Essential Energy

10.06.05 Resilience Tibooburra Network Investment Case

November 2022

Network Resilience Project

Project:	10.06.05 Resilience Tibooburra Network Investment Case
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Approvals

	Name	Division	Title & Function	Date
1.	[redacted]	Asset & 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.		

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1. Executive Summary

Major Project	10.06.05 Resilience Tibooburra Network Investment Case
Description	Establish back up supply to Tibooburra township
Drivers for Investment	Resilience: To improve the resilience of the network for customer in the Tibooburra township, as historical reliability performance is unacceptable and outside applicable standards. Poor reliability (frequency and duration) performance is primarily caused by lightning and wind, coupled with distance from the depot. Wind and bushfire impacts are forecast to increase significantly in the future. Following extreme weather events there has been extended periods of power outages, including: 12/11/2022: 92 hours 12/1/2022: 49 hours 6/11/2018: 46 hours 8/12/2016: 30 hours Reliability: To improve reliability for customers in the Tibooburra township. 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 > Line rebuild > 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 $4.2M)
Estimated Expenditure FY24$	2024/25: $0; 2025/26: $0; 2026/27: [redacted]; 2027/28: $0; 2028/29: $0

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

2. Network

Tibooburra township and the SWER lines beyond are supplied by a 292km 33kV radial line from Mt Gipps Zone substation via feeder MTG4B1. The township has approximately 90 connection points, from distribution substations, through a pole mounted step down 500 kVA, 33kV/22kV transformer. The load beyond recloser 6-R11485 is estimated to average 400kVA.

This line was built as part of the Far West Electrification Project and was completed in 1995. The line is 292km long travelling north from Mt Gipps Zone Substation near Broken Hill to Tibooburra. This line was constructed with 14 meter spun concrete poles with a load rating of 8/16kN. The pole top arrangement is a pitchfork with a lift of 385mm plus the insulator height for the two outside conductors. The centre conductor has an additional lift of 770mm above the outside conductors, allowing for a minimum mid span conductor height of 5.5m at a conductor temperature of 65C. The conductor is 7/4.40 + 7/1.60 AAC/ACSR “Cherry”.

Prior to construction of the line this area was supplied from a diesel power station however due to costs of running and capacity constraints permanent supply was established under the Far West Electricity Scheme. This location has an existing generator connection point which provides the opportunity for utilisation of potential backup generation infrastructure.

A number of outages on this feeder have taken extensive time to restore power, with two recent outages in excess of 45 hours following storm events, due to the remoteness and difficulty in accessing the lines. In late 2009 as a result of storms causing a series of microburst conditions five poles were broken and replaced with concrete poles which were emergency spares. A large number of adjacent poles also suffered stress as a result of excessive winds and now have permanent bending of various amounts with the worst being 930mm at the tip.

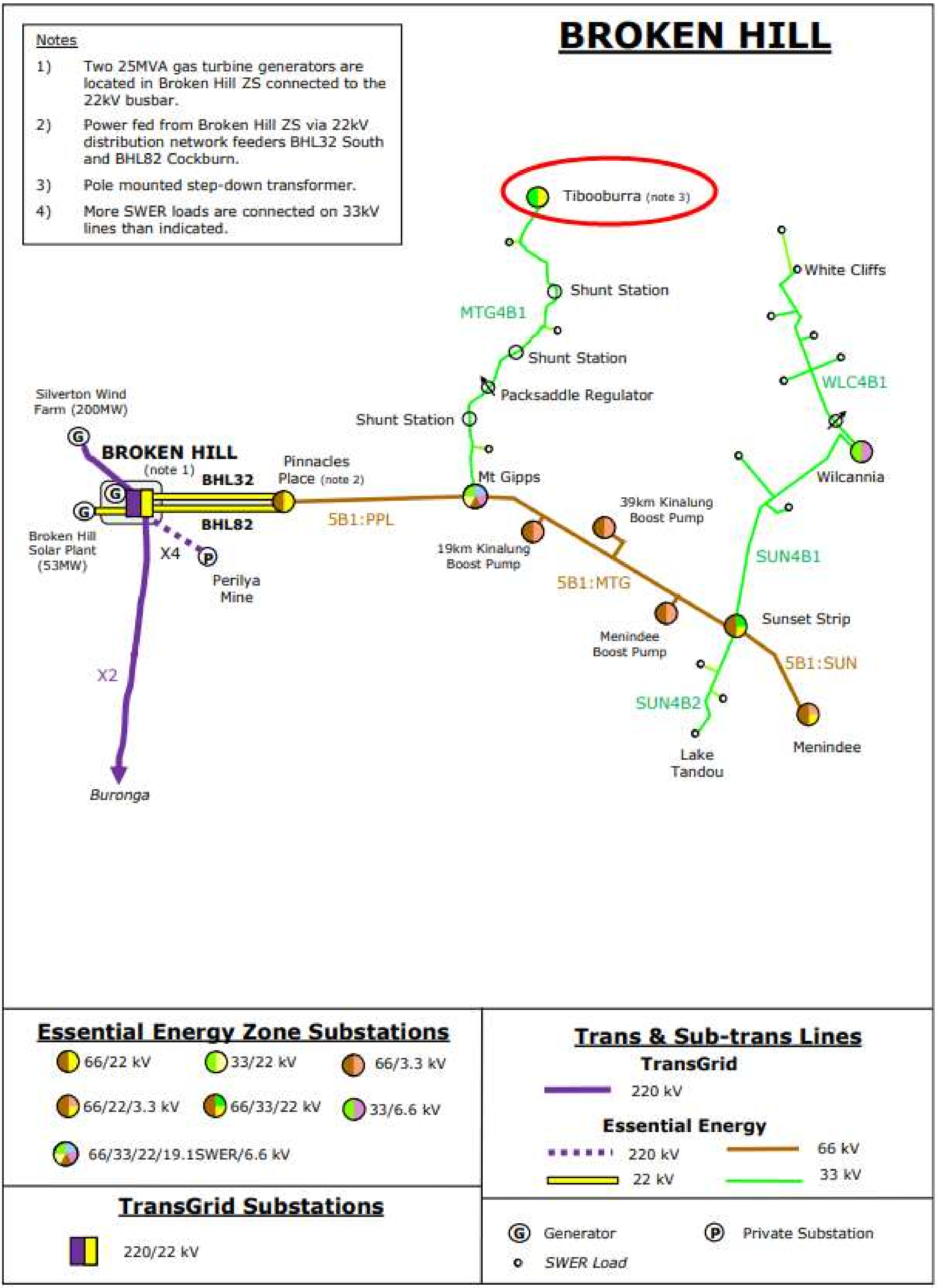

Figure 1 - Simplified Subtransmission Network

The majority of poles on this feeder are concrete with steel wishbone pole top construction, and porcelain post insulators, with vibration dampers and ACSR/GZ conductor (Aluminium Conductor Steel Reinforced/Galvanized).

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

Figure 2 - Typical Pole Top Configuration

The 33kV feeder in this distribution network is susceptible to lightning strikes, being unshielded, with no overhead earthwire for the entire length, other than 1km sections at zone substation entry and exit points. Typical pole top configurations are shown above in Figure 2.

3. Reliability

Reliability of the 66kV subtransmission network is mostly affected by weather. Storm activity and lightning impact the unshielded feeders causes the network to trip via the 33kV circuit breaker at Mt Gipps zone substation.

For faults on this feeder, resources patrol the feeder visually via adjacent public roads and other access tracks. 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 overhead assets including the pole top; crossarm or insulators. Conductor or pole faults are less common however, this failure mode has contributed to long duration outages due to access conditions and mobilisation of plant.

Historical outage data indicates there is an average of 9.6 unplanned outages per annum. These are well above typical rates for an unshielded 33kV feeder which on average is 2.5 outages/100km/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.

12/11/2022: 92 hours; Due to the significant winds (>140km/hr) caused significant damage of 10 poles beyond the recloser R12846.

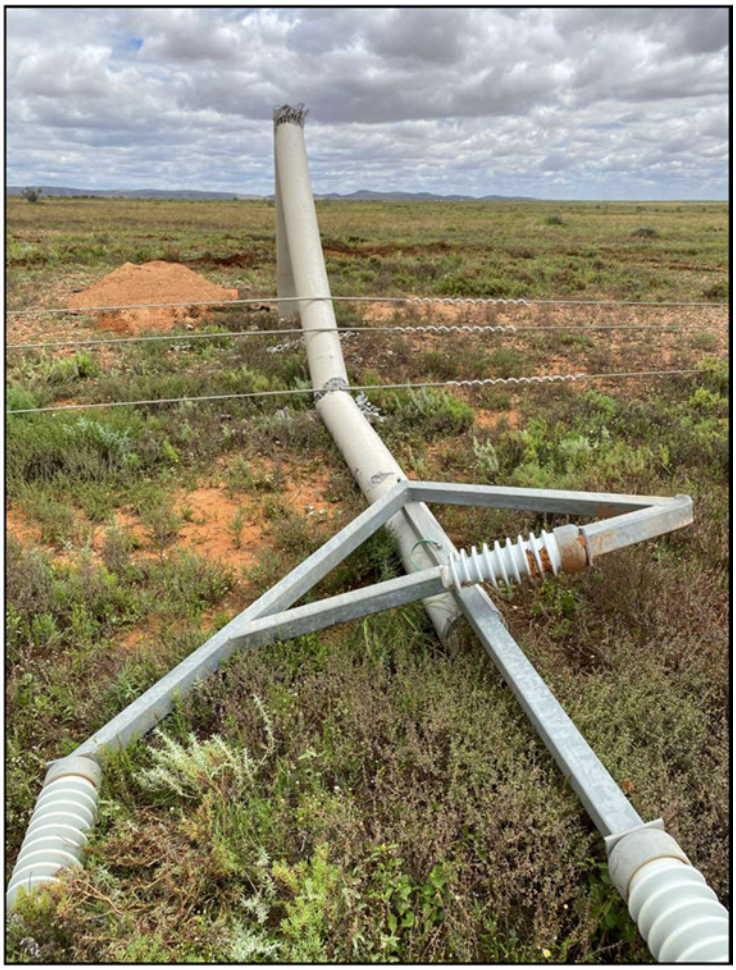

Figure 3 - Concrete Pole Failures INCD-38007-x

12/1/2022: 49 hours; multiple pole failures during a storm and flooded access via creeks preventing crews access to site

Figure 4 - Concrete Pole Failures INCD-104896-q

6/11/2018: 46 hours; Wires down due to bent HV pins and failed conductor ties (no imagery)

8/12/2016: 30 hours; Multiple pole failures

Figure 5 - Concrete Pole Failure INCD-50524-g

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 6 and the feeder has been non-compliant frequently due to duration of the faults.

This 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. Given the location of the township at the end of the radial supply outages these projects have resulted in limited improvement to the area.

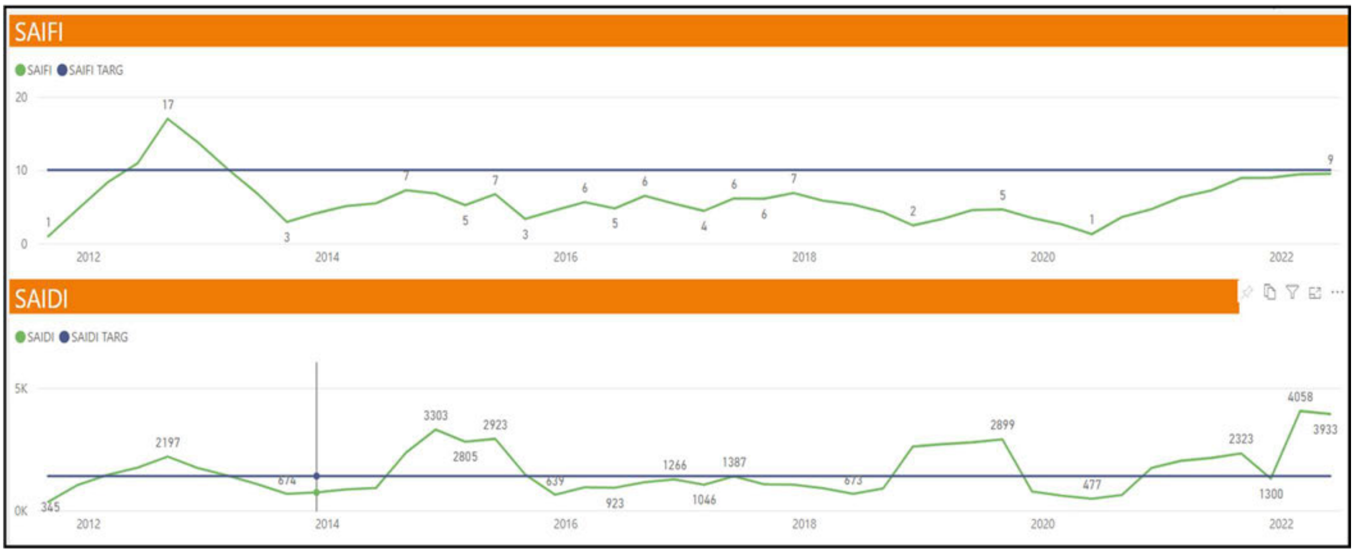

Figure 6 - SAIDI/SAIFI Performance

The Tibooburra township is downstream of recloser 6-R11485 on feeder MTG4B1. Over the past five years the unplanned Customer Minutes Lost (CML) in this particular recloser segment has been the highest on the feeder due to the concentration of customers at the location (refer Figure 7). Any fault on the 292km backbone results in an outage for the township of Tibooburra with non-transient faults having no alternative supply availability.

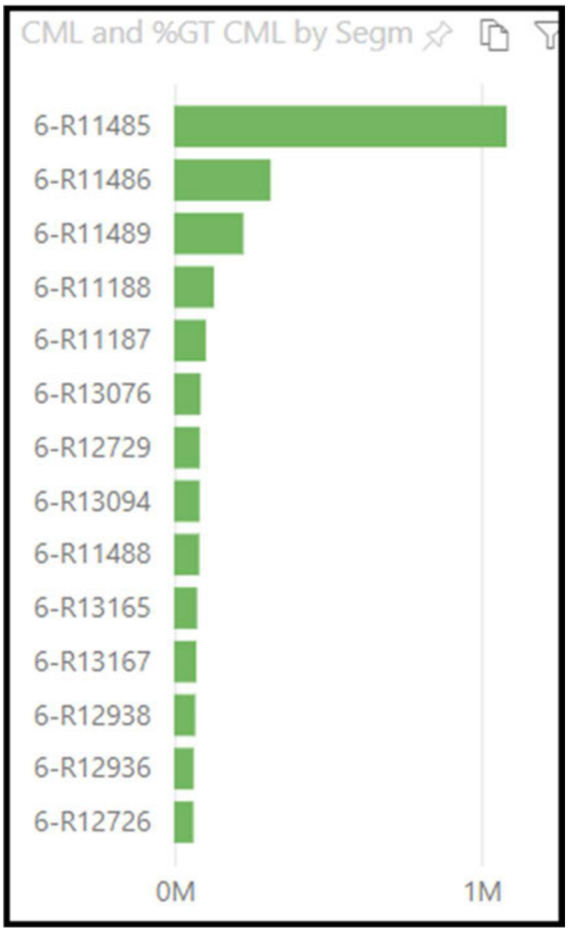

Figure 7 - Customer Minutes Lost By Segment

By cause, the majority of the unplanned outages affecting the segment 6-R11485 have been weather related and have occurred on the distribution feeder (refer Figures 8 and 9).

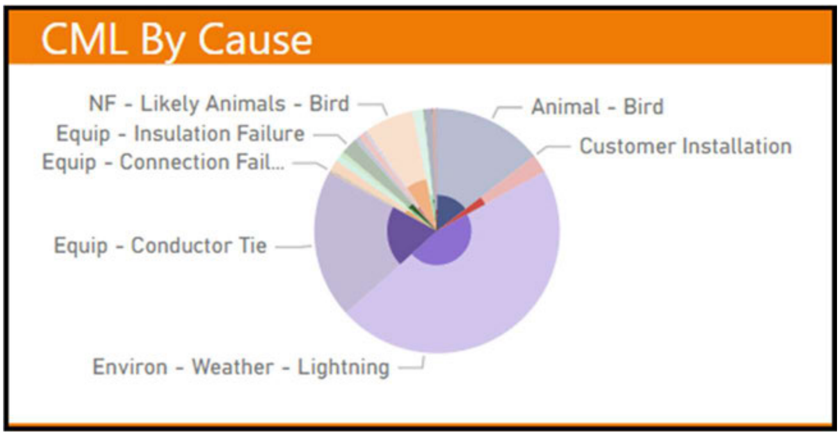

Figure 8 - Customer Minutes Lost Primary Cause

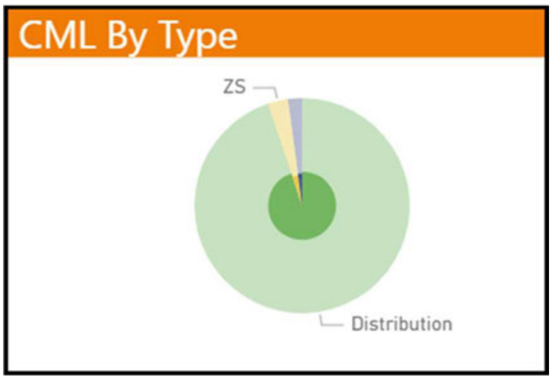

Figure 9 - Customer Minutes Lost by Network Level

3.1 Climate Impact Assessment

This project forms part of our Resilience Plan (**Attachment 6.02**) by strengthening the resilience of the network. The 292km line currently has a very high impact from weather, particularly storms and wind.

Incorporating the findings of our climate change impact assessment we can see in Figure 10 below, the line is also located in the area experiencing the highest forecast change in the combined impact for customer interruptions due to bushfire, flood, and windstorm using RCP4.5 by 2070.

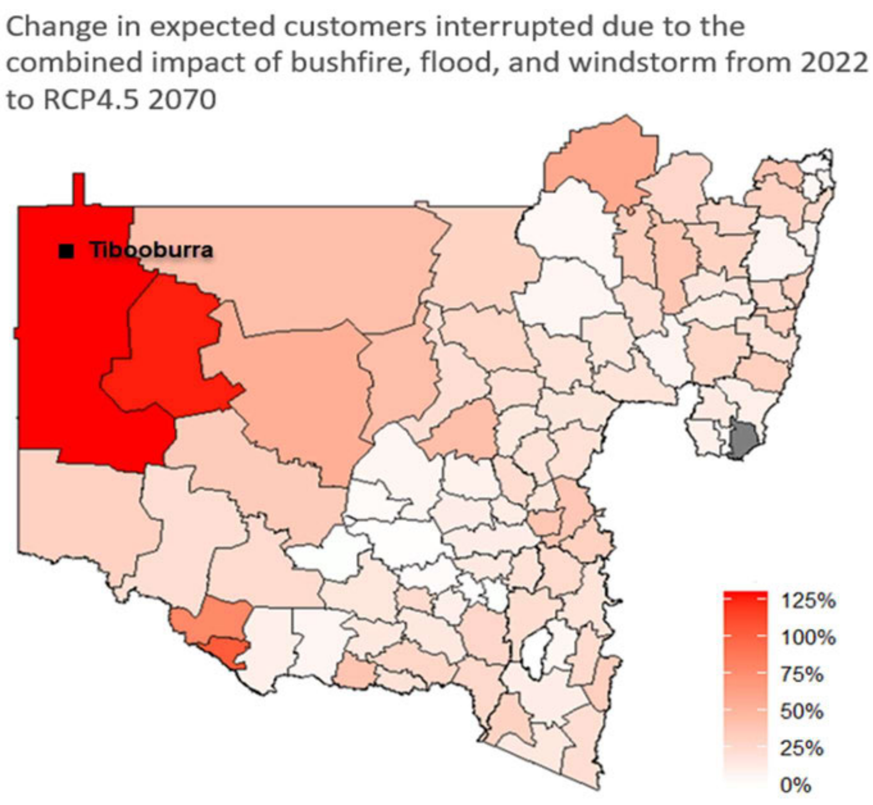

Figure 10 – Forecast customer interruption (Attachment 6.01 Climate Impact Assessment)

The forecast number of failed assets due to windstorm and bushfire on the in Broken Hill depot is shown below in Figure 11. Based on the analysis, climate change is predicted to have a significant impact on this section of network in the future.

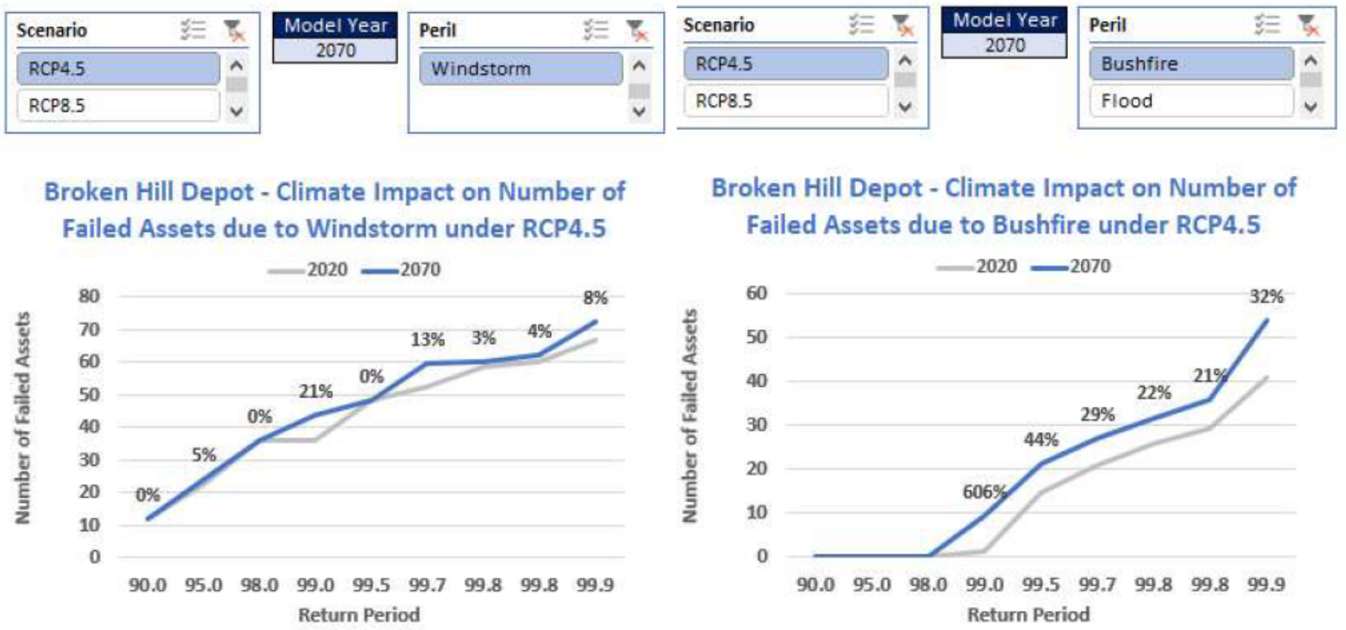

Figure 11 - Current and forecasted analysis of climate impact (Attachment 6.01.01 Climate Summary Line Graphs)

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

4. Options Analysis

Several options were investigated to improve resilience and reliability in the Tibooburra township. One of the options was for lightning protection, but it was ruled out of further analysis due to excessive capital costs to address the length of exposed network. A further three options were identified and 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 resulting from investment is the Network (reliability) benefit which has been valued utilising 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 Tibooburra Township.

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	9.6	Historical performance over the past seven years
Load Impacted	0.4MW	Average customer load in segment 6-R11485
Outage Timeframe	3hrs	Historical performance over the past seven years
NPV Period	40yrs	Current internal common modelling window

4.1 Option 1 - Diesel Generation- Tibooburra township

This option has a capital cost of [redacted] to procure and install a diesel powered generator unit at the Tibooburra township. The unit would be a semi containerised standard 415V output and connect to the 22kV busbar at the local zone substation site via a 415V/22kV step-up transformer. An existing step-up transformer at the old power station has been assumed to be available for use in this case. Considering peak demand, optimised generator protection and operation, one 0.5-1MVA unit would be installed at Tibooburra to supply the township. The unit would have fuel storage for at least eight hours of operation. 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 generator at 20 year intervals has been included. 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 automatically supply the township.

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 22kV transformer circuit breakers would open, and generator start-up would occur within minutes.

This option would not include any major capital investment on the 33kV backbone and it is expected that normal replacement practices will continue in accordance with asset renewal guidelines. The valuation of these asset renewals have not been included in the valuation of this option.

Option 1 has estimated capital cost of [redacted] and a Net Present Value of $4.2M with an adjustment to STPIS targets included in Service Target Performance Incentive Scheme (STPIS) Approach (Attachment 8.04).

4.2 Option 2 – Line Rebuild

Historically the two main components that caused the highest CML were failed HV pole and HV conductors. The network solution would be to reconductor and replace the defective poles for 292km of the backbone feeder. At a rate of [redacted] per km plus a generator during the planned outage is estimated to [redacted]. This solution will reduce the outages for the township caused by equipment failure only.
Unplanned outages due to weather and subtransmission failures will still be an ongoing issue. Live line work will still be required and some planned outages occurring for the township. Hence rebuilding the line may not be the ideal solution and was deemed economically unfeasible when considering the benefits being realised by generator installation.

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

4.3 Option 3 Battery Back-up Storage for Tibooburra township

A battery storage option would include the installation of containerised battery banks at Tibooburra township.

The battery banks would be connected directly to the 22kV network in the township. On loss of the 33kV supply, auto-changeover to the battery banks would occur. With a peak demand of 400KVA, 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 including stabilising the grid in frequency events and sale of spare capacity into the grid. 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 400kVA, for 24 hours requires a battery bank of 9.6MWh. 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 [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 to the township of Tibooburra 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 (i.e. as identified in Section 4.3). 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.

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 driven by 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 (6.03.01) and Network Risk Management Manual (6.03.02) underpins network investments in line with the risk Appraisal Value Framework (6.03.03) and provide a consistent approach to network asset risk management and augmentation evaluation. The purpose of these procedures are 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 township. Option 2 solution will reduce the outage for the township 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 MTG 4B1 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 a Value of Customer Reliability (VCR) [1] based on 6.03.03 Appraisal Value Framework.

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 Mount Gibbs and Tibooburra 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 Tibooburra township 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.

[1] AER Values of Customer Reliability Final report on VCR values Dec 2019

References

Doc No.	Document Name	Relevance
1	Tibooburra Generator NPV.xlsx	NPV Option Analysis
2	Tibooburra Unplanned Outages V1.xlsx	Unplanned outage analysis on 33kV subtransmission network
3	MTG4B1 Tibooburra Poor Performing feeder	Reliability history of the network
4	4.02 How Engagement Informed our Proposal	Reference material, justification
5	6.01 Climate impact assessment	Reference material
6	6.01.01 Climate summary line graphs	Reference material
7	6.02 Resilience Plan	Reference material
8	6.03.01 Corporate Risk Management Procedure	Reference material
9	6.03.02 Network Risk Management Manual	Reference material
10	6.03.03 Appraisal Value Framework	Reference material, risk evaluation
11	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)
VCR	Value of Customer Reliability
VUE	Value of Unserved Energy

Appendix A – Historic unplanned outages for the township

SUPPLY_LOST	SUPPLY_RESTORED	Interruption_Nu	Feeder Descriptio	Segment	Custs on Se	CUSTOMERS_AFFECTED	Duration	CML	OUTAGE_TYPE	INTERRUPTION_CAUSE	EQUIPMENT_TYPE	WEATHER
12/01/2022 21:11	14/01/2022 22:33	INCD-104896-q	MTG4B1 Tibooburra	6-R11485	106	104	2962	308048	Unplanned	Environ - Weather - Lightning	Pole - HV Failed	Lightning/ storm
6/11/2018 17:45	8/11/2018 16:06	INCD-1985091-a	MTG4B1 Tibooburra	6-R11485	106	99	2781	275319	Unplanned	Equip - Conductor Tie	Conductor - HV Failed	Lightning/ storm
8/12/2016 13:23	9/12/2016 19:24	INCD-50524-g	MTG4B1 Tibooburra	6-R11485	106	97	1801	174697	Unplanned	Environ - Weather - Lightning	Pole - HV Failed	Lightning/ storm
14/11/2014 16:49	15/11/2014 14:46	INCD-686204-a	MTG4B1 Tibooburra	6-R11485	106	86	1317	113262	Unplanned	Environ - Weather - High Winds	Conductor - HV Failed	Wind
16/11/2020 0:19	16/11/2020 22:03	INCD-48076-q	MTG4B1 Tibooburra	6-R11485	106	102	1304	133008	Unplanned	Environ - Weather - Lightning	Pole - HV Failed	Lightning/ storm
19/12/2019 16:43	20/12/2019 10:59	INCD-2268-q	MTG4B1 Tibooburra	6-R11485	106	101	1096	110696	Unplanned	NF - Likely Weather - Lightning	Conductor - HV	Lightning/ storm
9/09/2014 20:10	10/09/2014 12:33	INCD-634668-a	MTG4B1 Tibooburra	6-R11485	106	86	983	84538	Unplanned	Animal - Bird	Conductor - HV	Lightning/ storm
24/09/2014 6:22	24/09/2014 17:44	INCD-645108-a	MTG4B1 Tibooburra	6-R11485	106	86	682	58652	Unplanned	Equip - Connection Failed	Conductor - HV	Fine conditions
20/07/2015 4:51	20/07/2015 13:46	INCD-904469-a	MTG4B1 Tibooburra	6-R11485	106	3	535	1605	Unplanned	Equip - Connection Failed	Conductor - HV Failed	Fine conditions
20/07/2015 4:51	20/07/2015 11:37	INCD-904469-a	MTG4B1 Tibooburra	6-R11485	106	83	406	33698	Unplanned	Equip - Connection Failed	Conductor - HV Failed	Fine conditions
17/04/2019 8:39	17/04/2019 14:10	INCD-2109894-a	MTG4B1 Tibooburra	6-R11485	106	100	331	33100	Unplanned	NF - Likely Animals - Bird	Conductor - HV	Fine conditions
24/09/2016 14:44	24/09/2016 19:06	INCD-1279924-a	MTG4B1 Tibooburra	6-R11485	106	97	262	25414	Unplanned	Environ - Weather - Lightning	Conductor - HV	Lightning/ storm
1/10/2013 4:56	1/10/2013 8:44	INCD-349897-a	MTG4B1 Tibooburra	6-R11485	106	88	228	20064	Unplanned	Animal - Bird	Pole - HV	Extreme Wind (eg Cyclone)
15/09/2014 17:13	15/09/2014 19:24	INCD-639222-a	MTG4B1 Tibooburra	6-R11485	106	86	131	11266	Unplanned	NF - Likely Weather - Wind	Conductor - HV	Wind
26/12/2017 12:00	26/12/2017 13:16	INCD-63143-g	MTG4B1 Tibooburra	6-R11485	106	97	76	7372	Unplanned	Animal - Bird	Conductor - HV	Fine conditions
2/09/2020 10:02	2/09/2020 11:16	INCD-9985-x	MTG4B1 Tibooburra	6-R11485	106	102	74	7548	Unplanned	Animal - Bird	Pole - HV	Fine conditions
21/02/2021 17:56	21/02/2021 19:09	INCD-16091-x	MTG4B1 Tibooburra	6-R11485	106	102	73	7446	Unplanned	Equip - Fatigue	Conductor - HV	Fine conditions
5/02/2014 9:10	5/02/2014 10:11	INCD-17391-g	MTG4B1 Tibooburra	6-R11485	106	85	61	5185	Unplanned	Animal - Bird	Conductor - HV Failed	Fine conditions
24/09/2016 23:02	24/09/2016 23:43	INCD-1280140-a	MTG4B1 Tibooburra	6-R11485	106	97	41	3977	Unplanned	Environ - Weather - Lightning	Conductor - HV	Lightning/ storm