Essential Energy
10.02.24 Composite Poles Transition Business Case

November 2022

Project:	10.02.24 Composite Poles Transition Business Case
Date:	Nov 2022
Authors:	[redacted]
Version	1
Status:	Approved

Approvals

	Name	Division	Title & Function	Date
1.	[redacted]	Asset Engineering Risk & Compliance	Manager Asset Management System Framework	20/12/2022
2.				

Revisions

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

Table of Contents

1. Executive Summary

Business Case	10.02.24 Composite Poles Transition Business Case
Description	Essential Energy seeks funding to improve network resilience and supply constraints by transitioning to composite (fibreglass) [redacted] Composite poles have been successfully trialled in high value locations across the network since 2015. [redacted]
Options	Credible pole material options include: ○ CCA timber ○ PEC timber, unfeasible with higher cost than CCA ○ Steel and concrete (steel reinforced) unfeasible due to being affected by corrosion, have additional earthing requirements and costing around 2.5 times that of timber with a similar asset life ○ Composite (fibreglass), lower lifecycle costs and higher performance justifies cost of around [redacted] times timber Non-network resilience solutions such as standalone power systems (SAPS) are considered on case-by-case basis at project level, not suitable for broad application. The recommended option is a network wide composite poles transition – Additional expenditure of [redacted] with a network average NPV of $17.8M for FY25-29
Drivers for Transition	Essential Energy's aging 1.3M pole fleet is experiencing increasing failures due to termites and decay, while bushfire severity is predicted to increase driving the need for a more resilient material. Composite poles have greater life expectancy than timber, reduced life cycle costs and have performed well across the network in recent years. Key drivers for transition include: • Resilience: Bushfire, fungal decay, and termite resistance. • Operational benefits: Reduced weight, manual handling, safety, transport efficiencies and lower maintenance costs. • Lower risk: On average across the network a composite pole represents around one third of the annual risk of functional failure in comparison to a timber pole.
Risk & Value Benefits	Despite the higher upfront material cost for composite, its life expectancy, installation efficiencies, maintainance and risk reductions have shown composite to have lower life cycle costs than timber. Composite and timber pole materials have life expectancies of 60 and 40 years respectively. NPV calculations have shown that from 40 years onwards composite poles provide higher value than timber. [redacted]
Estimated additional expenditure $FY24M	2024/25: [redacted]; 2025/26: [redacted]; 2026/27: [redacted]; 2027/28: [redacted]; 2028/29: [redacted]

All values are in full year 2023-24 real dollar terms

2. Background

A significant portion of Essential Energy's 1.3 million poles are located within high bushfire risk areas. [redacted] ith an aging population, pole replacement rates are forecast to increase, and Essential Energy (EE) is committed to utilise pole materials which will deliver the greatest value and resilience for the future network.

Copper Chrome Arsenic (CCA) treated timber poles are currently the primary distribution and sub-transmission pole material with composite (woven fibreglass) poles as an alternate option. This business case outlines the process to justify the widespread use of composite poles throughout the EE network.

2.1 Options

- CCA Treated Timber – This is the predominant material currently used on the network for pole replacements/installations. This is a relatively low-cost material that is not bushfire resistant and can be subject to termite attack and fungal decay. The expected lifetime of this material is 40 years.
- PEC Treated Timber – Pressure Emulsified Creosote (PEC) treated timber is higher cost than CCA, has similar performance and has operational and union concerns associated with its use. Given this option provides less value than CCA treated timber, it is not considered feasible for further analysis.
- Steel – Steel poles have been used in parts of the network historically, and although they can provide good mechanical performance in some environmental conditions, they are expensive to manufacture (roughly three times the cost of a CCA timber equivalent), susceptible to corrosion (particularly in coastal environments) and can lead to heightened bushfire and reliability risk due to their electrical conductivity. Steel poles have very good bushfire resistance. The expected lifetime of this material in the EE network footprint is 50 years. Given these factors, this material is not considered feasible for generic conditions and is not considered for further analysis.
- Concrete – Similar to steel, this material has been used throughout the EE network with poor performance value due to corrosion, electrical conductivity, and a relatively high cost of manufacture (roughly 2.5 times the cost of CCA timber equivalent). Concrete poles have very good bushfire resistance. The expected lifetime of this material in the EE network footprint is 50 years. Given these factors, this material is not considered feasible for generic conditions and is not considered for further analysis.
- Composite (Fibreglass) – This material has been used increasingly on the network in recent years due to the numerous advantages of this material. A comprehensive list of these advantages over CCA treated timber can be found in Section 3 Key Benefits of Composite Poles. Fire exposed composite poles in the 2019/20 fires only required external coating maintenance while 3,200 timber poles were destroyed. Essential Energy has since increased the use of composite poles in high risk/value locations. Composite poles currently cost around [redacted] times that of timber poles but have many benefits to justify their use. Although this material is more expensive than timber, it has an expected lifetime of at least 60 years.
- Underground cable – This is a very expensive method of electricity distribution that as such will not be considered feasible for network interventions unless under unique conditions.
- Stand Alone Power Systems (SAPS) - Proposed to be deployed only in high cost to serve locations across the network as a cost reduction alternative. The installation of composite poles in locations identified for SAPS would not be feasible.

Essential Energy intends to perform a RIT-D to further demonstrate that composite poles are a high value pole material option for the network and customers.

[redacted] Bushfire severity is predicted to rise due to climate change and without more resilient materials the network will experience increasing pole failures due to fires in future.

---

[1] Unassisted failure is defined as assets which have failed to perform their intended function under normal design and operating conditions.

This business case demonstrates the risk mitigation and value which can be provided for the future network through this transition to composite poles in comparison to the use of CCA treated timber as the network-wide default pole material. Essential Energy's Executive Leadership Team have proposed a network wide transition and stakeholder engagement plan to support this transition.

Figure 1 - Adjacent composite and timber CCA poles exposed to bushfire

3. Key Benefits of Composite Poles

The key benefits composite poles provide for Essential Energy's network are summarised below:

- *Fungal and Corrosion resistant:* Fungal decay, acidic and alkaline soils, and chemical resistant. Fungal decay accounts for 55% and corrosion 6% (F2014-22) of unassisted pole failures.
- *Termite Resistant:* Not subject to termite attack, 36% (FY2014-22) cause of unassisted failures, despite maintaining a termite treatment program.
- *Life expectancy:* Accelerated ageing testing from two manufacturers and Essential Energy's in house Quality Assurance lab indicates composite pole life expectancy to be over 60 years whereas modern timber pole life expectancy is around 40 years. Evidence supports life expectancies of well over 60 years if UV coating is reapplied following exposure to bushfire.
- *Fire Resistant:* The fire-retardant laminate construction performs better than timber and alternate pole materials when exposed to bushfires. Bushfire is on average the leading cause of assisted pole failure over recent years. In fire prone locations CCA poles have been repeatedly burnt and replaced after short service lives. The CCA treatment on timber poles promotes timber combustion and afterglow, and ash and smoke from burnt CCA timber is harmful.
- *Transport & Installation:* Composite poles are one third of the weight of an equivalent timber pole. This has many benefits in transport, plant, handling, and installation efficiencies. Installation techniques are like timber poles however being lighter and available in multi-piece options, composite poles are more cost effective to transport and install in high civil cost, remote, heavily vegetated and/or difficult access sites. Three times as many composite poles as timber can often be carried on trucks and trailers when transporting from depots to installation sites.
- *Lower maintenance cost:* Composite material is not susceptible to termite or fungal decay unlike timber poles. Ongoing maintenance costs are significantly lower with no requirements to sound, dig around or drill poles. Longer term tasks due to timber contraction including hardware tightening will also be reduced. Increased use

may allow composite pole based ‘feeders’ to be inspected less frequently (e.g.: longer than current 4.5-year interval) on a ‘maintenance free’ structure with composite crossarms and durable pole top construction.

- *Lower unassisted failure rate:* The condition of composite poles is easier to determine from less intrusive techniques compared to timber poles which may see unassisted failures just after their inspections every 4-5 years. As a result, unassisted failure rates are expected to be lower than timber poles. Timber poles are often subject to termite attacks causing failure over periods between inspection cycles.
- *Superior electrical and mechanical performance*: Similar mechanical strength to timber poles for a much lower weight. Better electrical insulation properties than timber poles and therefore classified as insulating in the Electrical Safety Rules (ESR). Personal Protective Equipotential Bonds which are needed for timber and conductive poles are not required on composite poles.
- *Avoided young timber pole tasks:* Material numbers of timber rot, termite treatment and pole replacement tasks have been required on CCA timber poles less than 20 years old. This was reported by trades people in the field and supported by database analysis mostly in inland regions prone to termite attack. It is believed that this is due to dry climates causing modern timbers grown on the coast to split, allowing termites and fungal decay to bypass the CCA treatment.
- *Disposal & Reuse* – Savings are expected in disposal costs due to the reduced weight of pole materials going to land fill. This may further improve with technological advances allowing recycling / repurposing of composite materials. Hazardous CCA timber treatments inhibit the use of timber poles for reuse, burnt CCA poles damaged in bushfires have onerous disposal requirements. It is expected that the overall higher performance composite material will present additional opportunities for reuse and therefore reduced end of life costs with respect to timber CCA.
- *Safety* – The round and uniform construction of composite poles is easier and more predictable to handle which reduces risk of manual handling and fatigue related accidents.
- *Potential CCA exposure/contamination* – Copper Chrome Arsenic is a toxic and flammable chemical. CCA treated timber is banned from use in high contact structures. Composite poles are a relatively inert material which is safe for contact with humans and animals.

4. Supply Implications

4.1 Timber supply constraints

[redacted]

Approximately 50% of Essential Energy’s pole demand is for the key sizes 12.5m/4kN and 12.5m/6kN poles. FCNSW meet supply commitment in metre cubes to their pole suppliers but not for the key sizes as their contract KPIs are for metre cubes to be met for all sizes and not volumes for key sizes. Overall, FCNSW supply approx. 35,000-40,000 poles p.a. This supply volume covers all utility customers, with Essential Energy obtaining approx. 7,000 poles p.a. Greater durability timber poles used for high strength applications are increasingly difficult to source and are substituted for lower grade timber with shorter than 40-year life expectancy.

[redacted]

Recent wet weather experienced across the east coast of Australia has further constrained timber supplies as boggy conditions restrict access to harvest. Similarly, harvested logs are increasingly difficult to dry and treat to produce a quality product. This has constrained current pole supply and further increased timber prices.

As such, Essential Energy considers that having a sustainable supply option in locally manufactured composite poles for this critical asset is warranted, especially as other alternate materials like steel and concrete have a higher lifecycle cost and lower performance from our experience.

4.2 Composite pole supply ramp up

Essential Energy's current supplier [redacted] have increased capacity to [redacted] poles per annum based on recent orders of [redacted] from Essential Energy in the last year. Essential Energy has also proactively engaged our composite crossarm supplier [redacted] to invest in composite pole development. [redacted] poles have recently completed field testing and are now available at a capacity of [redacted] poles per annum. Between the two suppliers, the initial supply capacity is [redacted] poles per annum.

Both suppliers have indicated that with further commitment from utilities, they can double that capacity with 8-12 months' notice to [redacted] poles per annum combined capacity.

Essential Energy will work as a partner and industry leader in product development and trials for composite poles to stimulate competition, peer utility interest, improve pricing and provide economies of scale.

Figure 2 - Composite manufacturing facilities

5. Composite Performance

5.1 Crossarms

In 2009, Essential Energy transitioned away from treated timber crossarms to adopt composite (fibreglass) as our default crossarm material. After 13 years, 600,000 composite crossarms are installed across the network. This population has yet to experience an unassisted failure and has shown good fire resistance. The composite crossarm transition has allowed this material to mature in the field supporting Essential Energy's natural progression to composite poles.

5.2 Life Expectancy

Composite fibreglass materials have proven performance as an outdoor structural material. Composite is widely adopted with many examples of fibreglass marine and industrial equipment manufactured over sixty years ago still in service. Composite fibreglass materials themselves have been shown to improve in many structural properties with age. External coatings on fibreglass composite materials are recommended for external protection from ultraviolet (UV) light which can cause minor surface deterioration after many years of exposure.

Composite fibre/fiberglass poles were first installed in Hawaii in the early 1960s. After almost 45 years of service, these poles were removed from service and replaced, not for structural reasons but because of fibre blooming concerns from ultraviolet (UV) light exposure. These early poles did not contain the modern UV inhibitors or surface veils that provide protection for composite poles today, which allow an average life span of 80 years or more (80 years is the figure quoted extensively in North America and Europe). Composite poles for distribution and transmission applications are gaining popularity with electricity utilities internationally[2].

Since these first composite poles were installed, significant advancements have been made in composite pole and polymer technology, resulting in more durable and longer-lasting poles. Through our experience with composite crossarms we have developed specific composite and UV coating testing procedures and facilities and worked with manufacturers to improve product performance.

Essential Energy's in house Quality Assurance (QA) lab has performed a range of destructive and accelerated ageing tests on composite poles including:

- Real life accelerated ageing exposure- Combining UV, salt spray, freeze and thaw cycles in one test set up with samples exposed for several months simulating decades of in-service experience.
- Standalone UV-B exposure with much harsher UV spectrum than conventional UV-A for several months. This tests the UV coating which is the primary cause of the start of degradation.
- Mechanical destruction tests – Bolt pull through, mechanical impact, deflection, installation using excavator, pole run over by excavator etc to stress test the pole to worst case and unlikely service exposure.
- Real-life fire exposure where timber poles were destroyed, but composite poles in adjoining sites were fully serviceable requiring only minor outer gel coat repair before the next fire.
- Manufacturer's tests on UV, ultimate strength, deflection, fire-resistance etc.
- Manufacturer's service history estimates both for local product currently used, and well-established products in North America. This includes Hitachi, RS Poles etc who are well-established long-term suppliers. Our own suppliers estimate 70-80 years minimum service life.

Research in pole material technology validates Essential Energy's assessments with composite utility poles shown to outperform timber throughout their lifecycle. Light poles made of polyester-reinforced fibreglass were installed in Finland in 1961 and remain in service. The manufacturer's estimate is a lifetime of at least 80 years, based on experience of installed poles and weatherproofing coatings. Some other manufacturers of composite poles state a lifetime of 120 years. A lifetime of 80 years should therefore be a cautious estimate[3].

Essential Energy is confident in the 60-year composite pole life estimate used in this business case. This is considered a conservative minimum life which has been used in our NPV calculations. Sensitivity analysis on this value has been conducted to understand the full benefits of composite poles if they can provide an 80-year life.

5.3 Composite Pole Trial

A network trial of composite poles was underway when the Kosciuszko National Park witnessed the 2019-20 bushfires. The fire exposed composite poles showed far superior fire-resistance (with temperatures exceeding 600 degrees), compared to the surrounding timber poles which burnt to ash. The cost impacts of major fire events are greater than the sum of the immediate replacement work and can take several years. The 2019/20 bushfires subjected Essential Energy's network to unprecedented damage with total cost impacts of around $75M, requiring $34M in additional revenue to cover unexpected costs. Ongoing supply interruptions, disruption to existing priority work, maintenance and additional resource demands have been shown to contribute to exponential increases in recovery costs. The wider adoption of fire-resistant materials will increase network resilience and is likely to reduce the volume of destruction and ongoing expenses caused by such events in future.

[2] Vimmi Dutt and Lacoursiere, "Composite Utility Poles: Advances in Design, Materials & Manufacturing," *2005/2006 IEEE/PES Transmission and Distribution Conference and Exhibition*, 2006, pp. 1243-1243, doi: 10.1109/TDC.2006.1668688.

[3] Martin Erlandsoon, "Comparison of the environmental impacts from utility poles of different materials – a life cycle assessment" 2012. B-Rapport (ierol.se), 2012, pp. 14.

Fire-impacted composite poles have remained structurally intact and required minor repair to outer fire-retardant gel coat before the next fire. This gives crews performing restoration work valuable time (it can be years before next fire passes due to vegetation damage) to do higher value supply restoration work rather than review the integrity of fire-impacted composite poles.

Figure 3 – Left: Timber CCA poles 2019/20 bushfires. Right: Timber pole burnt away, only composite cross arm remaining

Composite poles currently account for around 20% of current annual pole replacements through targeted high value replacements and wider depot area adoption. This uptake has followed design and specification development, lab and field testing, tooling, fleet, work practices and customer expectation reviews to accommodate further deployment.

The initial adoption targeted high risk value asset specific locations to capture maximum benefit from composite stock. The installation efficiencies and the simplification of one pole material type led to complete transition to composite in several depot areas.

6. Resilience & Climate Change

6.1 Climate Modelling

The need for high performing composite material will be amplified in future as climate change is predicted to increase the severity and frequency of severe environmental conditions, see Climate Impact Assessment **(Attachment 6.01**). Third party peer reviewed climate change modelling has been performed to predict the effects of future environmental conditions on our network. This modelling shows the change in impacts from the perils of floods, windstorms, and bushfires. This modelling captures the predicted probabilities of network asset impacts from these perils under climate change scenarios RCP4.5 and RCP8.5 (these are two possible Representative Concentration Pathways (RCPs) accepted by the Intergovernmental Panel on Climate Change (IPCC)). The primary peril impacting the asset class of poles is bushfire. The total network impact on poles from bushfires is predicted to increase by up to 52% by 2090 under RCP4.5[4].

[4] This is under the assumption that the network is made up of entirely CCA treated timber poles which have the highest likelihood of failing in bushfire compared to all other pole materials used on the network.

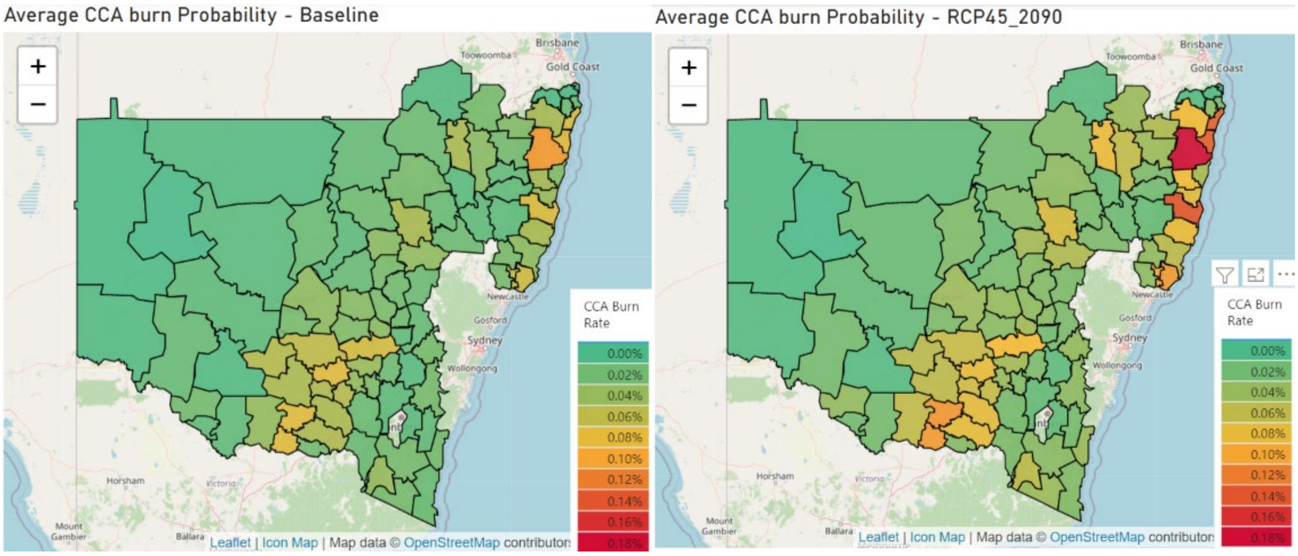


Figure 4 - Current and RCP4.5 - 2090 climate modelling for bushfire failures. These visuals show the average annual probability of a CCA pole being burnt within each depot area under the two climate snapshots shown.

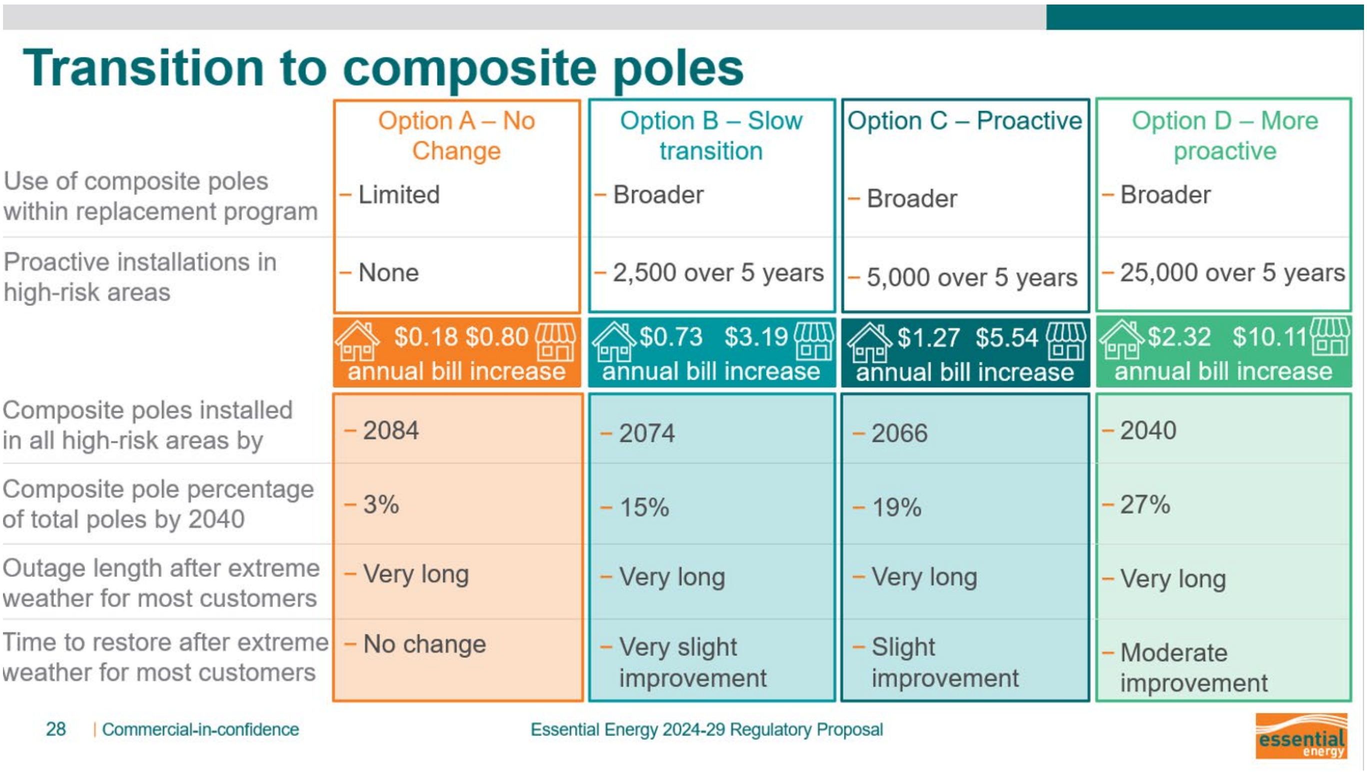
Composite poles are predicted to outperform timber in extended wet and dry weather extremes which are likely to increase in severity as climate change progresses. A network wide transition to composite poles is considered to be the most resilient choice to withstand future climate challenges.

7. Customer Appetite for Resilience

In preparing the 2024-2029 regulatory proposal, Essential Energy engaged with customers over four phases. During the first phase conducted in October/November 2021, customers were predominately polled on risks in operating our distribution network and how we value these. Customers supported our risk metrics and placed a high level of importance on reliability, bushfire prevention and safety.

During our second phase of engagement in February 2022 the concept of resilience was introduced to customers and how it differs from ‘standard’ reliability. Customers were offered a variety of scenarios to understand their appetite for investment in resilience across four options from a “change nothing” to large scale expenditure across many assets. In the options several investment methods were introduced, composite poles being one of the interventions identified. The outcome of this phase of engagement resulted in broad support across the two most expensive options, 47% and 44% respectively. In relation to composite poles specifically this outcome related to an option around broad use of composite poles and a usage of higher penetration. It must be noted that this was a directional decision process to understand a willingness to pay with a number of intervention types equating to the final “cost”.

Our third phase of engagement specifically addressed individual intervention types with high level numbers to understand customer willingness to pay per intervention type. For composite poles customers were presented the slide in Figure 5.



Transition to composite poles

	Option A – No Change	Option B – Slow transition	Option C – Proactive	Option D – More proactive
Use of composite poles within replacement program	– Limited	– Broader	– Broader	– Broader
Proactive installations in high-risk areas	– None	– 2,500 over 5 years	– 5,000 over 5 years	– 25,000 over 5 years
	$0.18 $0.80 annual bill increase	$0.73 $3.19 annual bill increase	$1.27 $5.54 annual bill increase	$2.32 $10.11 annual bill increase
Composite poles installed in all high-risk areas by	– 2084	– 2074	– 2066	– 2040
Composite pole percentage of total poles by 2040	– 3%	– 15%	– 19%	– 27%
Outage length after extreme weather for most customers	– Very long	– Very long	– Very long	– Very long
Time to restore after extreme weather for most customers	– No change	– Very slight improvement	– Slight improvement	– Moderate improvement

Figure 5 - Customer Engagement on Composite Poles

Customers overwhelmingly supported Option D (67%) in the results of our engagement. This option included full composite usage for conditional replacement, plus additional risk-based proactive replacements up to 25,000. The risk-based replacements are included in our Repex forecasts and do not form part of the context of this paper.

8. Value Justification

While the upfront cost of composite is higher than timber, the installation, maintenance, and lifecycle costs of composite poles are typically lower than timber when accounting for all factors including weight reduction, and bushfire, fungal decay and termite resistance over their entire respective life cycles.

The following inputs were used to perform NPV calculations comparing timber and composite pole investments:

- Common multiple of 120 years for the different material's life expectancies (40 and 60 years for timber-CCA and composite respectively)
- Long term forecast estimate of equivalent timber and composite pole material rates, [redacted] respectively for high volume pole types [5]
- Standard pole installation unit rate of [redacted] with 4% reduction for composite based on transport and handling efficiencies.

[5] This assessment is based on average material prices over recent years. Recent raw material imports and labour price increases have increased current composite pole prices, less so timber. The current market price differential is approximately [redacted] for the highest volume equivalent pole type considering required timber strength substitutions. For reasons detailed in Section 4 it is believed by EE SME's that timber pole prices will increase in future, while composite pole prices are considered more l kely to reduce as the market matures. This scenario was demonstrated with composite crossarms following their wider network adoption in 2010. The change in upfront material cost differential is assumed to make composite more favourable in future.

- Inspection duration costs on a 4.5-year cycle were at a cost of [redacted] for both materials until an age of 15 after which composite continues to cost [redacted] for just a visual inspection and timber will increase to [redacted] to capture the necessary time for drilling and digging around pole bases for timber condition assessments.
- Company discount rate of 3.54% p.a.

Using these figures, an NPV was developed to show how the relative NPV between the two materials changes over time. The relative NPV (Shown in Figure 6) is of most interest showing the difference in NPV between the two possible investments (where this is positive shows that composite is preferred). This shows that the time at which an NPV calculation is computed will have a large impact on the possible value due to the step changes induced from replacements at the given lifetimes. 120 years was chosen as the suitable time because it is the lowest common multiple of the two product lifetimes (note that in the sensitivity analysis, when these lifetimes were changed, the NPV period was also changed to the lowest common multiple of asset lifetimes).

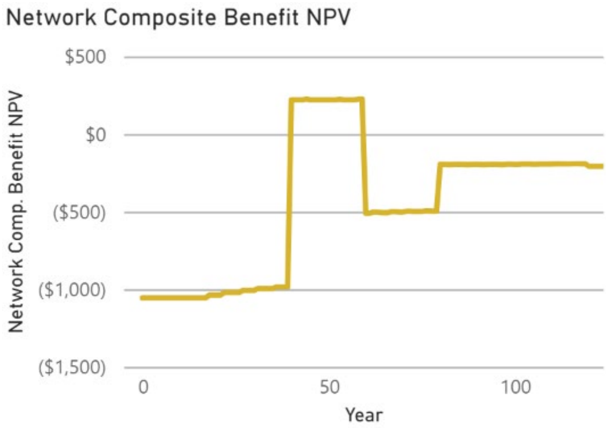


Figure 6 – Relative NPV Through Time

This shows that a composite pole provides a loss of $192.26 in NPV over the 120 period when compared with timber. This means that, considering life extension and installation & inspection efficiencies alone, for the average pole across the network, composite is not the best material choice in **all** locations.

The value of a composite poles, however, goes beyond the life extension. There is a very significant reduction in risk posed due to the lower probability of failure across many failure causes, including bushfire, termite attack and fungal decay. The NPV model was thus extended to consider this reduction in annual functional failure risk due to composite material as opposed to CCA treated timber. This was done in accordance with Essential Energy's Appraisal Value Framework[6] (**Attachment 6.03.03**). There are many additional transport, installation, maintenance, and conditional failure benefits yet to be fully realised. As such only conservative estimates of these benefits have been included in this work.

8.1 Risk Benefit

The risk benefits of composite poles are directly related to their operational environment. Bushfire, fungal decay, and termite attack risks vary significantly between regions across the vast geographic footprint of Essential Energy's network. As such, to develop a Probability of Failure (PoF) model to be used in the calculation of risk benefits of composite poles over CCA treated timber, population failure data was analysed based on location rather than age.

To calculate the probability of failure for a given location, the average annual number of failures (based on relevant functional pole failure data from 2013-2021) was divided by the population of that subset population. This gives the expected probability that a pole in that location will fail in any given year[7]. The population was first divided into depot area groups. This was then extended further to subsets of depot population based on Bushfire Priority (BFP) ratings (P1 through to P4). This was chosen as a suitable means of differentiating the population due to the distinction in

[6] Annualised composite pole risk has been determined using functional failure data. This does not consider the potential value of avoided future conditional pole failures (generated from asset inspections) which informs our current pole replacement program. Longer term as the network footprint transitions to composite this additional value will be realised. The risk benefits herein are considered a conservative minimum.

[7] Note that this PoF development relies on the assumption that all poles in the EE network perform similar to CCA treated timber poles. Supported by past performance data, company SMEs believe this is a good assumption given there are only very few non-timber, non-streetlight poles on the network and those that are not would still perform similar if not better than CCA timber across most failure causes.

consequence of failure (CoF) across these categories. This level of granularity also allowed averaging to produce meaningful results that did not just show individual failures in the observation period and zero likelihood of failure in other locations. This provides a PoF for a timber pole in each depot / BFP subset of the population which was then multiplied by the median CoF for poles in that location to give the expected annual monetized risk for a timber pole. The mean (average) CoF was initially used, however, it was found that the median provided a more realistic and conservative representation of the “typical” pole and avoided figures being blown out by very high consequence poles as displayed in Table 1.

Table 1 – Depot Mean vs Median Consequence of Failure Comparison

Depot	Average of CoF	Median of CoF
Temora Depot	$251,161.92	$33,905.30
Oberon Depot	$255,132.07	$43,387.90
Nyngan Depot	$169,332.78	$32,852.28
Cooma Depot	$187,115.04	$76,240.87
Albury Depot	$126,705.78	$42,565.37
Tweed Heads Depot	$115,311.27	$41,926.21
Moree Depot	$101,649.24	$33,316.97
Broken Hill Depot	$97,294.44	$33,936.13
Dubbo Depot	$99,091.15	$40,056.50
Parkes Depot	$91,706.11	$35,323.59
Narromine Depot	$87,533.30	$33,046.92
Tumut Depot	$93,367.38	$42,734.44
[illegible]	[illegible]	[illegible]
Total	**$77,350.49**	**$37,314.94**

Essential Energy’s Appraisal Value Framework has been used to provide financial consequence values for various risk types. This framework was used to determine the consequence of failure (CoF) for poles across the network considering their individual operational and environmental criticality.

To ensure risk was not exaggerated, the PoF and CoF were divided into bushfire and non-bushfire causes/consequences and combined (by multiplication) as per **Figure 7**[8].

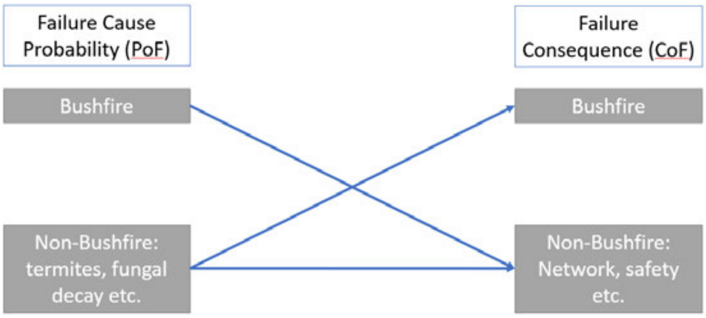


Figure 7 – Failure and consequence risk calculation

The equivalent risk of a composite pole in each depot / BFP subset of the population was then calculated by scaling the PoF by a suitable scalar based on the failure group. Subject Matter Experts (SMEs) from across Essential Energy were consulted to develop appropriate scaling factors (shown in Figure 8) to determine the perceived relative failure probability for composite poles compared to timber for each failure cause group. A value of 0 means that there is zero likelihood of a composite pole failing by this failure cause, while a value of 1 means that a composite pole is equally as likely to fail by this cause as a CCA treated timber pole. By multiplying this composite PoF by the same CoF, an average annual monetized risk for composite poles in each depot / BFP subset of the population was calculated. The difference between that of timber and composite was then calculated to give the resulting annual risk benefit of composite poles over CCA treated timber.

[8] The bushfire PoF was multiplied with non-bushfire CoF to capture risk $ not associated with bushfire when the failure was caused by a bushfire, while non-bushfire PoF was multiplied with all CoF to capture all risk $ possible when the failure isn’t caused by a fire.

Cause Group	Composite Scale Factor
Termites	0.00
Decay	0.01
Bushfire	0.20
Fire	0.20
Lightning	0.40
Wind	0.80
Other	1.00
Vegetation	1.00
Vehicle	1.00

Figure 8 - Composite Pole Risk Scale Factors

8.2 Climate Data Use

The initial analysis used all failure data from 2013 – 2021 across all failure modes. In relation to bushfire-cause probabilities of failure, the data was skewed to extremely high values for all locations which did have a fire during this observation period yet left very low for others which do still have a significant likelihood of failure due to bushfire, however, did not observe any during this period. For example, Bega and Moruya Depot areas had very high failure rates due to the widespread fires within those regions in the 2019/2020 bushfire season.

To reduce the impact of the observation period limits on the model outputs, a location-based probabilistic approach was taken for this failure cause. This utilised climate modelling data under climate change scenarios (RCP4.5 and RCP8.5) to give the probability of each pole being within the footprint of a fire. This data contained probabilities for current conditions as a baseline and then for the years 2050, 2070 and 2090 under the two climate change scenarios.

From this data, the number of functional failures within each depot / BFP subset of the population was calculated by summing over their probabilities and multiplying by a burn rate determined by SME's. This probability varied based on the severity of the fire (captured in the Forest Fire Danger Index (FFDI) range. This probability captures the likelihood of a pole functionally failing given that it lays within a fire footprint.

The above NPV model for the pole population was adapted to use this probabilistic approach for all bushfire failures yet continued to use the historical failures in the observation period of 2013 – 2021 for all other failure causes. This allowed the model to be run under one of the seven climate conditions (current, RCP4.5 – 2050, 2070, 2090 and RCP8.5 – 2050, 2070, 2090). Due to the difficulties of incorporating a dynamic fire probability through time in NPV calculations, the climate scenario was taken as static, and RCP4.5 in 2070 was chosen as a relevant average for the 120-year NPV calculations in the 'current inputs case'. This scenario was seen to be a somewhat conservative estimate of the increase in bushfire impacts on network assets, predicting a 32% increase in the number of fire impacted assets compared to current baseline conditions. Sensitivity analysis was completed to show variation in output metrics based on the climate scenario chosen.

8.3 Depot level Composite Benefit NPV

Essential Energy SMEs have determined from experience that transition of pole material is most practical across an entire depot. It is less effective for a depot area to attempt to use two different pole materials due to the inefficiencies of storage requirements for stocking two material types and their required tooling. As such, the data mentioned above was rolled up to a whole-of-depot level. This was done by taking a weighted average of the benefit in average annual monetized risk for composite poles across the population subsets in each Bushfire Priority Zone for each depot. Ie. For each depot, the weighted average of risk benefit was taken across the population in each BFP category. This gave an average annual risk benefit for each of the 95 depots across the Essential Energy network.

The previous 120-year NPV model was then further developed to include this risk benefit as an annual return for the investment in a composite pole. A total of 90 Depots were then shown to be NPV positive, meaning 96.91% of the pole population demonstrated positive value for composite material choice over timber. The resulting NPV can be seen for each depot in Figure 9. The NPV for each depot determines the colour scale with the most negative value (Wilcannia Depot: -$181.02) at the darkest red, and the most positive value (Young Depot: $2,350.40) in the darkest green with a neutral NPV ($0.00) is white. Note due to linear colour scaling on either side of zero, many depots show only a slight colouration despite being positive.

Depot	Population	Annual Failures BF	Annual Failures non-BF	Annual Failures	Annual Composite Failures	Weighted Average Annual Risk Benefit	Network NPV
Young Depot	10,617	6.43	9.56	15.98	4.96	$91.47	$2,350.40
Grafton Depot	11,468	26.53	4.00	30.53	7.47	$85.67	$2,189.24
Bulahdelah Depot	5,820	7.96	1.33	9.30	2.17	$77.27	$1,955.71
Ballina Depot	10,698	16.75	4.11	20.86	6.14	$75.75	$1,913.41
Maclean Depot	4,930	8.41	2.89	11.30	4.11	$57.98	$1,419.58
Kempsey Depot	11,443	19.48	3.56	23.04	6.33	$53.09	$1,283.49
Coffs Harbour Depot	6,317	8.31	2.67	10.98	3.58	$49.35	$1,179.63
Port Macquarie Depot	10,008	14.55	6.78	21.33	7.99	$48.46	$1,154.98
Narrabri Depot	15,997	5.95	32.11	38.06	13.98	$47.89	$1,138.99
Coolamon Depot	4,154	3.38	2.44	5.82	1.22	$44.04	$1,032.06
Corowa Depot	5,754	7.34	3.33	10.68	3.56	$42.32	$984.06
Nambucca Heads Depot	6,450	7.35	2.44	9.79	2.97	$41.58	$963.62
Stroud Depot	2,618	3.15	0.78	3.92	1.07	$39.48	$905.31
Griffith Depot	11,095	10.43	11.00	21.43	8.93	$39.31	$900.41
Jindabyne Depot	5,792	3.62	2.44	6.07	2.04	$38.52	$878.45
Wagga Wagga Depot	13,774	16.41	5.22	21.63	6.11	$36.85	$832.24
Nyngan Depot	10,179	2.58	8.67	11.25	2.58	$35.72	$800.58
Total	**870,646**	**470.81**	**398.33**	**869.15**	**281.34**	**$25.55**	**$518.12**

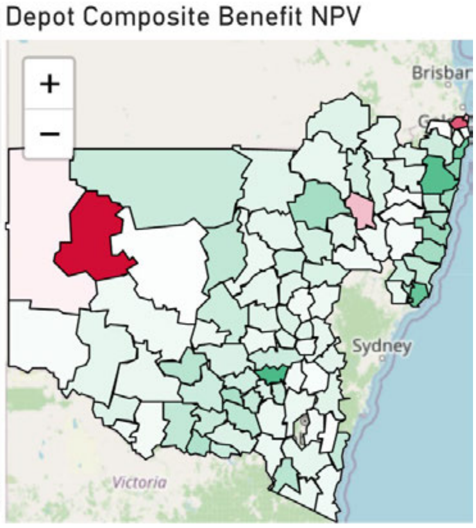


Figure 9 - Total NPV by depot area

8.4 Network-wide Composite Benefit NPV

The individual depot composite benefit NPV calculations were combined (by a weighted average over population) to inform a total network wide NPV with a value of positive $518.12. The change of this value through time can be seen in Figure 10.

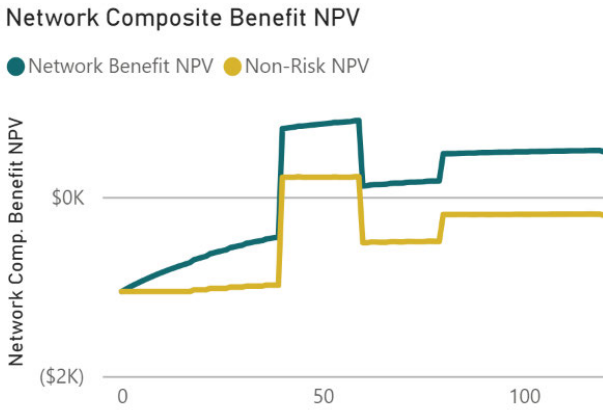


Figure 10 - Combined Depots Network NPV

8.5 Model Outputs

Two metrics are utilised as the outputs of the model to determine the validity of composite pole usage for Essential Energy. The primary output metric of the above NPV model is the percentage of Essential Energy's pole population that lay in a depot which is NPV positive. With all input parameters at the current input value, this is 96.91%. The second output metric is the whole-of-network average 120-year NPV described above with a result of $518.12.

8.6 Sensitivity Analysis

Significant work has been undertaken to determine values for current input parameters into the model used to determine the pole population that is justified for composite transition. However, the impact of possible deviations from these expected values has been studied in the below sensitivity analysis.

Definition and justification of decided value for input parameters for sensitivity analysis:

- **WACC rate**: The company's WACC rate for investments. 3.54% p.a. is Essential Energy's current rate and has been adopted for this work as the baseline figure.
- **Installation labour and transport cost**: The current average cost for the labour and transport component of pole installations on the network. Based on averages taken over FY 21/22 this figure was calculated as [redacted]. There is evidence to suggest that this figure could be higher given recent increases in fuel prices.
- **Composite installation efficiency**: The percentage reduction in costs associated with the installation and transport of composite poles compared to timber. The value of 4% has been determined based on input from field resource supervisors experienced in composite pole installation. Transport from depots to site is in the order of one third of the cost in comparison to timber through plant and labour resource benefits. This factor is increased in larger more geographically dispersed depots where travel time is a significant portion of operational expenditure. 4% is a conservative estimate of overall installation efficiency. Discussions with field supervisors have revealed many additional less tangible installation benefits relating to handling, plant requirements, safety and reduced fatigue when installing composite poles. Installation efficiencies for composite may be greater than 10% in isolated rural locations.
- **Bushfire scaling factor**: The scale factor used to represent the probability of a composite pole functionally failing due to bushfire (and asset-related fire) compared to CCA timber. The value of 0.2 has been derived from SME judgement across Engineering and Asset Management Teams (informed by lab testing and field experience). This 80% reduction in probability of failure captures the excellent bushfire resilience of the material and agrees with the field results of composite poles exposed in the 2019/20 bushfire season in the Snowy Mountains.
- **Climate scenario**: The climate scenario used to model the number of bushfire failures incurred across the network. As previously discussed, climate change scenario RCP4.5 in 2070 is a reasonably conservative estimate of the expected average bushfire risk to network assets with a 32% increase from current baseline levels.
- **Material cost difference**: The difference in material costs for an equivalent composite and CCA timber pole. The current (FY22) input value of [redacted] is intended to represent a long-term estimate of equivalent timber and composite poles. Recent increases in imported material and labour costs have caused composite pole prices to increase, while timber pricing has been less affected. Due to this, the current price differential is greater than the current input value used for this assessment. The current price differential including averages based on strength substitutions due to timber supply inconsistency is approximately [redacted] which was used for sensitivity in the moderate case resulting in 57.49% of population being NPV positive. This presents a short-term expenditure risk for EE, however, the majority of the pole population at that differential is NPV-positive for composite with the remainder then being justified through operational simplification in one pole material type. SME input indicates [redacted] is an acceptable long-term price differential estimate. As the composite pole market matures, production will increase promoting competition between suppliers and economies of scale are expected to reduce the cost of composite poles. This price reduction through product maturity was demonstrated during Essential Energy's transition to composite crossarms.
- **Timber lifetime**[9]: The expected lifetime of a CCA treated timber pole. 40 years is the current accepted book-life for CCA treated D2 durability class timbers currently used throughout the network.
- **Composite lifetime**: The expected lifetime of a composite pole. The book-life of 60 years has been derived from testing, manufacturer's specifications and observed excellent performance of composite fibre crossarms on the network compared to their timber counterparts. There is evidence to suggest that this lifetime could be longer, however, a conservative estimate of 60 years provides a strong justification for the transition to this long-life material. Accelerated age testing by manufacturers and Essential Energy supports a life span of greater than 60 years.

Table 2 shows the results of sensitivity analysis for these input variables. For each input parameter, the resulting output metrics were calculated for each of the best-, worst-, and moderate-case scenarios, with all other parameters left at the current input value.

[9] Note that when lifetimes are changed, the results are calculated over a different time period: the lowest common multiple of the two lifetimes.

Table 2 - Sensitivity analysis results

Parameter	Worst Case			Moderate Case			Current Inputs			Best Case		
	Input Value	Result NPV	Result %	Input Value	Result NPV	Result %	Input Value	Reslt NPV	Result %	Input Value	Reslt NPV	Result %
WACC Rate	4.20%	$235.77	70.49%	3.80%	$397.27	92.37%	3.54%	$518.12	96.91%	3.20%	$699.24	98.94%
Labour and Transport Cost	[redacted]											
Composite Install Efficiency	0%	$356.26	84.93%	2%	$437.19	94.71%	4.00%	$518.12	96.91%	6.00%	$599.05	98.94%
Bushfire Composite Scale Factor	0.6	$291.79	93.60%	0.4	$404.96	96.11%	0.2	$518.12	96.91%	0.1	$574.70	97.78%
Climate Scenario	Current	$411.12	96.11%	RCP4.5, 2050	$457.77	96.11%	RCP4.5, 2070	$518.12	96.91%	RCP8.5, 2090	$706.09	98.60%
Material Cost difference	[redacted]											
Timber Lifetime (years)	50	-$22.28	35.32%	45	$207.84	61.08%	40	$518.12	96.91%	35	$953.07	100.00%
Composite Lifetime (years)	50	$102.44	44.38%	55	$339.42	81.29%	60	$518.12	96.91%	80	$913.22	100.00%

The results of this sensitivity analysis show that the most sensitive parameters are the material cost difference and WACC (aside from product lifetimes).

[redacted]

Figure 12 shows the dependency of the two-output metrics to the WACC rate with all other inputs as in the current input case.

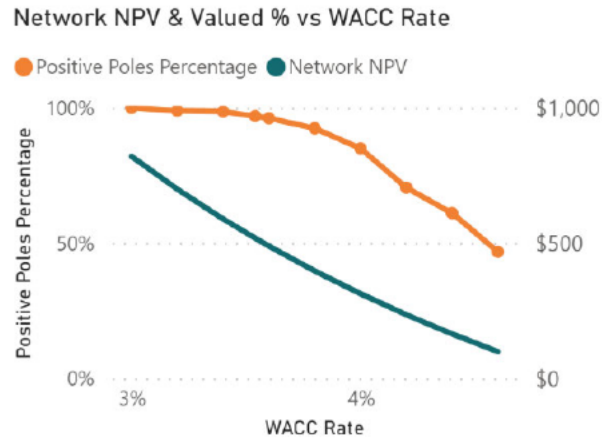


Figure 12 - WACC rate sensitivity for Network NPV and percentage of poles in NPV positive depots

Figure 13 shows the dependency of the two-output metrics to the chosen climate scenario and time horizon with all other inputs as in the current input case.

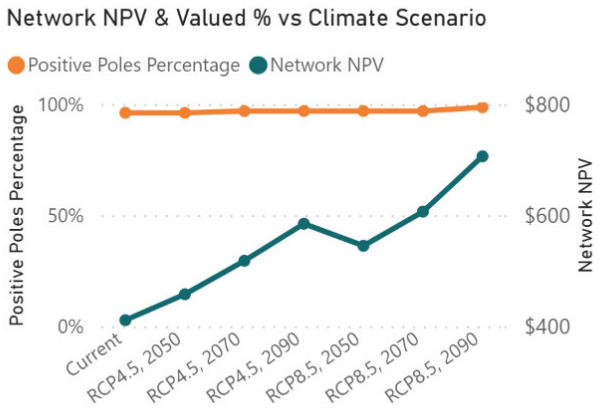


Figure 13 – Climate scenario sensitivity for Network NPV and percentage of poles in NPV positive depots

A Composite Poles Transition PowerBI model details the NPV and annualised risk benefit calculations has been submitted for review to accompany this business case.

9. Recommendation

Essential Energy's risk and value-based work approach aims to target investment in the highest value scenarios to provide the greatest value with the resources available. A network wide transition to composite poles can help deliver value by utilising a higher performance, longer-lasting product for pole replacements to improve the overall long-term health of the asset base. Essential Energy led the industry in transition to composite crossarms. Composite poles, used in conjunction with composite crossarms, provide a long-life, low maintenance 'complete structure' solution to increase the resilience of the future network.

[redacted]

The transition from current usage up to [redacted] is the preferred business direction for the following reasons:

- Maintains existing [redacted] pole supply options
- Assurance for manufacturing ramp up

- Technology maturity and validation in the field [redacted]
- Steady increase to improve network resilience and realise full benefits of composite poles

[redacted]

This analysis shows that composite poles can deliver greater value than timber poles throughout their respective lifecycles. Positive value is demonstrated for composite transition across 96.91% of the network. Additional benefits including supply security, reduced long term maintenance and safety improvements are anticipated to provide further value as the product matures. [redacted]

The additional cost for this transition to composite poles for the 2024-29 period is [redacted] (as shown in Table 3) with an NPV Benefit of $17.8M (assuming the network average NPV benefit of composite). This additional amount is included in the Repex forecast for 2024-29.

Table 3 - Additional composite material costs based on forecast conditional pole replacements

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

References

Doc No.	Document Name	Relevance
1	Composite Poles Transition V2.pbix (PowerBI report available on request)	Composite pole NPV and relative risk modelling
2	4.02 How engagement informed our Proposal	Customer Engagement
3	6.03.02 Network Risk Management Manual	Reference Material
4	6.03.03 Appraisal Value Framework	Value Framework
5	6.01 Climate Impact Assessment	Reference Material

Key Terms and Definitions

Term	Definition
$M	Dollars expressed in millions
AEMO	Australian Energy Market Operator
BFP	Bushfire Priority
CoF	Consequence of Failure
CCA	Copper Chrome Arsenic timber treatment
DNSP	Distribution Network Service Provider
FY	Financial Year
NPV	Net Present Value
NPVM	Net Present Value to Market (NPB subtract NPC)
PoF	Probability of Failure
RIT-D	Regulatory Investment Test – Distribution
VCR	Value of Customer Reliability
VUE	Value of Unserved Energy
WACC	Weighted Average Cost of Capital