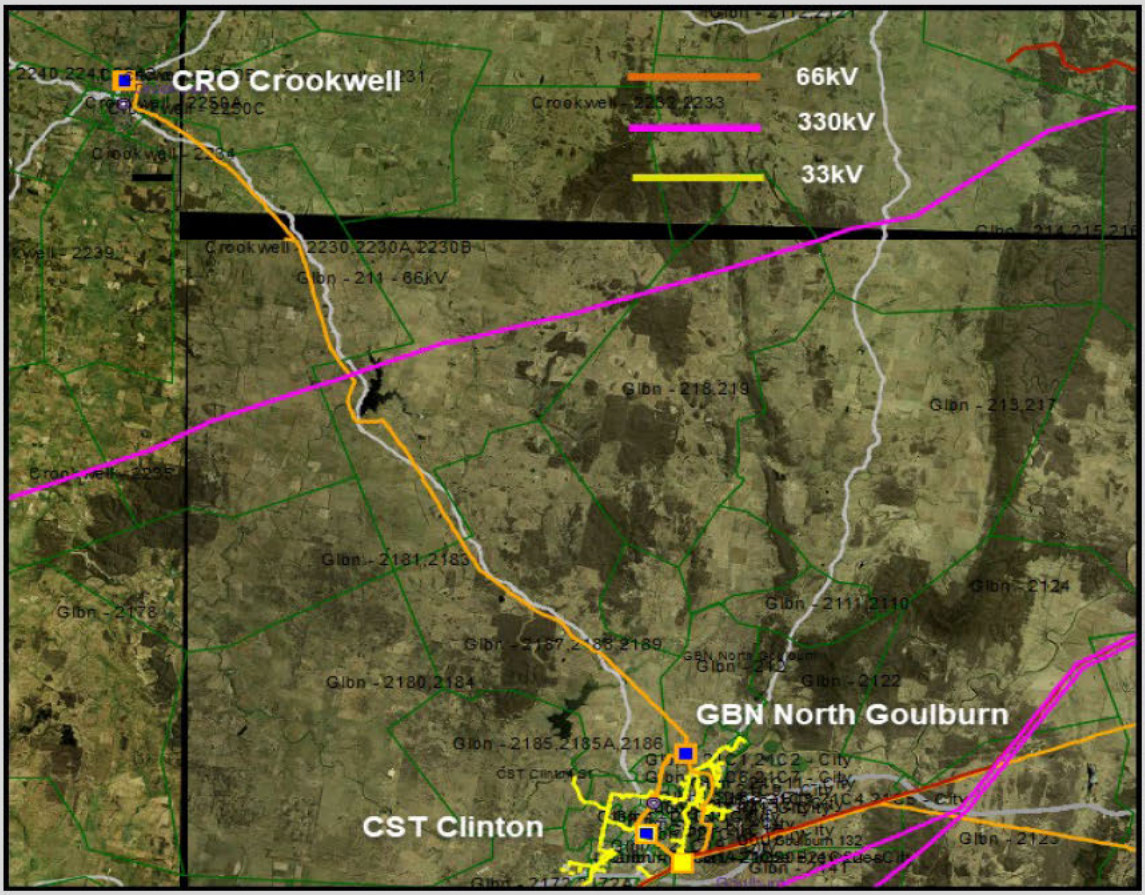
Essential Energy

10.06.08 Resilience Crookwell Network Investment Case



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Network Resilience Project

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Approvals

	Name	Division	Title & Function	Date
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	10.06.08 Resilience Crookwell Network Investment Case
Description	Establish back up supply to Crookwell ZS
Drivers for Investment	Resilience: To improve the resilience of the network for customer on the Crookwell Zone Substation due to current poor reliability in adverse weather conditions and distance from a depot. Climate change analysis is forecasting an increase in wind and bushfire risk in this area. Following weather events there has been extended periods of power outages, including: 19/12/2021: 26 hours 17/07/2015: 11 hours 26/11/2019: 4 hours Reliability: To improve reliability for those customers in the Crookwell ZS. 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 $3.7M)
Estimated Expenditure FY24$	2024/25: $0 | 2025/26: $0 | 2026/27: $0 | 2027/28: $0M | 2028/29: [redacted]

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

2. Network

841:GBN-Goulburn North-Crookwell is the backbone 66kV sub-transmission line out of North Goulburn Zone Substation. It extends 42km of 6/.104+1/.186 ACSR/GZ conductor from North Goulburn ZS to Crookwell ZS which is radial.

It was constructed in 1955 with 177 single wood poles, crossarm and half configuration, porcelain/glass disc insulators and the conductor is Pickerel (6/.105" + 1/ .188" (6/2.67 + 1/4 .78) ACSR/SB (Smooth body)). This is a non-standard legacy conductor, which results in additional complexity when performing work. There is no overhead earthwire for the entire length of the feeder other than approximately 1km at the entry and exits of the zone substations.

The forecasted average load for Crookwell ZS is 4MVA. The 42km radial 66kV feeder (#841) between North Goulburn 66/11kV zone substation and Crookwell 66/11kV zone substation supplies Crookwell (4MW) and provides 66kV connection for Crookwell wind farm (4MW) as shown in Figure 1.

The main components that resulted in the highest Customer Minutes Lost (CML) were pole top failure and conductor damage caused by weather and lightning

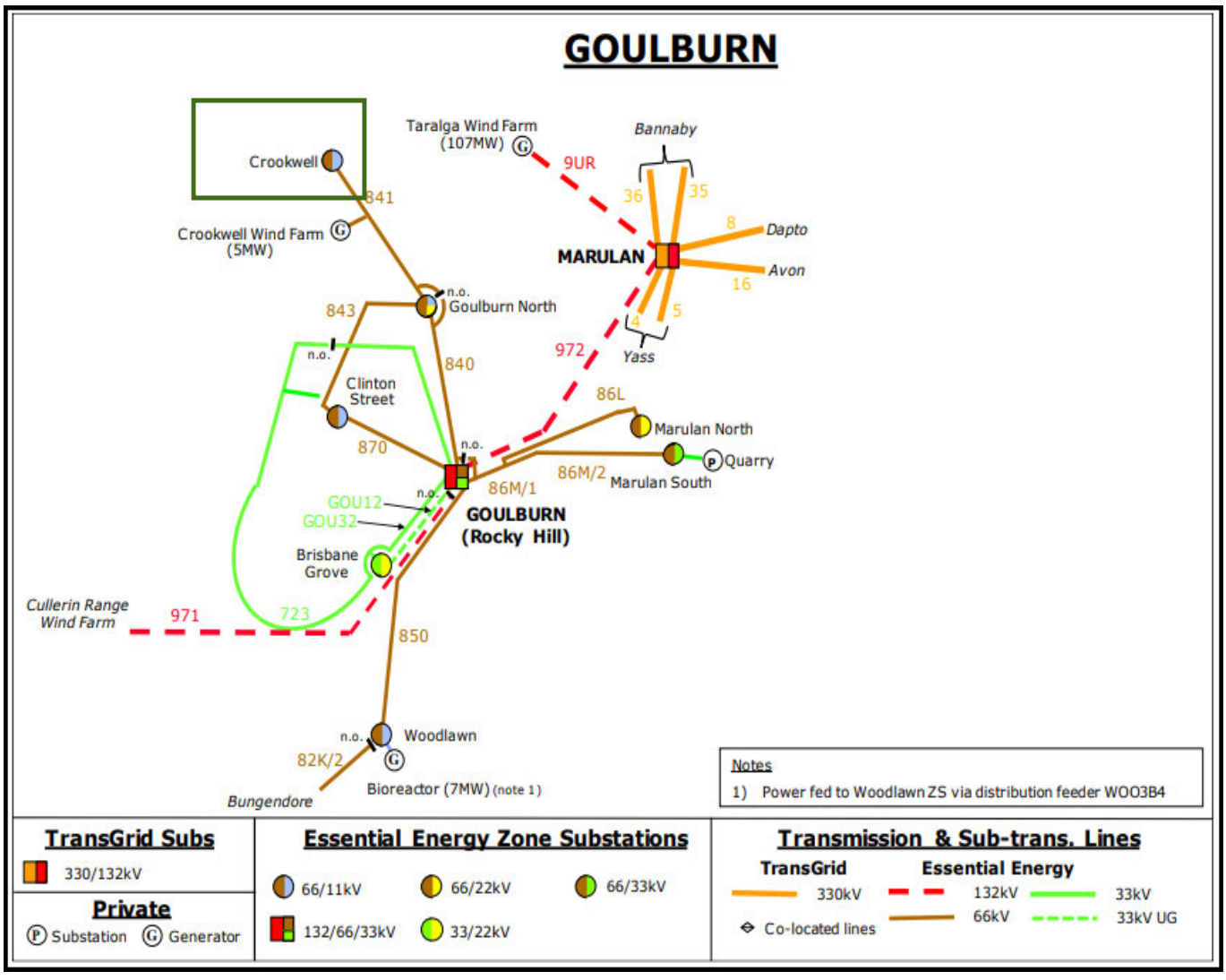

Figure 1 - Simplified Subtransmission Network

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

Feeders emanating from the Crookwell ZS to supply the Crookwell township and surrounding areas have generally been within IPART obligations. However, this has generally been due to lower rates of failure of the distribution network with outages impacting the area resulting primarily from the 66kV sub-transmission network suppling the zone substation. The 66kV network is predominately impacted during weather events which both cause damage and access issues to visually patrol and rectify faults. Depending on weather and time of day, patrols may take several hours to locate faults and or confirm system integrity prior to re-energisation. Generally, on location of fault emergency repairs are completed straight away. Typical storm/lightning faults impact the pole top; crossarm or insulators, conductor or pole faults are less common. The network is also exposed to an extreme climate from averages from -10 degree to 50 degrees.

Historical outage data indicates there is an average of 1.7 unplanned outages per annum, which equates to 4.25 outages/100km/annum. This rate is nearly three times the typical rate for an unshielded 66kV feeder which on average is 1.5 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:

19/12/2021: 26 hours; sub-transmission pole failure during a high winds, storms and lightning.

Figure 2 - Timber Pole Failure INCD-97660-q

26/11/2019: 4 hours; Broken Tie on 66kV line during lightning and storm.

Figure 3 – Cross arm tie failure INCD-2144062-a

7/07/2015: 11 hours; Subtransmission trip CB 8402 Goulburn to Crookwell. After closing 66kV found 11kV CB 5502 trip. HV conductors down with trees on the line with multiple faults. (no imagery)

Figure 4 – Poles damaged by lightning and by high winds

Further historical reliability data for this feeder can be found in Appendix A. In addition, the climate impact due to windstorm on the number of failure of assets in Crookwell depot is shown below in Figures 2 and 4. Based on the analysis, climate is predicted to have a higher impact on the network in this area.

Crews attending to repairs and maintenance on this feeder are faced with additional access issues compared to other areas which in turn affect reliability. The number of nailed poles are particularly high in swampy wet areas providing logistical issues for access with heavy plant for most of the year.

Figure 5 – Example of poles in swampy areas

As per Figure 1 a privately owned windfarm is also connected on this sub-transmission feeder. The point of connection for the windfarm is within a privately owned and operated switchyard teed off the main line (see Figure 6). As there is no point of isolation on the Essential Energy network for this spur, isolation is required to be completed by operators for the windfarm within their switchyard. This isolation is required before construction activities can commence on the network. Isolation of the private network can take extended periods of time dependant on the availability of operational staff by the customer.

Figure 6 – Windfarm switch yard connection point

3.1 Climate Impact Assessment

This project forms part of our Resilience Plan (**Attachment 6.02**) and strengthening the resilience of the network. The line has a very high impact from weather events, particularly wind and lightning. From the **Climate Impact Assessment (Attachment 6.01)**, it is forecast by 2070 that the impact on asset failures of combined bushfire, flood and wind will increase by approximately 40% using RCP4.5 as shown in Figure 8 below.

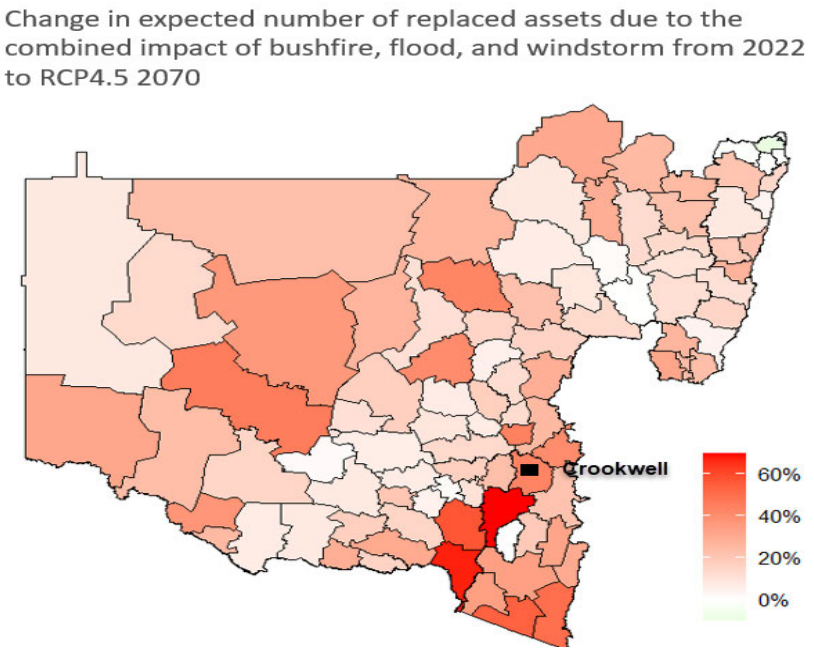

Figure 7 – Expected increase in asset replacement due of climate impact (Attachment 6.01 Climate Impact Assessment)

From climate change modelling, this area is also expected to see an increased impact on assets (as shown in Figure 8), thus increasing the criticality of the electrical supply for at risk customers.

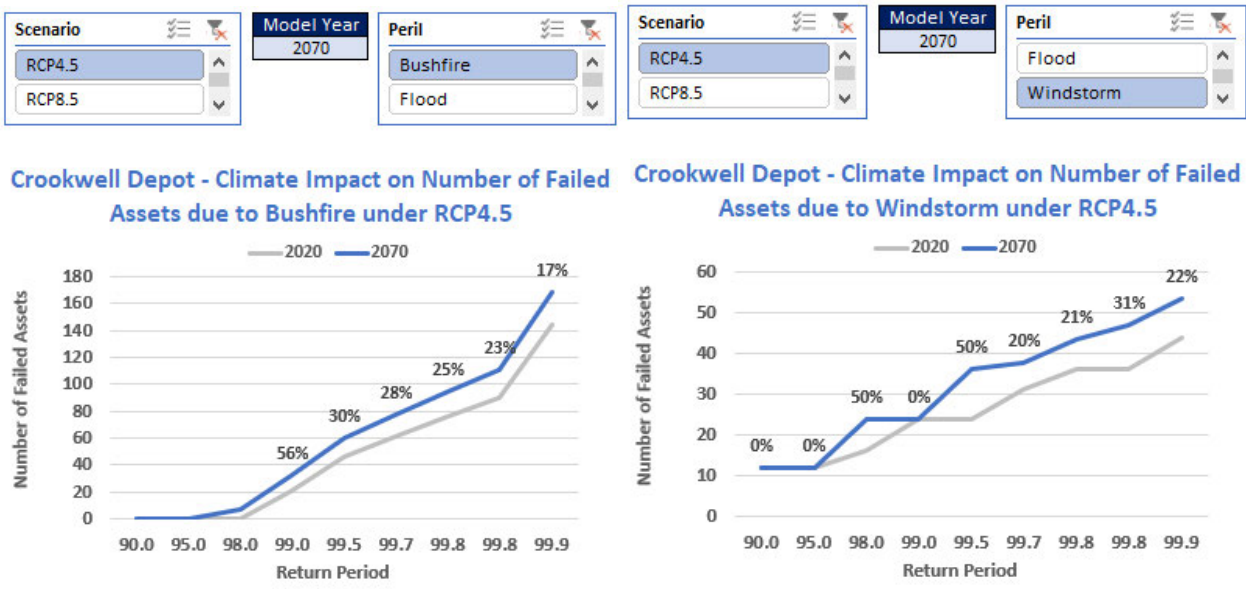

Figure 8 - Current and forecasted analysis of climate impact (Attachment 6.01.01 Climate Summary Line Graph)

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 Crookwell township and surrounding areas. One of the options was for lightning protection, but it was ruled out of further analysis due to excessive capital costs due to the length of exposed network. The following three options below were compared via Net Present Value (NPV) analysis:

- Option 1 – Diesel generation;
- Option 2 – Second supply line;
- Option 3 – Battery storage;
- Option 4 – Market-led non-network solution.

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 Crookwell 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	1.7	Historical performance over the past seven years
Load Impacted	4MW	Average customer load in the Crookwell 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- Crookwell ZS

This option has a capital cost of [redacted] and would require diesel powered generator units to be installed at the secondary side of Crookwell zone substation. The units would be a semi containerised standard 415V output and connect to the 11kV busbars at the zone substation via 415V/11kV step-up transformer. Considering peak demand, optimised generator protection and operation, three 1.5MVA units would be installed at Crookwell ZS to supply the downstream distribution feeders. 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. Planned outages for customers will also reduce as the generator can be utilised during planned outages which would otherwise result in customer outage due lack of system reduncancy.

On loss of the 66kV supply, the 11kV transformer circuit breakers would open, and generator start-up would occur within minutes.

This option would not include any major capital investment on the 66kV sub-transmission network 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] a Net Present Value of $3.7M and an impact to STPIS targets included in Service Target Performance Incentive Scheme (STPIS) Approach (Attachment 8.04).

4.2 Option 2 – Second supply line

The network solution would be to construct a second 66kV line between North Goulburn ZS to Crookwell ZS thereby creating an alternate supply. 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.

Unplanned outages due to weather would still be an ongoing issue. 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 Crookwell ZS

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

The battery banks would be connected directly to the 11kV network in the Crookwell ZS. On loss of the 66kV supply, auto-changeover to the battery banks would occur. With a peak demand of 4MVA, 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 4MVA, for 24 hours requires a battery bank of 5MWh. 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 to the Crookwell 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 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 Crookwell 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 Value of Customer Reliability (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 North Goulburn ZS and Crookwell ZS is deemed to be a high bushfire risk. All three proposed augmentation options have the existing 66kV subtransmission network 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 Crookwell 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 66kV 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	Crookwell ZS Generator NPV.xlsx	NPV Option Analysis
2	Goulburn - Crookwell Design Option Report	Background of the network
3	6.01 Climate Impact Assessment	Reference material
4	6.01.01 Climate Summary Line Graph	Reference material
5	6.02 Resilience Plan	Reference material
6	4.02 How Engagement Informed our Proposal	Reference material, justification
7	6.03.01 Corporate Risk Management Procedure	Reference material
8	6.03.02 Network Risk Management Manual	Reference material
9	6.03.03 Appraisal Value Framework	Reference material, risk evaluation
10	8.04 Service Target Performance Incentive Scheme (STPIS) Approach	STPIS target adjustment

Key Terms and Definitions

Term	Definition
$M	Dollars expressed in millions
AEMO	Australian Energy Market Operator
DNSP	Distribution Network Service Provider
FY	Financial Year
MW	MegaWatt
NER	National Electricity Rules
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 the Crookwell ZS

DATE	ZONE	EQUIPMENT	CAUSE	START TIM	FINISH TIM	TOTAL	TOTAL	Sub	IR	Min	LCM	Comment (New Field)
Sun 19/12/21	CROOKWELL	Pole - HV Failed	Environ - Weather - Lightning	19/12/21 00:22	20/12/21 02:11	3022	4673430	Y	INCD-9766	1549	4680826	Multi faults: poles down, broken cross-arms, lines dropped
Fri 14/03/14	CROOKWELL	Conductor - HV Failed	Environ - Weather - Lightning	14/03/14 18:07	14/03/14 23:19	3166	929197	Y	INCD-4977	312	986737	Lightning caused wires down on 66kV 841 Line to Crookwell. No backfeed available.
Fri 17/07/15	CROOKWELL	Conductor - HV Failed	Environ - Weather - Blizzard	17/07/15 02:31	17/07/15 13:15	1504	447267	Y	INCD-9018	643	967548	Subtransmission trip CB 8402 Goulburn to Crookwell. After closing 66kV found 11kV CB 5502
Fri 12/10/12	CROOKWELL	Conductor - HV Failed	Environ - Weather - High Winds	12/10/12 06:35	12/10/12 14:22	1888	188448	Y	INCD-1903	466	879997	Wire down on the 66kV 841 at pole ce164099.
Mon 25/02/13	CROOKWELL	Insulator Failed	Equip - Insulation Failure	25/02/13 12:11	25/02/13 16:59	2926	390451	Y	INCD-8067	288	842688	Emergency outage to repair severely damaged insulator on 66kV into Crookwell zone.
Tue 26/11/19	CROOKWELL	Conductor Tie - HV	Environ - Weather - High Winds	26/11/19 15:34	26/11/19 19:40	3305	807265	Y	INCD-214	246	813195	BROKEN TIE ON 66KV LINE
Sat 16/05/15	CROOKWELL	CB Failed	NF - Likely Animals - Bird	16/05/15 06:41	16/05/15 10:19	2984	641723	N	INCD-8455	218	650960	CB CLOSE COIL FAIL
Thu 26/09/13	CROOKWELL	Joint / Connection - HV	Urgent Network Repair	26/09/13 13:03	26/09/13 15:09	2957	359770	N	INCD-2556	126	373173	High wind
Sun 26/12/21	CROOKWELL	CB	Environ - Weather - Lightning	26/12/21 16:16	26/12/21 18:02	3373	357538	N	INCD-1010	106	356414	Possible limit switch issue causing the close coils not to charge meaning the CB will not clos
Sat 02/05/20	CROOKWELL	CB Failed	NF - Likely Network - Overload	02/05/20 12:54	02/05/20 14:27	3320	308760	N	INCD-2922	94	310807	CB 8432 had CBF operation which tripped bus.
Sat 20/10/18	CROOKWELL	CB	Environ - Weather - Lightning	20/10/18 14:33	20/10/18 16:00	3251	277958	Y	INCD-1970	86	281103	Appears 66kV feeder has tripped during intense storm activity. No ETR at this stage
Sun 03/02/19	CROOKWELL	Unknown - No Fault Fou	NF - Likely Weather - Lightning	03/02/19 17:44	03/02/19 19:06	3284	260928	N	INCD-2066	83	271696	Zone substation lost all supply. Lightning strike suspected as per stormtracker
Sun 01/11/15	CROOKWELL	Transformer - Zone Subs	Environ - Weather - Lightning	01/11/15 22:10	01/11/15 23:02	3215	141383	N	INCD-9995	51	164287	TRIPPED ON TX1 DIFF
Fri 28/09/12	CROOKWELL	Conductor - HV	Environ - Weather - Lightning	28/09/12 17:19	28/09/12 18:04	2938	120696	Y	INCD-6237	44	130545	840 Fdr Tripped supply restored through 843 Fdr. Staf advised this line has previously tripped
Thu 30/06/16	CROOKWELL	Conductor - HV Failed	NF - Likely Animals - Unknown	30/06/16 02:59	30/06/16 03:17	3202	57636	N	INCD-4409	18	56409	Gunning Wind Farm
Mon 06/02/17	CROOKWELL	CB	Environ - Weather - Lightning	06/02/17 23:02	06/02/17 23:14	3221	38652	Y	INCD-1402	12	39726	
Fri 12/10/12	CROOKWELL	Sectionaliser / Recloser	Environ - Weather - High Winds	12/10/12 14:21	12/10/12 14:22	1258	1258	N	INCD-190	1	671	