

# Essential Energy

## 10.03.11 Augex Mudgee Transformer Replacement Investment Case



November 2022

## Distribution Major Project

Project: 10.03.11 Augex Mudgee Transformer Replacement Investment Case

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### Approvals

	Name	Division	Title & Function	Date
1.	[REDACTED]	Asset & Operations	Manager Network Planning	14/12/22
2.				

### Revisions

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

## Table of Contents

<b>1. Executive Summary</b>	<b>4</b>
<b>2. Network</b>	<b>5</b>
<b>3. Load Growth</b>	<b>7</b>
<b>4. Identified Need</b>	<b>7</b>
<b>5. Options Analysis</b>	<b>9</b>
5.1 Option 1 – Replace 132/22kV Power Transformer at Zone Substation	10
5.2 Option 2 - Install 22kV Reactors At Mudgee Zone Sub	10
5.3 Option 3 - Install 2 <sup>nd</sup> 132/22kV Transformer at Mudgee	10
5.4 Option 4 - Market led Non-Network Solution	11
5.5 Recommended Option	11
<b>6. Risk Framework</b>	<b>11</b>
6.1 Safety	11
6.2 Environmental	11
6.3 Compliance	11
6.4 Reputation	12
6.5 Financial	12
<b>References</b>	<b>12</b>
<b>Key Terms and Definitions</b>	<b>13</b>
<b>Appendix A – Value of high voltages</b>	<b>14</b>

# 1. Executive Summary

<b>Major Project</b>	10.03.11 Augex Mudgee Transformer Replacement Investment Case				
<b>Description</b>	Replace Mudgee 132/22kV 30MVA transformer with new standard buck range unit.				
<b>Drivers for Investment</b>	<p>The driver of the investment is to reduce customer voltage levels on the Mudgee area electrical network to meet NER 6.5.7 capital objectives. There are periods where high voltages are recorded at premises across the network.</p> <p><b>Financial:</b></p> <p>Electronic equipment is susceptible to failure and decreased life expectancy when exposed to high voltages. The impact on customer equipment supplied from the Mudgee network is estimated to be as follows:</p> <div data-bbox="515 745 1083 891" style="background-color: black; width: 100%; height: 100%;"></div> <p><b>Reputation and Compliance:</b></p> <p>Essential Energy incurs both compliance and reputational costs when customers complain of high voltage levels. The estimated annual cost incurred by high voltage complaints in the Mudgee area are as follows:</p> <div data-bbox="520 1048 1045 1122" style="background-color: black; width: 100%; height: 100%;"></div>				
<b>Investment Options</b>	<p>Several options were considered to reduce voltage levels including.</p> <ul style="list-style-type: none"> <li>- Installing 22kV reactors at the Mudgee Zone Substation</li> <li>- Installing 2<sup>nd</sup> 132/22 kV transformer at Mudgee</li> <li>- Due to the financial cost 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.</li> </ul> <p>The option recommended from the Net Present Value of cost and benefit is as follows:</p> <ul style="list-style-type: none"> <li>- Replace the 132/22kV transformer at the zone substation (NPV \$3.6m)</li> </ul>				
<b>Estimated Expenditure \$FY24</b>	2024/25	2025/26	2026/27	2027/28	2028/29
	\$0			\$0	\$0

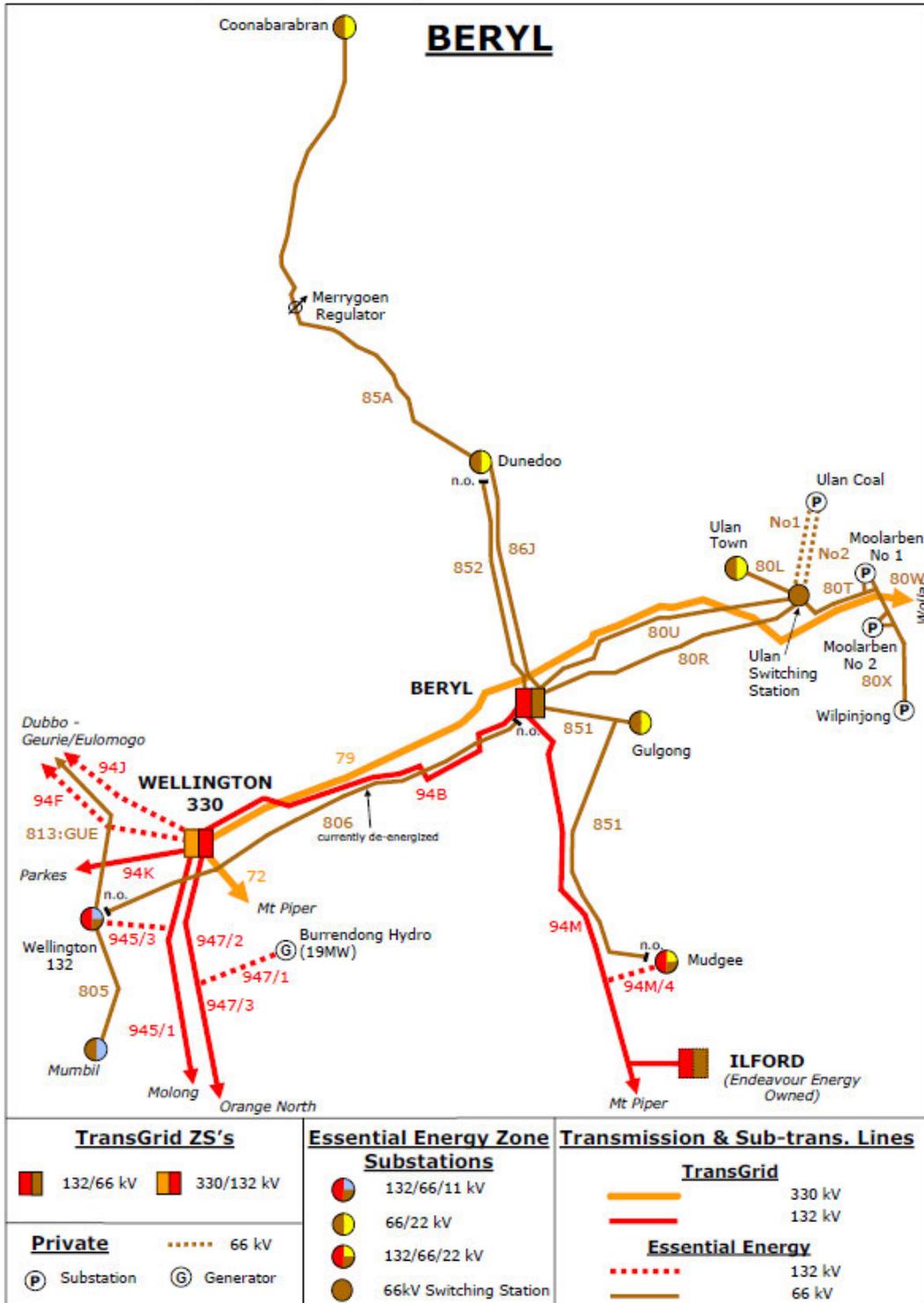
All values are in middle of the year 2023-24 real dollar terms

## 2. Network

The Mudgee 132/66/22kV Zone Substation is normally supplied by a tee connection from Transgrid's 132kV network between Mt Piper and Wellington. The Mudgee Zone Substation includes a single 132/22kV transformer with limited alternate supply from a 66/22kV transformer supplied by the 66kV line 851 from Beryl.

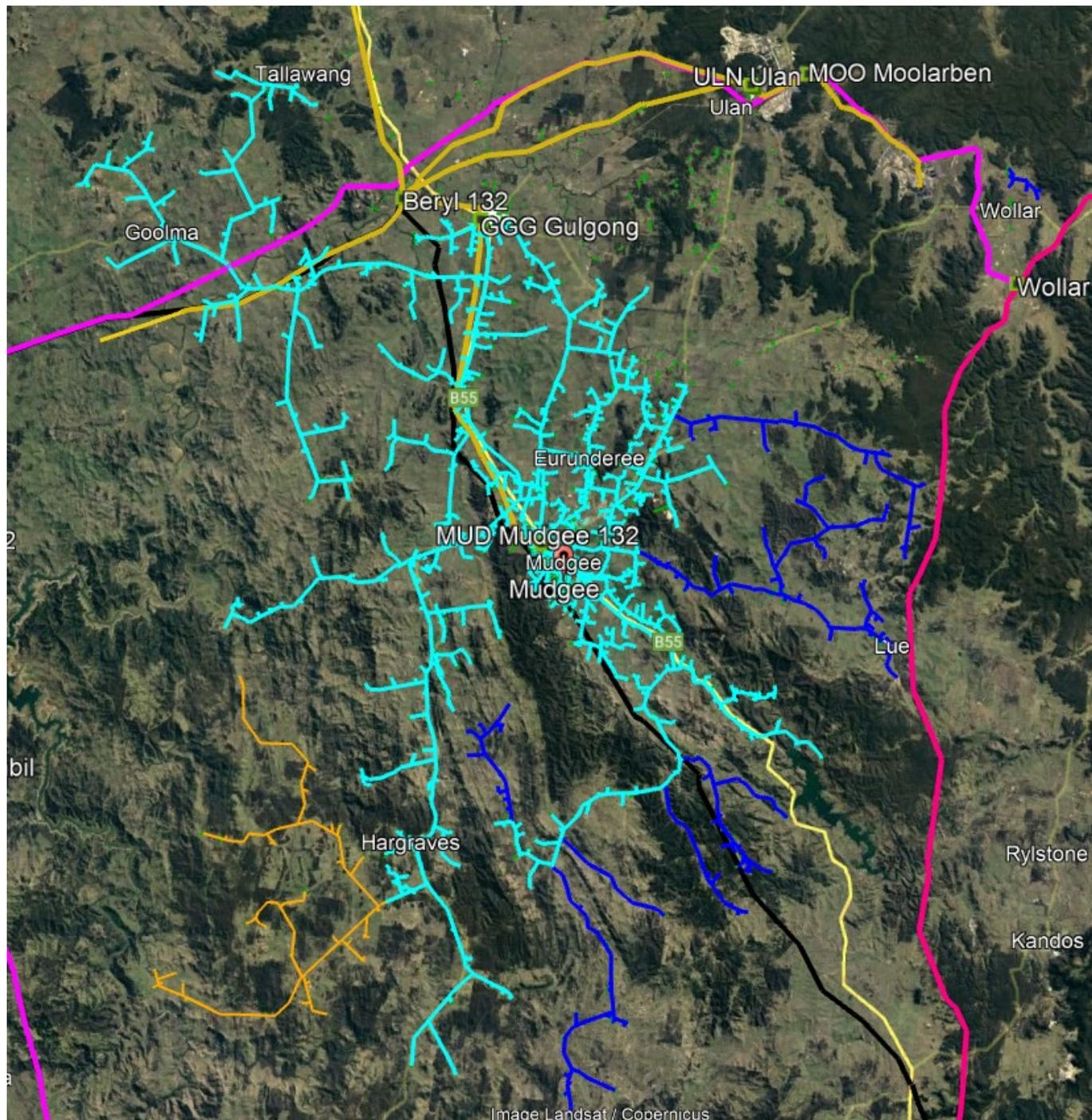
Figure 1: Subtransmission Network supplying Mudgee

Sub-transmission Single Line Diagram of Beryl area



Customers supplied by the Mudgee zone substation range from Tallawang north of Mudgee to Hargraves in the South

Figure 2: Mudgee Distribution Network



### 3. Load Growth

Moderate winter demand growth is forecast by Frontier Economics (**Attachment 11.01**) for Mudgee, but little overall increase in summer maximum demand is expected as shown in Table 1.

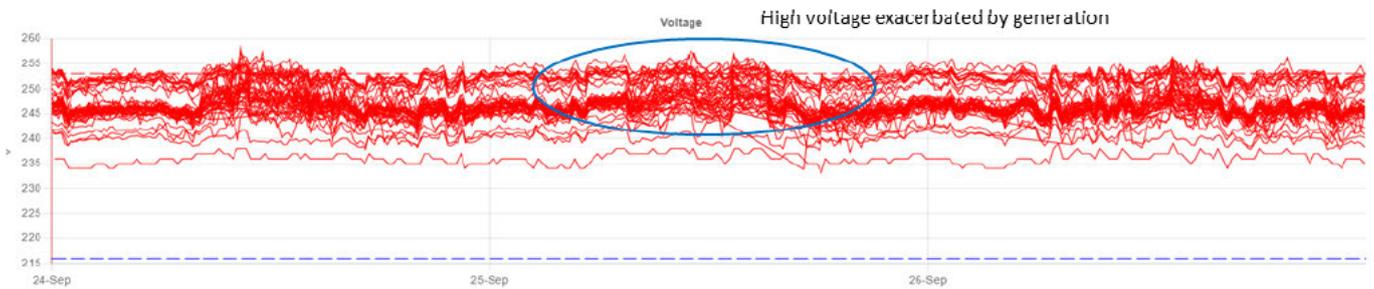
**Table 1: Forecast Mudgee ZS Demand**

Financial Year	Summer (MVA)	Winter (MVA)
2022	26.7	25.0
2023	26.5	25.1
2024	26.4	25.2
2025	26.3	25.2
2026	26.4	25.4
2027	26.6	25.5
2028	27.0	25.7
2029	26.6	26.0

### 4. Identified Need

High voltage levels have been recorded across the Mudgee network from customers smart meters. Figure 3 shows a voltage trace from 24<sup>th</sup> to 27<sup>th</sup> September 2022 for the Cudgegong feeder supplying the Mudgee urban load.

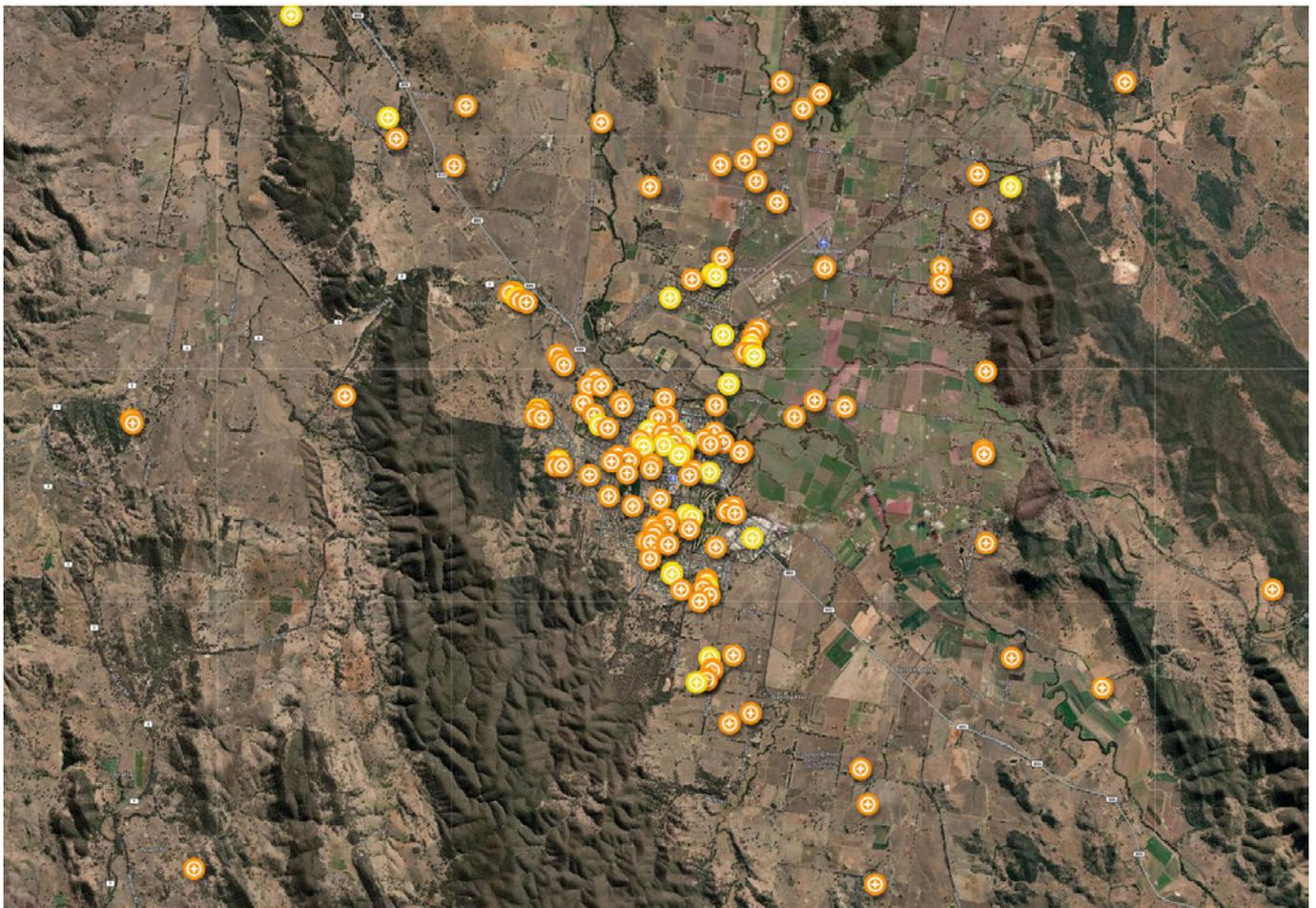
**Figure 3: Smart meter Voltage Trace for Cudgegong (Urban) Feeder in September 2022**



This trace shows voltages above the 253V upper limit in the Australian standard at all times of day, but especially exacerbated by rooftop solar generation in daylight hours.

High voltage issues are not confined to a single area on the Mudgee network, widespread high voltage issues are demonstrated in Figure 4, which highlights transformers that have experienced a high voltage issue between January and October 2022.

**Figure 4: High Voltage Issues Detected in 2022**



Customer Smart meter data has been used to estimate the cost to customers from overvoltage, with a full breakdown of the assumptions given in Appendix 1.

**Table 2: Cost due to Overvoltage / Annum**

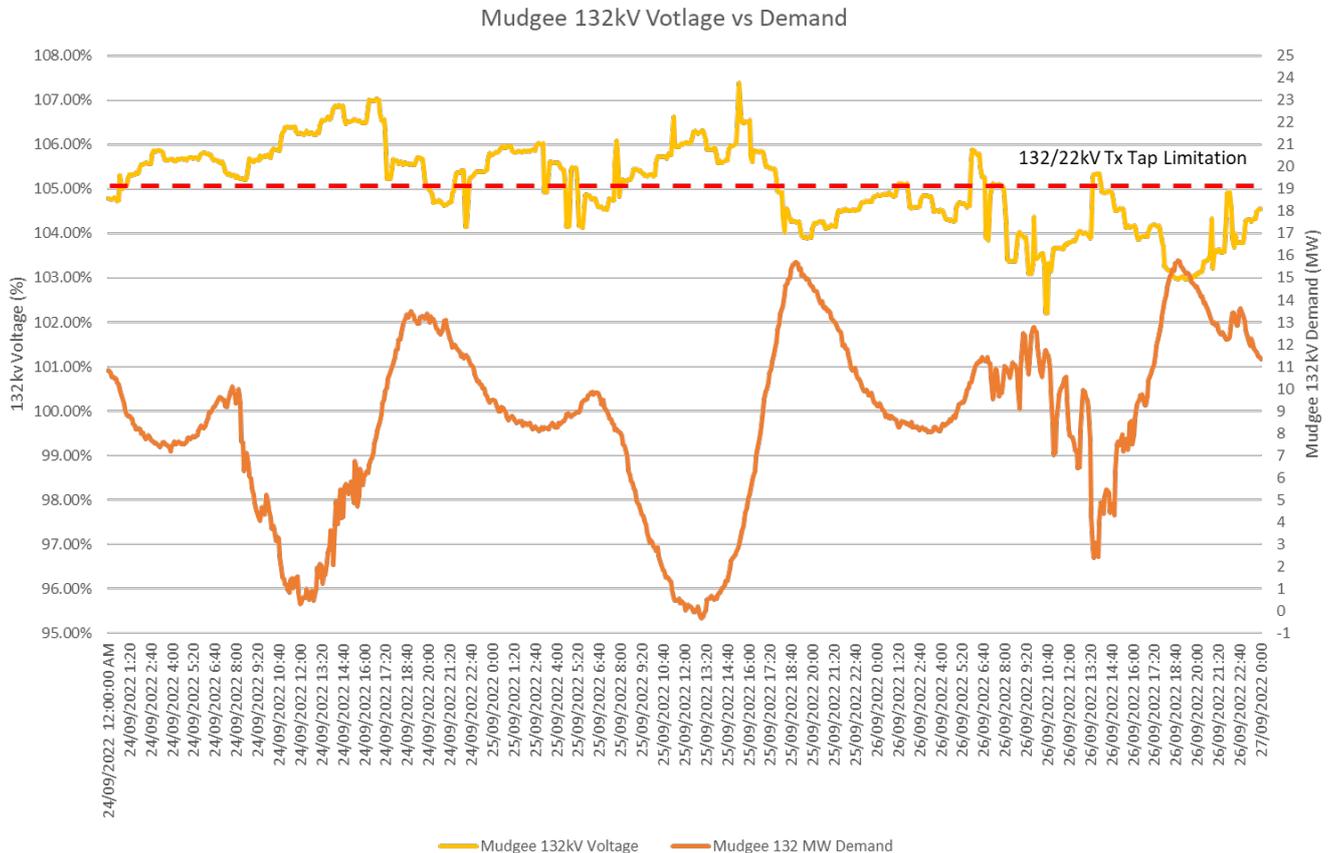
Reduced Life	Lost Equipment	Curtailement	Reputation	Compliance	Annual Cost
[Redacted Data]					

The identified need is high voltage levels measured at customer premises which need to be lowered to meet Essential Energy’s obligation in relation to quality of supply, as required by AS600038 Standard Voltages.

## 5. Options Analysis

Following a voltage review of the Mudgee network it has been determined that a voltage setting change on the Mudgee 22kV bus would address a majority of the recorded high voltages. The issue with this solution is the lack of buck tap on the 132/22kV power transformer, which is limited to a ratio of 1.05 p.u between the HV and LV sides of the transformer. Figure 5 shows demand on the Mudgee ZS and corresponding 132kV voltage level for the same period as the customer voltage trace shown in Figure 3.

Figure 5: Mudgee 132kV Load and Voltage Recordings September 2022

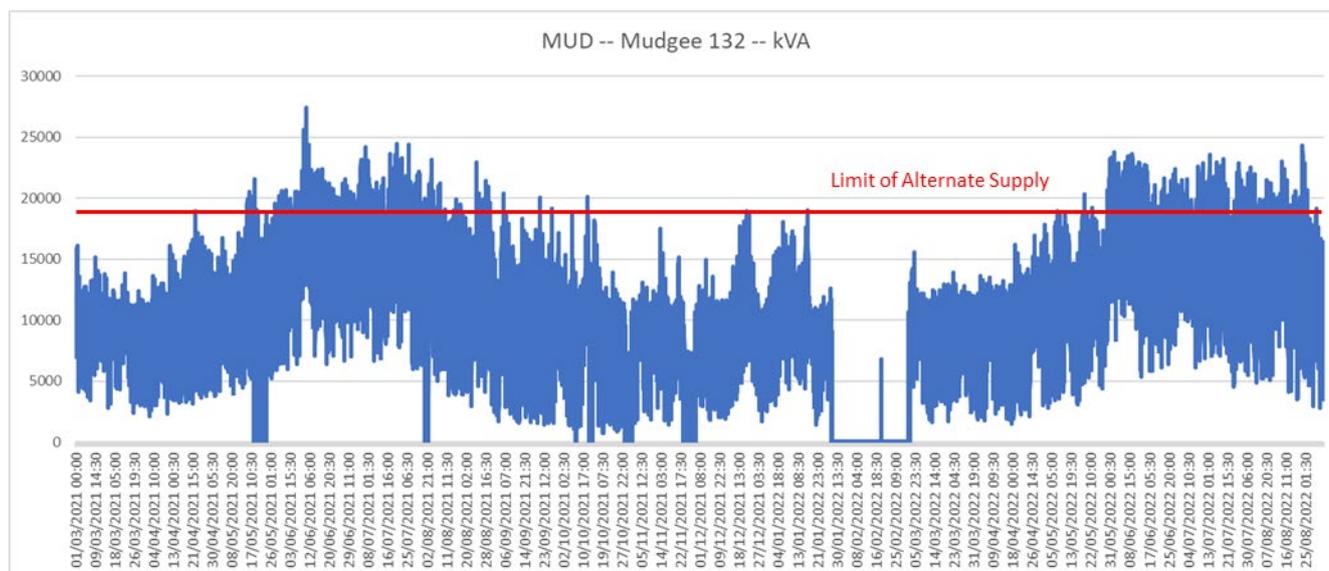


The 132/22kV transformer tap changer will limit any change to the 22kV bus voltage at the Mudgee Zone Substation. This issue also limits the effectiveness of future network options, such as closed loop voltage control to improve the voltage levels, as this relies on the ability to adjust voltage levels at the zone substation.

Transgrid have been approached about reducing the 132kV voltage level, but the network is constrained by low voltage levels for N-1 contingencies at peak load.

Supplying the substation from the 66/22kV transformer is not a viable option as the supply from Beryl to Mudgee over the 66kV line 851 is voltage constrained, only allowing partial backup and alternate supply for routine maintenance. Demand on the Mudgee zone frequently exceeds the 19MVA voltage limit of the alternate 66kV supply, as shown in Figure 6.

**Figure 6: Mudgee Zone Substation Demand – March 2021 to August 2022**



Below are the feasible options that were considered to address the high voltage issue.

### 5.1 Option 1 – Replace 132/22kV Power Transformer at Zone Substation

Replacing the 132/22kV Power Transformer at the Mudgee Zone Substation would allow for a greater buck tap range to be specified for the new transformer. The existing Mudgee 132/122kV transformer has a 5% buck range, where Essential Energy’s new specification requires a 10% buck range. This additional range would allow the zone substation 22kV voltage level to be lowered, alleviating a vast majority of the high voltage complaints. As this is the replacement of an existing unit maintenance costs for this option are considered to remain the same.

**Option 1 has estimated capital cost of [REDACTED] and a Net Present Value of \$3.6M.**

### 5.2 Option 2 - Install 22kV Reactors At Mudgee Zone Sub

Installing switched reactors at the Mudgee Zone substation would allow inductive reactive power to be switched in when the 132kV voltage exceeded the tap range of the power transformer. Inductive reactive power flowing through the reactive impedance of the power transformer would produce a voltage drop, allowing the 22kV voltage to stay in range for higher voltages on the 132kV network. Based on the impedance of the existing transformer it is calculated that three 4 MVar reactors would be required at the Mudgee Zone Substation. Adding new equipment to the Substation would increase the annual maintenance costs.

**Option 2 has estimated capital cost of [REDACTED] and a Net Present Value of \$1.9m.**

### 5.3 Option 3 - Install 2<sup>nd</sup> 132/22kV Transformer at Mudgee

Mudgee relies on a limited capacity 66kV supply from Beryl when the main 132kV supply is out of service. Installing a second 132/22kV transformer with a larger buck tap range which is operated as the duty transformer would allow the Mudgee 22kV voltage to be lowered for a majority of the time. To provide the alternate supply a new 1.5km 132kV line from the 94M Mudgee Tee to the Mudgee ZS would be constructed along with in and out 132kV circuit breakers to maintain supply when either side of the 94M line is out of service. This would provide additional reliability benefits, in that there would be a full capacity alternate supply available to Mudgee and the 66kV line 851 from Gulgong could be removed, improving reliability of supply to Gulgong which is connected by a tee to the 851 line.

**Option 3 has estimated upfront cost of [REDACTED] and a Net Present Value of \$0.3m.**

## 5.4 Option 4 - Market led Non-Network Solution

The requirements to improve voltage levels on the Mudgee network may be advertised to the market 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 3<sup>rd</sup> party owned solutions. The basis of the EOI will be to request alternative energy storage or devices that can provide voltage reduction under any business model and operation 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.

## 5.5 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 increased life of customers' electronic equipment.

Option 2 to install 22kV reactors has a high capital cost and does not provide any other benefits besides voltage reduction

Option 3 to duplicate the 132kV supply and 132/22kV transformer at Mudgee provides the most benefit but does not represent the best value due to the very high upfront 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 to replace the 132/22kV power transformer is a feasible option to address the high voltage issue, and it has the highest NPV.

## 6. 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 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.

### 6.1 Safety

Safety consequence considers the risk to both public and Essential Energy personnel. Safety is not likely to be a major contributing factor to this investment as the level of overvoltage is minimal and not likely to cause a safety risk.

### 6.2 Environmental

All businesses must manage the risks their activities may pose to human health and the environment from pollution or waste. There is no environmental risk that needs to be addressed with this constraint.

### 6.3 Compliance

Compliance risk is assessed for issues that may arise because of not complying to relevant Standards, Acts or Guidelines. Essential Energy is exceeding the upper voltage threshold in the Australian Standard in this case, so there is the risk of compliance related costs which this project will aim to minimise.

## 6.4 Reputation

Reputational consequences are categorised as those risks associated with the tarnishing of the company's reputation. This investment will address a majority of the risk associated with solar PV tripping offline due to high voltage levels which is where most complaints are generated.

## 6.5 Financial

Financial costs in this instance are borne by customers who have to replace their electronic equipment sooner and have their rooftop PV curtailed by high voltage levels.

## References

Doc No.	Document Name	Relevance
1	Mudgee High Voltage Options Comparison NPV.xlsx	NPV Option Analysis
2	ESS_1_Voltage_ValueCalc	Calculation method to value high voltages
3	6.03.01 Corporate Risk Management Procedure	Reference material
4	6.03.02 Network Risk Management Manual	Reference material
5	6.03.03 Appraisal Value Framework	Reference material, risk evaluation
6	11.01 Forecasts of Customer numbers, energy consumption and demand	Reference material

## Key Terms and Definitions

Term	Definition
\$M	Dollars expressed in millions
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 – Value of high voltages

All figures are based on the ESS1 Value Calculator being applied to 12 months of smart meter data and scaled by the number of customers on the zone substation unless otherwise indicated.

Table 3: Cost due to Overvoltage / Annum

Reduced Life	Lost Equipment	Curtailement	Reputation	Compliance	Annual Cost

### Reduced Life

Electronic equipment is sensitive to high voltage, with the mean time to fail reduced as voltage increases. This measure is applied directly from the PIP1 value calculator.

### Lost Equipment

If the voltage exceeds the supply standard there is a chance of electronic equipment failure, this measure is applied directly from the PIP1 value calculator.

### Curtailement

Based on rooftop solar curtailement for voltages above the supply standard. The value of lost generation is 30c/kWh in the PIP1 value calculator which has been scaled down to 5c/kWh for this assessment to allow for the reduction in feed in tariffs since the PIP1 calculator was authored.

### Reputation

Cost to Essential Energy from reputational damage due to complaints of high voltages. This value has been scaled back by a factor of 30 from the PIP1 value calculator in line with the compliance cost below as we're considering every premise, not just the ones that complain and initiate a PIP1 value calculation.

### Compliance

Cost to Essential Energy of compliance related activities from high voltages levels. The total compliance costs for all sites have been scaled back to the actual costs incurred on high voltage complaints, which results in a scaling of 1/30 from the PIP1 calculator.