OPTIONS EVALUATION REPORT (OER)

Line 94M - Refurb

OER- N2580 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

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Change history

Revision	Date	Amendment
0	04/10/2021	Initial Issue
1	15/11/2021	Minor Formatting and update to bushfire risk

Executive summary

Line 94M is a 132kV transmission line between Beryl Substation and Crudine Ridge wind farm. The line is part of the original line built between Mt Piper and Beryl Substations in 1976, which was broken up when Crudine Ridge was connected to the grid in 2020. The line has a route length of 70 km strung over 264 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.

The most significant element of concern is the condition of the wood pole structures on the line. Line 94M was first placed into service in 1976, and the wood poles are approaching 50 years of age and toward the end of their nominal lives. The defect rate on the line has increased from 2017 onwards, which is in line with the expected condition of the asset based on its original design parameters.

The total number of structures required to be replaced is 47.

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

- Manage network safety risk levels "As-Low-As Reasonably-Practicable" 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'; and
- Provide economic benefit to consumers through reduction in safety and bushfire risks

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 the wood pole structures known to be exhibiting deterioration with steel or concrete pole structures including associated insulators and fittings.	6.16	0.62	6.78	39.56	1
Option B	Rebuild the entire line, replacing wood poles with concrete or steel pole structures including associated insulators and fittings.	32.76	2.42	35.18	25.26	2

[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 circa 1976 line, replacing wood poles with concrete or steel pole structures including associated insulators and fittings. The existing Panther conductor is to be replaced with Lemon ACSR/GZ.	40.29	2.97	43.26	22.63	3

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 2024/2025.

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

1. Need/opportunity

Line 94M is a 132 kV line between Beryl Substation and Crudine Ridge windfarm. The line consists of one part originally built in 1976 as a Mount Piper 132 kV to Beryl substation. It was cut-in to Crudine Ridge windfarm in 2020 with a 46 double circuit structures over a route length of.13.7 km. The double circuit section is a negotiated asset and is outside the scope of this NOSA. The section to Mount Piper was given the new line number '9ML'. The remaining 94M Beryl Substation to the cut-in location has a route length of 70 km strung over 264 structures.

Line 94M, between Beryl 132kV substation and Crudine Ridge Wind Farm, 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. Line 94M was first placed into service in 1976, and the wood poles are approaching 50 years of age and toward the end of their nominal lives. The defect rate on the line has increased from 2017 onwards, which is in line with the expected condition of the asset based on its original design parameters. It is noted that the neighbouring Line 94B between Beryl and Wellington had amongst the highest defect rates of TransGrid's wood pole lines, prior to its replacement with concrete pole structures between 2012 and 2015.

Detailed analysis of asset condition information records has identified that 32 structures, or 13% of the line are currently having deteriorating condition issues. A further 15 structures will have decayed to the point of requiring replacement by 2028, based on the average defect rates of structures assessed to require additional monitoring due to their condition (also known as "conditionally serviceable") over the past 10 years on this line.

The total number of structures expected to require replacement by 2027/2028 is 47.

Other Line Condition Issues

Given the age of the asset, it is also noted that other line components are in a deteriorating condition that is reflective of them approaching the end of their serviceable lives. These other condition issues impact 225 of the 246 structures on Line 94M, and cover multiple line components, including:

- Deterioration of conductor & earthwire dampers due to corrosion – failure of these components can lead to a conductor drop.
- Angle structure eye bolts – Wherein insulators are connected to the pole, as opposed to a crossarm. These bolts can "pull through" defected timber causing a conductor drop. Due to the design of these structures it is not possible to sound the poles in this area without an outage. The preferred connection is a pole band.
- Deterioration of earthwire bonding due to corrosion – this can lead to possible transfer potential, earth current and voltage gradient issues
- A large number of structures (222) still have porcelain insulators installed that are of pre-1974 vintage. These insulators are approaching the end of their serviceable lives. A sample 11 of 1960 manufacture porcelain disc insulator found five of them exhibit porosity (die penetrate testing). This is typical long-term deterioration. The insulators, despite being in good condition visually, are at risk of puncture through the porcelain.
- Condition issues with Panther ACSR/GZ conductor have also been identified, attributed to deterioration and inadequate welding practices during manufacturing of the conductor inner steel cores.

There is a need to remediate condition issues in order to:

- Manage network safety risk levels "As-Low-As Reasonably-Practicable 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.'

- 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 in sufficient time, then the asset will operate with increasing risk of failure as it continues to deteriorate. The level of reactive corrective maintenance needed to keep the line operating within required standards may also increase, particularly when asset failures ultimately occur.

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

2. Related needs/opportunities

- N2579 – Line 9ML refurbishment – 9ML is the other side of the Crudine Ridge cut-in on the connection between Mount Piper and Beryl. Projects could not happen concurrently without constraining the wind farm to zero.
- Need 000000001942 (not N1942) – Beryl Area Renewables Connection – Upgrading of these lines of augmenting by a new lines alongside are being considered as part of this need. Whilst not included as an option in this need, rebuilding 9ML and 94M as double circuit 132 kV would address both needs.

3. Options

In developing the options to address this need, TransGrid considered the followings:

- A Base case for this assessment as 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

A 'run to fail' scenario, where the identified issues are addressed through increased asset monitoring and preventative maintenance tasks, is not considered a valid base case for this need. The condition issues on the asset have already been identified through existing maintenance inspections; increasing inspections and preventative maintenance will not rectify 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 the wood pole structures known to be exhibiting deterioration with steel or concrete pole structures. [NOSA N2580, OFS N2580A]

Option A is targeted replacement which will address the wood pole structures that exhibiting ground line degradation. The number of structures to be replaced for this option is 47.

It is estimated that this option would cost $6.78 million ± 25% in $2020-21.

This project is expected to be completed within 25 months following the DG1 approval.

Option B — Rebuild the entire line, replacing wood poles with concrete or steel pole structures. [NOSA N2580, OFS N2580B]

Given the age of the asset, it is also noted that other line components are in a deteriorating condition that is reflective of them approaching the end of their serviceable lives. This option addresses other condition issues which impact 225 of the 246 structures on Line 94M, and cover multiple line components, including:

- Deterioration of conductor & earthwire dampers due to corrosion.
- Angle structure eye bolts – Wherein insulators are connected to the pole, as opposed to a crossarm. These bolts can "pull through" defected timber causing a conductor drop. Due to the design of these structures it is not possible to sound the poles in this area without an outage. The preferred connection is a pole band.
- Deterioration of earthwire bonding due to corrosion.
- A large number of structures (222) still have porcelain insulators installed that are of pre-1974 vintage.

While these issues are widespread, it is not considered economically efficient to conduct a refurbishment program to remediate them. Due to the advanced age and condition of the wood pole structures on the line, it is likely that full replacement of the structures will be required within the short to medium term. Were these components to be replaced under any refurbishment programme, they would need to be replaced again at the time of the structure replacement, and will accordingly only be in service for a fraction of their nominal expected lives.

Hence, replacement of all remaining wood pole structures is proposed including the wood pole structures stated in option A. The number of structures to be replaced for this option is 264.

It is estimated that this option would cost $35.18 million ± 25% in $2020-21.

This project is expected to be completed within 34 months following the DG1 approval.

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. [NOSA N2580, OFS N2580C]

Condition issues with Panther ACSR/GZ conductor have also been identified, attributed to deterioration and inadequate welding practices during manufacturing of the conductor inner steel cores.

This option will address the condition issues in Option A, B and also the Panther conductor by rebuilding the entire line .This will provide efficiency in the delivery.

The number of structures to be replaced for the option is 264. 70km of conductor and overhead earthwire are also to be replaced under this option.

It is estimated that this option would cost $43.26 million ± 25% in $2020-21.

This project is expected to be completed within 37 months following the DG1 approval.

3.3 Options considered and not progressed

The following options were considered but not progressed:

Table 2 Options considered and not progressed

Option	Reason for not progressing
Increased inspections	The condition issues have already been identified and cannot be rectified through increased inspection.
Elimination of all associated risk	This can only be achieved through retirement and decommissioning of the associated assets which is not feasible. Line 94M is required to maintain the security of supply to the north-west region of the network, and connect Crudine Ridge Wind Farm to the National Electricity Market.
Non-network solutions	TransGrid does not consider non-network options to be commercially or

Option	Reason for not progressing
	technically feasible to address 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 Scenario parameters

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

Parameters used in this commercial evaluation:

Table 4 Key parameters

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
Useful life of asset	Depreciation period applied to 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 0 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 Table 5.

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	5.63	33.78	11.70	79.00	39.56	1
Option B	27.90	18.53	-9.12	73.07	25.26	2
Option C	34.29	15.56	-14.33	73.74	22.63	3

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.

Table 6 - Reasonably practicable test ($ million)

Option	Network Safety Risk Reduction	Annualised Capex	Reasonably Practicable?[5]
A	0.45	0.36	Yes
B	1.65	1.87	No

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

[4] In accordance with the framework for applying the ALARP principle, a disproportionality factor of 6 has been applied to risk cost figures. 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.

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

Option	Network Safety Risk Reduction	Annualised Capex	Reasonably Practicable?[5]
C	2.08	2.30	No

The result of the ALARP evaluation is that Option A meets 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. Option A also meets the ALARP threshold. The optimal delivery date for this option is 2024/2025 based on an optimal timing analysis (see Section 5)

Capital and Operating Expenditure

The required capital expenditure is $6.78 million.

Regulatory Investment Test

A regulatory investment test for transmission (RIT-T) will be 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 NPV analysis for the need, its optimal timing is 2024/2025.

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 costs and safety disproportionality tests) of the preferred option exceeds the annualised costs of the option. The commencement year is determined based on the required project disbursement to the meet the commissioning year based on the OFS.

The results of optimal timing analysis is:

- Optimal commissioning year: 2024/2025
- Commissioning year annual benefit: $0.52 million
- Annualised cost: $0.36 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.

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 $6.78 million including an amount of $0.5 million to progress the project from DG1 to DG2.

Appendix A – Option Summaries[6]

Project Description	Line 94M Refurb		
Option Description	Option A - Replace known wood pole structures exhibiting deterioration 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, $m)	33.78	Annualised CAPEX @ Central Benefit Scenario ($m)	Annualised Capex - Standard (Business Case) 0.36
NPV @ Lower Bound Scenario (PV, $m)	11.70	Network Safety Risk Reduction ($m)	Network Safety Risk Reduction 0.45
NPV @ Higher Bound Scenario (PV, $m)	79.00	ALARP	ALARP Compliant? Yes
NPV Weighted (PV, $m)	39.56	Optimal Timing	Optimal timing (Business Case) 2025
Cost (Central Scenario)			
Total Capex ($m)	6.78	Cost Capex (PV,$m)	5.63
Terminal Value ($m)	3.25	Terminal Value (PV,$m)	0.84
Risk (Central Scenario)	**Pre**	**Post**	**Benefit**
Reliability (PV,$m)	Reliability Risk (Pre) 1.44	Reliability Risk (Post) 0.25	Pre – Post 1.19
Financial (PV,$m)	Financial Risk (Pre) 4.39	Financial Risk (Post) 0.98	Pre – Post 3.41
Operational/Compliance (PV,$m)	Operational Risk (Pre) 0.00	Operational Risk (Post) 0.00	Pre – Post 0.00
Safety (PV,$m)	Safety Risk (Pre) 0.07	Safety Risk (Post) 0.00	Pre – Post 0.07
Environmental (PV,$m)	Environmental Risk (Pre) 41.58	Environmental Risk (Post) 8.06	Pre – Post 33.52
Reputational ($m)	Reputational Risk (Pre) 0.52	Reputational Risk (Post) 0.12	Pre – Post 0.40
Total Risk (PV,$m)	Total Risk (Pre) 47.99	Total Risk (Post) 9.42	Pre – Post 38.57
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 38.57

Commissioning year annual benefit ($k): 520.23

[6] Figures may vary due to rounding

Project Description	Line 94M Refurb		
Option Description	Option B - Replace all wood pole structures with steel or concrete poles.		
Project Summary			
Option Rank	*2*	Investment Assessment Period	*25*
Asset Life	*50*	NPV Year	2021
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, $m)	18.53	Annualised CAPEX @ Central Benefit Scenario ($m)	Annualised Capex - Standard (Business Case) 1.87
NPV @ Lower Bound Scenario (PV, $m)	-9.12	Network Safety Risk Reduction ($m)	Network Safety Risk Reduction 1.65
NPV @ Higher Bound Scenario (PV, $m)	73.07	ALARP	ALARP Compliant? No
NPV Weighted (PV, $m)	25.26	Optimal Timing	Optimal timing (Business Case) 2033
Cost (Central Scenario)			
Total Capex ($m)	35.18	Cost Capex (PV,$m)	27.90
Terminal Value ($m)	17.59	Terminal Value (PV,$m)	4.52
Risk (Central Scenario)	**Pre**	**Post**	**Benefit**
Reliability (PV,$m)	Reliability Risk (Pre) 1.44	Reliability Risk (Post) 0.16	Pre – Post 1.28
Financial (PV,$m)	Financial Risk (Pre) 4.39	Financial Risk (Post) 0.59	Pre – Post 3.80
Operational/Compliance (PV,$m)	Operational Risk (Pre) 0.00	Operational Risk (Post) 0.00	Pre – Post 0.00
Safety (PV,$m)	Safety Risk (Pre) 0.07	Safety Risk (Post) 0.00	Pre – Post 0.07
Environmental (PV,$m)	Environmental Risk (Pre) 41.58	Environmental Risk (Post) 5.24	Pre – Post 36.34
Reputational ($m)	Reputational Risk (Pre) 0.52	Reputational Risk (Post) 0.07	Pre – Post 0.45
Total Risk (PV,$m)	Total Risk (Pre) 47.99	Total Risk (Post) 6.08	Pre – Post 41.91
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 41.91

Commissioning year annual benefit ($k): **1893.42**

Project Description	Line 94M Refurb		
Option Description	Option C - Rebuild the entire circa 1976 line, replacing wood poles with concrete or steel pole structures. The existing Panther conductor is to be replaced with Lemon ACSR/GZ.		
Project Summary			
Option Rank	*3*	Investment Assessment Period	*25*
Asset Life	*50*	NPV Year	2021
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, $m)	15.56	Annualised CAPEX @ Central Benefit Scenario ($m)	Annualised Capex - Standard (Business Case) 2.30
NPV @ Lower Bound Scenario (PV, $m)	-14.33	Network Safety Risk Reduction ($m)	Network Safety Risk Reduction 2.08
NPV @ Higher Bound Scenario (PV, $m)	73.74	ALARP	ALARP Compliant? No
NPV Weighted (PV, $m)	22.63	Optimal Timing	Optimal timing (Business Case) 2034
Cost (Central Scenario)			
Total Capex ($m)	43.26	Cost Capex (PV,$m)	34.29
Terminal Value ($m)	21.63	Terminal Value (PV,$m)	5.55
Risk (Central Scenario)	**Pre**	**Post**	**Benefit**
Reliability (PV,$m)	Reliability Risk (Pre) 1.44	Reliability Risk (Post) 0.08	Pre – Post 1.36
Financial (PV,$m)	Financial Risk (Pre) 4.39	Financial Risk (Post) 0.36	Pre – Post 4.03
Operational/Compliance (PV,$m)	Operational Risk (Pre) 0.00	Operational Risk (Post) 0.00	Pre – Post 0.00
Safety (PV,$m)	Safety Risk (Pre) 0.07	Safety Risk (Post) 0.00	Pre – Post 0.07
Environmental (PV,$m)	Environmental Risk (Pre) 41.58	Environmental Risk (Post) 3.20	Pre – Post 38.38
Reputational ($m)	Reputational Risk (Pre) 0.52	Reputational Risk (Post) 0.04	Pre – Post 0.48
Total Risk (PV,$m)	Total Risk (Pre) 47.99	Total Risk (Post) 3.69	Pre – Post 44.30
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 44.30

Commissioning year annual benefit ($k): **2381.58**