.

Maintaining a reliable supply is a key investment driver in determining network augmentation expenditure.

Examples of some of the longer outages that have occurred are detailed below:

28/2/2022: 11 hours; short notice 66kV pole replacements, affecting over 5000 customers for over 4 hours.

15/12/2018: 10 hours; pole snapped off on 806Fdr into 66Kv 813Fdr.

30/04/2022: 7 hours; conductor broke environment and equipment deterioration.

Further historical reliability data for this feeder can be found in Appendix A. The SAIDI and SAIFI of the feeder is as shown in Figure 2, and the feeder has been non-compliant frequently due to duration of the faults.

Figure 2 - SAIDI/SAIFI Performance

Breaching of Licence Conditions reliability standards has occurred primarily due to SAIDI thresholds being exceeded. To date a small number of low cost projects have been implemented in an attempt to reduce the number of and impact from outages including installation/replacement of reclosers and switching points, however, given the location of the ZS at the end of the radial supply outages these projects have had limited improvement to the area.

3.1 Climate Impact Assessment

This project forms part of our Resilience Plan (Attachment 6.02) and strengthening the resilience of the network. From **6.01 Climate Impact Assessment**, it is forecast by 2070 that the impact on asset failures of combined bushfire, flood and wind will increase by approximately 20% in this depot using RCP4.5 as shown in Figure 3 below.

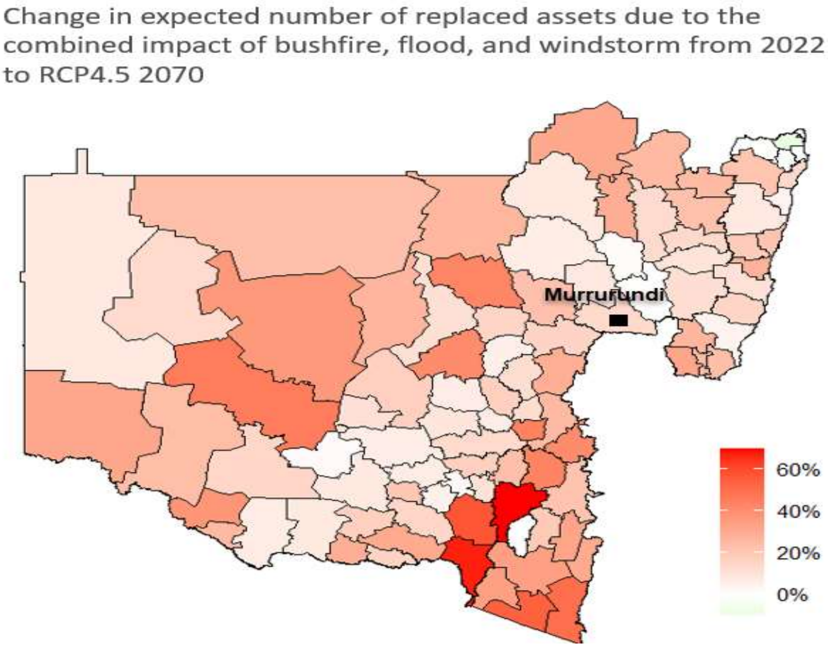

Figure 3 – Expected increase in asset replacement due of climate impact (Attachment 6.01 Climate Impact Assessment**)**

The climate impact due to windstorm and bushfire on the number of failed assets in Quirindi depot (nearest depot to Murrurundi) is shown below in Figure 4.

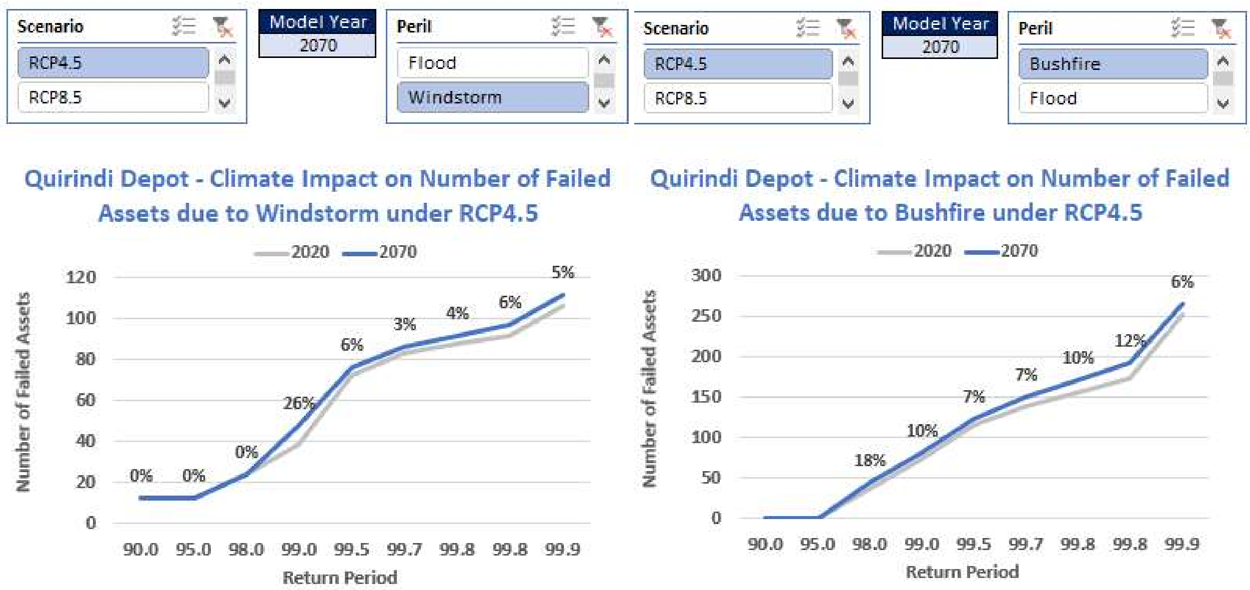

Figure 4 - Current and forecasted analysis of climate impact (Attachment 6.01.01 Climate Summary Line Graph)

Climate impact modelling **has not** been included in the NPV analysis for this project but does offer additional qualitative benefits.

4. Options Analysis

Several options were investigated to improve reliability in the Murrurundi ZS. The following three options below were compared via Net Present Value (NPV) analysis. NPV analysis considers both costs and benefits over typical life of asset (40 years). Costs include both capital and operating. The key benefit in this case is the Value of Customer Reliability (VCR).

Beyond reliability benefit other risk value benefits were considered as per Appraisal Value Framework (**Attachment 6.03.03**). The benefit of alleviating specific network risks such as safety, environment (bushfire), financial, reputation and compliance were also considered. A summary of the risk framework assessment is detailed below in Section 5.

Table 1 includes the primary variable assumptions to calculate the Baseline risk of the overhead network supplying the Murrurundi ZS.

Table 1 - Variables for Baseline Risk

Variable	Value	Source
Discount Rate	3.54%	Current internal rate for standard control CAPEX
Failure Rate of OH Line	2.6	Historical performance over the past seven years
Load Impacted	3MW	Average customer load in segment Murrurundi ZS
Outage Timeframe	4hrs	Historical performance over the past ten years
NPV Period	40yrs	Current internal common modelling window

4.1 Option 1 - Diesel Generation- Murrurundi ZS

This option has a capital cost of [redacted] and would require diesel powered generator units to be installed at the Murrurundi ZS. The unit would be semi containerised standard 415V output and connect to the 11kV busbars at each zone substation via a 415V/11kV step-up transformer. Considering peak demand, optimised generator protection and operation, two 1.5MVA units would be installed at Murrurundi ZS. The units would have fuel storage for at least eight hours of running. The NPV analysis assumes the life of the generator to be 20 years, thus for the 40 year NPV analysis the cost of a replacement of the generator at 20 years has been considered. For the purpose of residual risk a conservative assumed failure rate of 1 in 10 years has been included for the diesel generator in the event that the generator fails to supply the ZS.

Qualitative benefits exist for this option that have not been quantified in the NPV analysis. In particular generation will allow field staff to perform construction activities for both unplanned and planned outages. This benefits field staff in reducing time constraints on outage timeframes and the requirement to perform live-line work. Planned outages for customers will also reduce as the generator can be utilised during activities that can't be performed live. Fault and emergency response can be better planned (i.e. resources, materials etc) improving efficiencies.

On loss of the 33kV supply, the 11kV transformer circuit breakers would open, and generator start-up would occur within minutes.

Option 1 has estimated capital cost of [redacted] and a Net Present Value of $4.1M and an impact to STPIS targets included in Service Target Performance Incentive Scheme (STPIS) Approach (Attachment 8.04).

4.2 Option 2 – Construct Duplicate Line

The radial Quirindi - Murrurundi 33kV 798 Feeder supplies the Murrurundi 33/11kV substation. The 798 feeder consists of 7/0.80 copper conductor. The main components that resulted in the highest Customer Minutes Lost (CML) is due to weather impact. The network solution would be to construct a new 40km 66kV line from Scone (Ausgrid). This solution will reduce outage times but is restricted by the time taken to validate the fault and ensure the alternate supply can be safely and practically utilised.
The initial cost is very high; therefore, this option was deemed economically unfeasible.

Option 2 has a capital cost estimated in excess of [redacted] and is deemed uneconomical.

4.3 Option 3 Battery Back-up Storage for Murrurundi ZS

Battery storage would require installation of containerised battery banks at Murrurundi ZS.

The battery banks would be connected directly to the 11kV network in the Murrurundi ZS. On loss of the 33kV supply, auto-changeover to the battery banks would occur. With a peak demand of 3MVA, the battery banks would need significant capacity to provide backup supply over the extended unplanned outage periods, which is anticipated to be at least 24 hours.

The advantages of battery storage are they are fast acting sources of supply, they are relatively quick to install, can be extended readily and have low running cost. They can provide benefits beyond backup supply: stabilise the grid in frequency events and sale of spare capacity into the grid at high wholesale price points. Neither of these benefits can be considered as Essential Energy is not in a regulated position to do so. Disadvantages of batteries are they are relatively costly, and at this stage the battery life is expected to be less than 20 years. In comparison to other network options with typical asset life of 40 years, it is assumed the battery would be replaced after 20 years.

It is estimated that the average power consumption is 3MVA, for 24 hours requires a battery bank of 72MWh. This option has been ruled out of further analysis due to an estimated capital cost of [redacted], with an expected cost of [redacted] per MWh based on energy storage costs received from Essential Energy network battery trial project in 2022.

Option 3 has a capital cost estimated in excess of [redacted] and is deemed not economical without subsidies or grants.

4.4 Option 4 Market led Non-Network Solution

The requirements to improve resilience and reliability of Murrurundi ZS may be advertised via an EOI process to enable the market to respond with alternative non-network solutions. The response from the market could include another option not previously investigated by Essential Energy and could include other market benefits driven from 3rd party owned solutions. The basis of the EOI will be to request alternative energy storage and backup power solutions under any business model and operational conditions to ensure all new solutions can be assessed. Because of this approach, submissions may need to be reviewed against any applicable regulatory rules and if a solution is deemed to be economically viable, engagement with regulators may be required. Solutions from this market exercise will then be assessed against network solutions.

As such, Option 4 does not have NPV analysis at this stage but will be considered as part of the project development.

4.5 Recommended Option

In recommending a preferred option, the initial capital costs are considered along with the NPV analysis of overall 40-year benefit which is primarily based on improved reliability.

Option 2 has a capital cost estimated in excess of [redacted] and is deemed not economical.

Option 3 has been evaluated as not being economically viable solution due to the high initial and cyclical capex cost.

Option 4 will be evaluated prior to Essential Energy commencing the project to ensure up to date market pricing and solutions are used in the final evaluation.

Option 1 diesel generation is currently the recommended option due to lower capital cost, and positive NPV benefit over a 40 year period.

5. Risk Framework

Essential Energy's Corporate Risk Management Procedure (Attachment 6.03.01) and Network Risk Management Manual (Attachment 6.03.02) underpins network investments in line with the risk Appraisal Value Framework (Attachment 6.03.03) and provide a consistent approach to network asset risk management and augmentation evaluation. The purpose of the procedures is to estimate the level of risk via probability of failure, likelihood of consequence and evaluate cost of consequence for network investments. The framework looks at overall network risk across six key areas: Safety, Network (Reliability), Environment, Compliance, Reputation and Financial.

5.1 Safety

Safety consequence considers the risk to both public and Essential Energy personnel. The existing risk in this case is live conductor dropping to the ground mostly from storm activity or possible vehicular contact with pole, leading to possible injury or fatality. The protection equipment which opens the feeder when conductor drops to the ground is fast acting and reinforced by secondary backup equipment if primary equipment fails. Although the consequence is severe, the probability of failure and likelihood of consequence deems the risk to public and personnel safety to be acceptable. Options 1 and 3 offer reliability and resilience to the network and will allow repair/maintenances work to be done as best as possible as without a negative impact on the customers in the ZS. Option 2 solution will reduce the outage for the Murrurundi ZS caused by equipment failure only. Unplanned outages due to weather and subtransmission failures will still be an ongoing issue, hence, the network solution may not be the ideal solution. Due to the low probability and likelihood of consequence a value for Safety has been deemed negligible and excluded from the NPV for all options.

5.2 Network (Reliability)

Network risk captures the consequences associated with loss of supply. As noted above in Section 3 Reliability, the existing reliability to customers supplied by feeder Murrurundi ZS is the main risk that is addressed in this network investment evaluation. The probability of failure and the consequence associated with loss of supply are relatively straight forward and readily valued, via average unplanned outages rates and VCR. Loss of supply is assessed utilising the historic failure rate and length projected forward utilising VCR.

5.3 Environmental

The prevalent environmental risk is bushfire. As a pole top/conductor fails and live conductor touches the ground, it may, dependant on conditions and environment ignite fire, causing property damage. Essential Energy uses the Phoenix Rapid Fire system and internal modelling to determine a fire risk per pole. The area between Quirindi and Murrurundi is deemed to be a low bushfire risk. All three proposed augmentation options have the existing feeder remain in service. Although the consequence is moderate, the probability of failure and likelihood of consequence deems the risk to be acceptable. Other environmental risks would be transformer oil and diesel fuel spillage. Essential Energy complies to all relevant standards with oil containment and fuel storage. The risk and consequences associated with transformer oil and diesel fuel is negligible and acceptable. Due to a lack of difference between baseline and residual risks environmental risk has been excluded from the NPV.

5.4 Compliance

Compliance risk is assessed for issues that may arise because of not complying to relevant Standards, Acts or Guidelines. Essential Energy complies to all relevant Standards and Acts. There is no compliance risk that needs to be addressed.

5.5 Reputation

Reputational consequences are categorised as those risks associated with the tarnishing of the company's reputation as the result of mostly, in this case, ongoing loss of supply due to overhead asset failure. This investment will address some of the risk associated with Murrurundi ZS having long outage durations.

5.6 Financial

Financial consequences, in this case, are generally those costs associated with fault and emergency work, over-and-above typical planned maintenance costs. Ongoing asset failure has a consequence of ongoing fault and emergency work, which could be costly if the annual probability of failure was significant and increasing exponentially. The existing 33kV network will remain in service. The addition of new assets (Diesel Generator, switchgear, control, and communication devices) will require maintenance. The generator will require regular maintenance to ensure that it will be able to perform as expected. The life of the generator is expected to be 20 years.

References

Doc No.	Document Name	Relevance
1	Murrurundi Gen Value V1	NPV Option Analysis and Outages
2	Quirindi to Murrurundi Line Refurb PDF	Network details
3	4.02 How engagement informed our Proposal	Reference material, justification
4	6.01 Climate impact assessment	Reference material
5	6.02 Resilience Plan	Reference material
6	6.03.01 Corporate Risk Management Procedure	Reference material
7	6.03.02 Network Risk Management Manual	Reference material
8	6.03.03 Appraisal Value Framework	Reference material, risk evaluation
9	8.04 Service Target Performance Incentive Scheme (STPIS) Approach	STPIS target adjustment

Key Terms and Definitions

Term	Definition
$M	Dollars expressed in millions
CML	Customer Minutes Lost
DNSP	Distribution Network Service Provider
FY	Financial Year
MW	MegaWatt
NPB	Net Present Benefit (Benefits over 40-year expressed in present value)
NPC	Net Present Cost (Capital and operation costs over 40-year expressed in present value)
NPV	Net Present Value
NPVM	Net Present Value to Market (NPB subtract NPC)
RIT-D	Regulatory Investment Test – Distribution
VCR	Value of Customer Reliability
VUE	Value of Unserved Energy

Appendix A – Historic unplanned outages for Murrurundi ZS

DATE	ZONE	REGION	EQUIPMENT	CAUSE	START TIM	FINISH TIM	TOTAL	TOTAL	Sub Tr	IR	Min	LCM
Sat 15/12/18	MURRURUNDI	Northern	Pole - HV Failed	Environ - Weather - High Winds	15/12/18 15:37	16/12/18 01:41	716993	716993	Y	INCD-1258	604	433243020
Sat 23/04/16	MURRURUNDI	Northern	nsulator Failed	Environ - Weather - Lightning	23/04/16 20:33	24/04/16 06:30	1178	700144	N	INCD-1150	597	703384
Sat 30/04/22	MURRURUNDI	Northern Tal	Conductor - HV Failed	Environ - Weather - Lightning	30/04/22 15:55	30/04/22 22:59	1214	514736	N	INCD-1192	425	515505
Sat 18/02/12	MURRURUNDI	Northern	Conductor - HV Failed	Environ - Weather - Lightning	18/02/12 19:34	19/02/12 01:46	1062	394530	Y	INCD-1662	373	395666
Sun 20/05/18	MURRURUNDI	Northern	Conductor - HV Failed	Equip - Connection Failed	20/05/18 01:04	20/05/18 07:15	1192	442232	N	INCD-1832	371	442311
Fri 26/01/18	MURRURUNDI	Northern	Conductor - HV Failed	Environ - Weather - Lightning	26/01/18 18:45	27/01/18 00:35	1190	414561	Y	INCD-1731	350	416500
Sat 22/02/14	MURRURUNDI	Northern	Joint / Connection - HV	Equip - Connection Failed	22/02/14 20:54	23/02/14 02:41	1112	370179	N	INCD-5478	347	386086
Sat 25/01/20	MURRURUNDI	Northern Tal	Conductor Tie - HV	Environ - Weather - High Winds	25/01/20 19:30	26/01/20 01:16	1714	261035	N	INCD-1493	346	593244
Wed 01/01/20	MURRURUNDI	Northern Tal	Pole - HV	Environ - Weather - Lightning	01/01/20 23:17	02/01/20 04:57	1199	407660	N	INCD-4436	340	407980
Thu 10/01/19	MURRURUNDI	Northern	Cross-arm - Failed	Equip - Decay or Rot	10/01/19 09:12	10/01/19 13:59	1193	341407	Y	INCD-2040	287	342073
Mon 23/01/17	MURRURUNDI	Northern	Joint / Connection - HV	Equip - Fatigue	23/01/17 06:04	23/01/17 10:42	1021	280222	N	INCD-1386	278	283838
Thu 22/10/15	MURRURUNDI	Northern	Conductor - HV Failed	Environ - Weather - Lightning	22/10/15 12:26	22/10/15 16:30	1200	248160	N	INCD-9894	244	292540
Tue 05/06/12	MURRURUNDI	Northern	Pole - HV Failed	Unauth Contact - Road Vehicle	05/06/12 11:26	05/06/12 15:27	1117	254381	N	INCD-1774	240	268303
Fri 07/12/18	MURRURUNDI	Northern	Pole - HV Failed	Environ - Weather - Lightning	07/12/18 01:00	07/12/18 04:37	308148	308148	Y	INCD-1244	218	67047869
Mon 03/12/12	MURRURUNDI	Northern	Conductor - HV	Environ - Weather - Lightning	03/12/12 18:13	03/12/12 21:32	1107	208503	N	INCD-1015	199	219795
Thu 19/11/20	MURRURUNDI	Northern Tal	Insulator Failed	Environ - Weather - Lightning	19/11/20 11:43	19/11/20 14:58	1202	234390	Y	INCD-4846	195	233829
Fri 24/01/20	MURRURUNDI	Northern Tal	Unknown - No Fault Found	NF - Likely Weather - Lightning	24/01/20 17:10	24/01/20 20:01	1197	204687	Y	INCD-1449	171	205206
Tue 08/12/20	MURRURUNDI	Northern Tal	Isolator	Equip - Insulation Failure	08/12/20 14:27	08/12/20 16:43	1201	163336	Y	INCD-2854	136	163676
Thu 26/07/12	MURRURUNDI	Northern	Surge / Lightning Arrester Blown	Environ - Weather - Lightning	26/07/12 14:56	26/07/12 17:06	1065	36587	Y	INCD-1828	130	138752
Sat 17/10/15	MURRURUNDI	Northern	Other - Please Specify	NF - Likely Animals - Bird	17/10/15 09:00	17/10/15 11:07	1200	144145	Y	INCD-5538	127	152880
Thu 06/06/13	MURRURUNDI	Northern	Cross-arm - Failed	Equip - Decay or Rot	06/06/13 17:32	06/06/13 19:16	1109	115336	Y	INCD-3141	105	115909
Wed 29/01/20	MURRURUNDI	Northern Tal	Insulator Failed	Environ - Weather - Lightning	29/01/20 16:03	29/01/20 17:23	1199	95920	N	INCD-1685	80	95960
Tue 17/08/21	MURRURUNDI	Northern Tal	Conductor - HV Failed	Equip - Fatigue	17/08/21 08:33	17/08/21 09:34	1000	61000	N	INCD-3517	60	60167
Thu 12/09/13	MURRURUNDI	Northern	Transmission System Fault	Other - Switching Error	12/09/13 09:02	12/09/13 09:56	1109	59886	N	INCD-4125	54	59609
Fri 24/06/16	MURRURUNDI	Northern	Transformer - Zone Substation	Environ - Weather - Heavy Rain	24/06/16 11:50	24/06/16 12:28	1182	44916	N	INCD-1203	37	44030
Thu 13/04/17	MURRURUNDI	Northern	Cross-arm - Failed	Equip - Fatigue	13/04/17 09:32	13/04/17 09:46	1188	16632	Y	INCD-8632	13	15979