OPTIONS EVALUATION REPORT (OER)

Line 966 - Refurb

OER- N2599 revision 1.0

Ellipse project no(s):
TRIM file: [TRIM No]

Project reason: Reliability - To meet overall network reliability requirements
Project category: Prescribed - Replacement

Approvals

Author	Zaeem Khan	Transmission Lines & Cables Asset Analyst
Endorsed	Charles Kurniawan	Transmission Lines and Cables Asset Managers
	Debashis Dutta	Asset Analytics and Insights Manager
Approved	Andrew McAlpine	A/Head of Asset Management
Date submitted for approval	6 October 2021	

Change history

Revision	Date	Amendment
0	06/10/2021	Initial Issue
1	15/11/2021	Minor Formatting

Executive summary

Line 966 is a 132 kV transmission line between Armidale 330 kV and Koolkhan 132 kV (near Grafton) Substations. Commissioned in 1961, it has a route length of 176.5 km and spread over 588 structures, 488 of which are wood pole structures.

Detailed analysis of the asset condition information indicates that the line has several condition issues which require refurbishment to address its health and maintain appropriate risk levels across the network. These issues primarily concern the wood pole structures on the line and the impact of 2019 bushfire damage. Also it is noted that other line components are also approaching an end of life condition.

The scope of work involves a targeted replacement of wood pole structures that experience the greatest deterioration with steel or concrete poles including the bushfire impacted wood poles. The total number of structures expected to be replaced by 2027/2028 is 94 (74 due to condition issues and 20 that were impacted by the bushfires).

The main drivers of the need to remediate these issues is:

> Provide economic benefit to the consumers through safety and bushfire risks reductions. The direct impact of asset failure can result in a conductor drop event with potential fire ignition and/or safety hazard consequences to the general public, as evaluated in the associated modelling.

The assessment of the options considered to address the need/opportunity appears in Table 1.

Table 1 - Evaluated options

Option	Description	Direct capital cost ($m)	Network and corporate overheads ($m)	Total capital cost[1] ($m)	Weighted NPV (PV, $m)	Rank
Option A	Replace known wood pole structures exhibiting ground line degradation and those impacted by bushfire with steel or concrete pole structures only.	11.91	1.17	13.08	37.00	1
Option B	Rebuild the bushfire impacted sections of the line, to the nearest tension structure outside the impacted areas, replacing wood poles with concrete or steel pole structures. Existing concrete poles to remain where practicable. As part of the rebuild, replace the existing Panther conductor with Lemon ACSR/GZ.	77.02	5.28	82.30	27.83	3

[1] Total capital cost is the sum of the direct capital cost and network and corporate overheads. Total capital cost is used in this OER for all analysis.

Option	Description	Direct capital cost ($m)	Network and corporate overheads ($m)	Total capital cost[1] ($m)	Weighted NPV (PV, $m)	Rank
Option C	Rebuild the entire line, replacing wood poles with concrete or steel pole structures. The existing Panther conductor is to be replaced with Lemon ACSR/GZ, and the earthwire replaced like-for-like. All phase conductor and earthwire components, including insulators, hardware and fittings are to be replaced.	84.44	5.77	90.21	31.97	2

The preferred option is Option A, as it has the highest weighted NPV result of the technically and commercially feasible options which were considered. It is therefore recommended that Option A be scoped in detail and progressed from DG1 to DG2.[2] In consideration of the delivery requirements and the economic benefit NPV analysis for the need, its optimal timing is 2027/2028.

[2] DG stands for 'decision gate' that forms a part of TransGrids investment decision process.

1. Need/opportunity

Line 966, a 132 kV transmission line between Armidale 330 kV and Koolkhan 132 kV (near Grafton) Substations, has widespread condition issues on various line components, all of which increase the probability of asset failure. These issues present a bushfire and safety risk which TransGrid is obligated to manage.

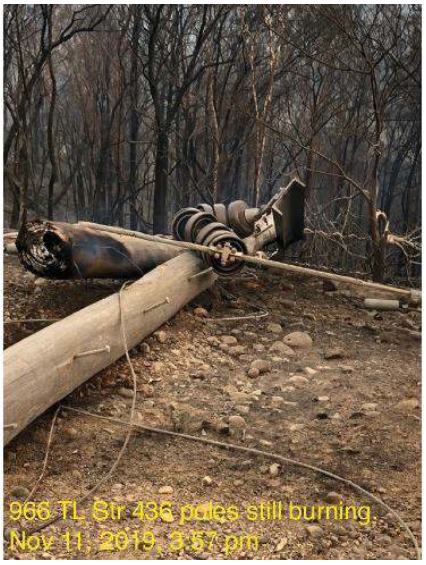
Wood Pole Structures

The most significant element of concern is the condition of the wood pole structures on the line. Available recent inspection data and existing asset condition records have identified that 58 of the 488 structures, or 10% of wood pole structures on the line, have condition issues or deterioration.

In addition to the 58 structures already identified to have condition issues, it is anticipated that a further 16 structures will have decayed and/or deteriorated to the point of requiring replacement by 2028. The estimate of additional structures is based on average rates of condition issues over the past 10 years on this line.

2019 Bushfire Damage

Line 966 was impacted by both the Liberation Trail Andersons Creek Fire and the Guya Road Fire in November 2019. Six wood pole structures (No.'s 407, 408, 411, 422, 429 and 436) were burnt out with conductors on the ground, whilst another (Structure 450) experienced extensive damage.



The fire impacted a total of 190 structures across the following sections

- Strs 155-167 – 14 structures of 3.8km route length
- Strs 185-219 – 35 structures of 10km route length
- Strs 321-328 – 8 structures of 2.2km route length
- Strs 349-479 – 133 structures of 47.7km route length

Subsequent inspections of the sections impacted by the fire identified an additional 23 structures as burnt to the extent the timber is charred, of which 20 were not already identified as having condition issues in recent inspections or existing asset condition records. The fire damage affects the outer annulus of the pole at the region in the vicinity of the ground line and above. This is the main load bearing area of the structure, and damage to this section of the pole can impact its structural integrity.

The total number of structures expected to be replaced by 2027/2028 is 94 (74 due to condition issues and 20 that were impacted by the bushfires).

Other Line Condition Issues

Other condition issues on the line impact 390 of the 588 structures across multiple line components include, but are not limited to:

- Conductor issues - significant heat, such as that from a bushfire event, can cause aluminium to anneal and lose mechanical strength. It is expected that the heat has caused significant stress on the conductors, and this may be further exacerbated by impact with the ground where the abovementioned six severely burnt structures failed and resulted in the fallen conductor. The loss of strength through annealing has been confirmed in a sample of conductor taken from Line 966 and tested.
- Condition of the porcelain insulators – the majority of the line is installed with pre-1965 porcelain insulators, and laboratory testing has indicated a deterioration of insulation resistance. These insulators have a porcelain mixture formula that is no longer in use and the manufacturer has recommended their replacement. Failure of an insulator may result in a fallen conductor which was most recently experienced on Line 966 in 2018. The replacement of insulators has been included as part of a wider line refurbishment programme.
- Deterioration of conductor dampers & fittings and earthwire dampers & fittings due to corrosion – failure of these components can lead to a fallen conductor.
- Deterioration of earthwire bonding and structure earthing – this can lead to possible transfer potential, earth current and voltage gradient issues.

Given the extent of condition issues across both the wood pole structures and other transmission line components on Line 966, it is considered that the entire line is approaching the end of its serviceable life. In 2026, the asset will have reached 65 years of age.

There is a need to remediate these issues to:

- Provide economic benefit to the consumers through safety and bushfire risks reductions. The direct impact of asset failure can result in a conductor drop event with potential fire ignition and/or safety hazard consequences to the general public, as evaluated in the associated modelling.

If the condition issues on the line are not addressed through the timely implementation of the preferred technically and commercially feasible remediation option, then the asset will operate with increasing probability of failure as it continues to deteriorate.

Consequently, the proposed project has an economic benefits need, and addressed this need will provide avoided cost savings from reduced in bushfire and safety risk, and maintenance costs that would otherwise occur without refurbishment.

2. Related needs/opportunities

- Need 000000001558: 132 kV Wood Pole Replacement Programme.
- N2595: Various Lines - Conductor Condition. Condition issues with Panther ACSR/GZ conductor have been identified, attributed to deterioration and inadequate welding practices during manufacturing of the conductor inner steel cores.

3. Options

The base case for this assessment is a ‘do nothing’ scenario, where the assets are left in service until they fail and require replacement. In addition to the base case, three other options have been considered. The Option A involves a targeted replacement of wood pole structures that experience the greatest deterioration with steel or concrete poles. Option B and C involves rebuilding of the entire line.

3.1 Base case

It is noted that a 'run to fail' scenario, where the issues are addressed through increased asset monitoring and preventative maintenance tasks, is not a valid base case for this Need. The condition issues on the asset have already been identified through maintenance inspections, and increasing the frequency of inspections to monitor the condition issues will not necessarily address them.

The base case will instead be defined as a 'do nothing' scenario, where the assets are left in service until they fail and require replacement. The replacement cost has been captured in the NPV assessment under financial risk cost.

3.2 Options evaluated

Option A — Replace known wood pole structures exhibiting ground line degradation and those impacted by bushfire with steel or concrete pole structures only. [NOSA N2599, OFS N2599A]

The Option A involves a targeted replacement of wood pole structures that experience the greatest deterioration with steel or concrete poles including the bushfire impacted wood poles. The total number of structures expected to be replaced by 2027/2028 is 94 (74 due to condition issues and 20 that were impacted by the bushfires).

It is estimated that this option would cost $13.08 million ± 25% ($2020-21). This option is expected to be completed within 25 months following DG1.

Option B — Rebuild the bushfire impacted sections of the line, to the nearest tension structure outside the impacted areas, replacing wood poles with concrete or steel pole structures. Existing concrete poles to remain where practicable (Str 155-167, Str 185-219, Str 321-328, Str 349-479). [NOSA N2599, OFS N2599B]

This option will address the wood pole condition issues on the bushfire impacted section of the line and other line condition issues including fitting, insulator and conductor. The existing Panther conductor is to be replaced with Lemon ACSR/GZ including all components, hardware and fittings, and all insulators.

The scope of work covers replacement of 451 wood pole structures, 162.7 km of conductor, and 335.4 km of earthwire. It is estimated that this option would cost $82.30 million ± 25% ($2020-21). This option is not expected to be completed within the 2024 – 2028 regulatory period with optimal timing in 2033. Works for the project would be completed within 59 months following DG1.

Option C — Rebuild the entire line, replacing wood poles with concrete or steel pole structures. The existing Panther conductor is to be replaced with Lemon ACSR/GZ, and the earthwire replaced like-for-like. [NOSA N2599, OFS N2599C]

Given the extent of condition issues across both the wood pole structures and other transmission line components on Line 966, it is considered that the entire line is approaching the end of its serviceable life. In 2026, the asset will have reached 65 years of age. Hence, rebuilding of the entire line is proposed under this option to address the line condition issues and provide efficiency in delivery.

The scope of work covers replacement of 488 wood pole structures, 177 km of conductor, and 354 km of earthwire. It is estimated that this option would cost $90.21 million ± 25% ($2020-21).This option is not expected to be completed within the 2024 – 2028 regulatory period with optimal timing in 2034. Works for the project would be completed within 60 months following DG1.

3.3 Options considered and not progressed

The following options were considered but not progressed:

Table 2 Options considered but not progressed

Option	Reason for not progressing

Option	Reason for not progressing
Increased inspections	The condition issues have already been identified and cannot be rectified through increased inspections, and therefore is not technically feasible.
Elimination of all associated risk	This can only be achieved through retirement and decommissioning of the associated assets which is not technically feasible.
Non-network solutions	TransGrid does not consider non-network options to be commercially and technically feasible to assist with meeting the identified need, as non-network options will not mitigate the environment (bushfire) and safety posed as a result of corrosion-related asset deterioration.

4. Evaluation

4.1 Commercial evaluation methodology

The economic assessment undertaken for this project includes three scenarios that reflect a central set assumptions based on current information that is most likely to eventuate (central scenario), a set of assumptions that give rise to a lower bound for net benefits (lower bound scenario), and a set of assumptions that give rise to an upper bound on benefits (higher bound scenario).

Assumptions for each scenario are set out in the table below.

Table 3 Scenarios

Parameter	Central scenario	Lower bound scenario	Higher bound scenario
Discount rate	4.8%	7.37%	2.23%
Capital cost	100%	125%	75%
Risk costs benefit	100%	75%	125%
Scenario weighting	**50%**	**25%**	**25%**

Parameters used in this commercial evaluation are set out in the table below

Table 4 Parameters used in the NPV evaluation

Parameter	Parameter Description	Value used for this evaluation
Discount year	Year that dollar values are discounted to	2020/2021
Base year	The year that dollar value outputs are expressed in real terms	2020/2021 dollars
Period of analysis	Number of years included in economic analysis with remaining capital value included as terminal value at the end of the analysis period.	25 years
Expected asset life	Period of depreciation of the asset	50 years

ALARP disproportionality	Multiplier of the environmental and safety related risk cost included in NPV analysis to demonstrate implementation of obligation to reduce to ALARP.	Refer to section 4.3 for details.

The capex figures in this OER do not include any real cost escalation.

4.2 Commercial evaluation results

The commercial evaluation of the technically feasible options is set out in Table 5. Details appear in Appendix A.

Table 5 - Commercial evaluation (PV, $ million)

Option	Capital Cost PV	Central scenario NPV	Lower bound scenario NPV	Higher bound scenario NPV	Weighted NPV	Ranking
Option A	9.43	30.03	7.11	80.84	37.00	1
Option B	59.76	16.14	-27.93	106.96	27.83	3
Option C	65.36	18.69	-30.35	120.87	31.97	2

Based on the commercial analysis, Option A is the preferred option as it yields the highest weighted NPV and is technically and commercially feasible. The main driver of the benefit in the NPV is bushfire risk benefit.

4.3 ALARP evaluation

TransGrid manages and mitigates bushfire and safety risk to ensure they are below risk tolerance levels or 'As Low As Reasonably Practicable' ('ALARP'), in accordance with the regulation obligations and TransGrid's business risk appetite. Under the Electricity Supply (Safety and Network Management) Regulation 2014 Section 5 'A network operator must take all reasonable steps to ensure that the design, construction, commissioning, operation and decommissioning of its network (or any part of its network) is safe.' TransGrid maintains an Electricity Network Safety Management System (ENSMS) to meet this obligation.[3]

In its Network Risk Assessment Methodology, under the ALARP test with the application of a gross disproportionate factor[4], the weighted benefits are expected to exceed the cost. TransGrid's analysis concludes that the costs are less than the weighted benefits from mitigating bushfire and safety risks. The proposed investment will enable TransGrid to continue to manage and operate this part of the network to a safety and risk mitigation level of ALARP.

Evaluation of the above options has been completed in accordance with As Low As Reasonably Practicable (ALARP) obligations. The Network Safety Risk Reduction is calculated as 6 x Bushfire Risk Reduction + 6 x Safety Risk Reduction + 0.1 x Reliability Risk Reduction.

Results of the ALARP evaluation are set out in Table 6.

[3] TransGrid's ENSMS follows the International Organization for Standardization's ISO31000 risk management framework which requires following hierarchy of hazard mitigation approach

[4] The values of the disproportionality factors were determined through a review of practises and legal interpretations across multiple industries, with particular reference to the works of the UK Health and Safety Executive. The methodology used to determine the disproportionality factors in this document is in line with the principles and examples presented in the AER Replacement Planning Guidelines and is consistent with TransGrid's Revised Revenue Proposal 2023/24-2027/28.

Table 6 - Reasonably practicable test ($ million)

Option	Network Safety Risk Reduction	Annualised Capex	Reasonably Practicable?[5]
A	0.59	0.69	N
B	3.84	4.37	N
C	4.29	4.79	N

The result of the ALARP evaluation is that all options do not meet the ALARP threshold.

4.4 Preferred option

The preferred option is Option A, as it has the highest weighted NPV result of all the technically and commercially feasible options considered as part of this need. The optimal delivery date for this option is 2027/2028 based on an optimal timing analysis (see Section 5).

Capital and Operating Expenditure

The required capex expenditure is $13.08 million.

Regulatory Investment Test

A regulatory investment test for transmission (RIT-T) is required as the estimated capital cost for the preferred option is above the threshold of $6 million.

5. Optimal Timing

In consideration of the delivery requirements and the economic benefit NPV analysis for the need, its optimal timing is 2027/2028.

The test for optimal timing of the preferred option has been undertaken. The approach taken is to identify the optimal commissioning year for the preferred option where net benefits (including avoided risk costs and safety disproportionality tests) of the preferred option exceeds the annualised costs of the option. The optimal timing assessment considers the delivery requirements of the project and the estimated delivery timeline of 25 months in the OFS.

The commencement year is determined based on the required project disbursement to meet the commissioning year based on the OFS.

The results of optimal timing analysis is:

- Optimal commissioning year: 2027/2028
- Commissioning year annual benefit: $0.71 million
- Annualised cost: $0.69 million

Based on the optimal timing, the project is expected to be completed in the 2024-2028 Regulatory Period.

6. Recommendation

The preferred option is Option A, as it has the highest weighted NPV result of all the technically and commercially feasible options considered as part of this need.

[5] Reasonably practicable is defined as whether the annualised CAPEX is less than the Network Safety Risk Reduction.

It is therefore recommended that this option be scoped in detail, so that it can be progressed from DG1 to DG2. Total project cost is $13.08 million including an amount of $1 million to progress the project from DG1 to DG2.

Appendix A – Option Summaries[6]

Project Description	Line 966 Refurbishment		
Option Description	Option A - Replace known wood pole structures exhibiting ground line degradation and those impacted by bushfire with steel or concrete pole structures only.		
Project Summary			
Option Rank	*1*	Investment Assessment Period	*25*
Asset Life	*50*	NPV Year	2021
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, $m)	30.03	Annualised CAPEX @ Central Benefit Scenario ($m)	Annualised Capex - Standard (Business Case) 0.69
NPV @ Lower Bound Scenario (PV, $m)	7.11	Network Safety Risk Reduction ($m)	Network Safety Risk Reduction 0.59
NPV @ Higher Bound Scenario (PV, $m)	80.84	ALARP	ALARP Compliant? No
NPV Weighted (PV, $m)	37.00	Optimal Timing	Optimal timing (Business Case) 2028
Cost (Central Scenario)			
Total Capex ($m)	13.08	Cost Capex (PV,$m)	9.43
Terminal Value ($m)	6.28	Terminal Value (PV,$m)	1.40
Risk (Central Scenario)	**Pre**	**Post**	**Benefit**
Reliability (PV,$m)	Reliability Risk (Pre) 0.00	Reliability Risk (Post) 0.00	Pre – Post 0.00
Financial (PV,$m)	Financial Risk (Pre) 12.15	Financial Risk (Post) 6.53	Pre – Post 5.62
Operational/Compliance (PV,$m)	Operational Risk (Pre) 0.00	Operational Risk (Post) 0.00	Pre – Post 0.00
Safety (PV,$m)	Safety Risk (Pre) 0.02	Safety Risk (Post) 0.02	Pre – Post 0.00
Environmental (PV,$m)	Environmental Risk (Pre) 78.95	Environmental Risk (Post) 47.18	Pre – Post 31.77
Reputational ($m)	Reputational Risk (Pre) 1.44	Reputational Risk (Post) 0.77	Pre – Post 0.67
Total Risk (PV,$m)	Total Risk (Pre) 92.56	Total Risk (Post) 54.50	Pre – Post 38.06
OPEX Benefit (PV,$m)			OPEX Benefit 0.00
Other benefit (PV,$m)			Incremental Net Benefit 0.00
Total Benefit (PV,$m)			Business Case Total Benefit 38.06

Commissioning year annual benefit ($k): 714.71

[6] Figures may not add due to rounding

Project Description	Line 966 Refurbishment		
Option Description	Option B - Rebuild the bushfire impacted sections of the line, to the nearest tension structure outside the impacted areas, replacing wood poles with concrete or steel pole structures. Existing concrete poles to remain where practicable.		
Project Summary			
Option Rank	*3*	Investment Assessment Period	*25*
Asset Life	*50*	NPV Year	2021
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, $m)	16.14	Annualised CAPEX @ Central Benefit Scenario ($m)	Annualised Capex - Standard (Business Case) 4.37
NPV @ Lower Bound Scenario (PV, $m)	-27.93	Network Safety Risk Reduction ($m)	Network Safety Risk Reduction 3.84
NPV @ Higher Bound Scenario (PV, $m)	106.96	ALARP	ALARP Compliant? No
NPV Weighted (PV, $m)	27.83	Optimal Timing	Optimal timing (Business Case) 2035
Cost (Central Scenario)			
Total Capex ($m)	82.30	Cost Capex (PV,$m)	59.76
Terminal Value ($m)	39.50	Terminal Value (PV,$m)	8.81
Risk (Central Scenario)	**Pre**	**Post**	**Benefit**
Reliability (PV,$m)	Reliability Risk (Pre) 0.00	Reliability Risk (Post) 0.00	Pre – Post 0.00
Financial (PV,$m)	Financial Risk (Pre) 12.15	Financial Risk (Post) 2.99	Pre – Post 9.16
Operational/Compliance (PV,$m)	Operational Risk (Pre) 0.00	Operational Risk (Post) 0.00	Pre – Post 0.00
Safety (PV,$m)	Safety Risk (Pre) 0.02	Safety Risk (Post) 0.01	Pre – Post 0.01
Environmental (PV,$m)	Environmental Risk (Pre) 78.95	Environmental Risk (Post) 22.11	Pre – Post 56.84
Reputational ($m)	Reputational Risk (Pre) 1.44	Reputational Risk (Post) 0.35	Pre – Post 1.09
Total Risk (PV,$m)	Total Risk (Pre) 92.56	Total Risk (Post) 25.46	Pre – Post 67.09
OPEX Benefit (PV,$m)			OPEX Benefit 0.00
Other benefit (PV,$m)			Incremental Net Benefit 0.00
Total Benefit (PV,$m)			Business Case Total Benefit 67.09

Commissioning year annual benefit ($k): **4503.86**

Project Description	Line 966 Refurbishment		
Option Description	Option C - Rebuild the entire line, replacing wood poles with concrete or steel pole structures. The existing Panther conductor is to be replaced with Lemon ACSR/GZ, and the earthwire replaced likefor-like. All phase conductor and earthwire components, including insulators, hardware and fittings are to be replaced.		
Project Summary			
Option Rank	*2*	Investment Assessment Period	*25*
Asset Life	*50*	NPV Year	2021
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, $m)	18.69	Annualised CAPEX @ Central Benefit Scenario ($m)	Annualised Capex - Standard (Business Case) 4.79
NPV @ Lower Bound Scenario (PV, $m)	-30.35	Network Safety Risk Reduction ($m)	Network Safety Risk Reduction 4.29
NPV @ Higher Bound Scenario (PV, $m)	120.87	ALARP	ALARP Compliant? No
NPV Weighted (PV, $m)	31.97	Optimal Timing	Optimal timing (Business Case) 2036
Cost (Central Scenario)			
Total Capex ($m)	90.21	Cost Capex (PV,$m)	65.36
Terminal Value ($m)	43.30	Terminal Value (PV,$m)	9.66
Risk (Central Scenario)	**Pre**	**Post**	**Benefit**
Reliability (PV,$m)	Reliability Risk (Pre) 0.00	Reliability Risk (Post) 0.00	Pre – Post 0.00
Financial (PV,$m)	Financial Risk (Pre) 12.15	Financial Risk (Post) 2.13	Pre – Post 10.02
Operational/Compliance (PV,$m)	Operational Risk (Pre) 0.00	Operational Risk (Post) 0.00	Pre – Post 0.00
Safety (PV,$m)	Safety Risk (Pre) 0.02	Safety Risk (Post) 0.01	Pre – Post 0.01
Environmental (PV,$m)	Environmental Risk (Pre) 78.95	Environmental Risk (Post) 15.79	Pre – Post 63.16
Reputational ($m)	Reputational Risk (Pre) 1.44	Reputational Risk (Post) 0.25	Pre – Post 1.19
Total Risk (PV,$m)	Total Risk (Pre) 92.56	Total Risk (Post) 18.18	Pre – Post 74.38
OPEX Benefit (PV,$m)			OPEX Benefit 0.00
Other benefit (PV,$m)			Incremental Net Benefit 0.00
Total Benefit (PV,$m)			Business Case Total Benefit 74.38

Commissioning year annual benefit ($k): **5045.19**