OPTIONS EVALUATION REPORT (OER)

Line 977-1 - Refurb

OER- N2479 revision 1.0

Ellipse project no(s):
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Project reason: Reliability - To meet overall network reliability requirements
Project category: Prescribed - Replacement

Approvals

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Change history

Revision	Date	Amendment
0	15/10/2021	Initial Issue
1	14/11/2021	Minor Formatting

Executive summary

Line 977/1 is a 132 kV transmission line between Canberra 330 kV and Queanbeyan 132 kV Substations, with a route length of 54 km. It mainly traverses through agricultural land on the outskirts of Canberra in both the ACT and NSW.

Detailed asset condition records analysis indicate that the line has several condition issues which require refurbishment to address its health and maintain appropriate risk levels across the network.

These known issues primarily concern the 16 wood pole structures on the line. In addition to the wood pole condition issues, detailed asset condition analysis have identified that various condition issues impact 263 of the 278 structures across multiple line components.

Other issues on the line include:

- Condition of pre-1975 vintage of porcelain insulators, which have reached the end of their expected lives. Some deterioration of insulation resistance has occurred – the line also has a number of structures with pre-1965 porcelain insulators where laboratory testing has indicated deterioration of insulation resistance and the manufacturer recommending their replacement. Failure of an insulator may result in a fallen conductor which was recently experienced on another 132kV transmission line.
- Flying angle and tension structures with the structure type BD, D, EB, and EL have the insulators connected to the pole via eyebolts. Where timber is defective, these bolts are known to "pull through" the pole – there have been three failure incidents resulting in conductor drop since 1998. There are 20 structures on Line 977/1 which are impacted, and the eyebolts are to be replaced with pole bands.
- Deterioration in the steel crossarms due to corrosion, which can compromise structural integrity and potentially result in a fallen conductor.
- Deterioration of guys and anchors – failure of these components can potentially compromise structural integrity.

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

[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 A	Remediate all identified condition issues on the line as per the Transmission Line Refurbishment Criteria, and remediate low spans	7.91	0.83	8.74	59.12	1
Option B	Remediate all identified low spans	0.91	0.09	1.00	-0.58	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 2025/2026.

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

1. Need/opportunity

Line 977/1 had 13 wood pole structures that have been identified as defective requiring maintenance replacement. Available recent inspection data and existing asset condition records have identified that another 7 currently have condition issues. A further 9 structures have been identified as having decay and deterioration. These known condition issues affect 16 structures, or 6% of the line.

Inspection records indicate a relatively good condition outlook on the remaining structures on Line 977/1, despite their age. As the wood poles may have an extended life remaining before they are deemed unserviceable, only targeted replacement is proposed as part of the refurbishment option.

In addition to the wood pole condition issues, detailed asset condition analysis have identified that various condition issues impact 263 of the 278 structures across multiple line components.

Other issues on the line include:

- Condition of pre-1975 vintage of porcelain insulators, which have reached the end of their expected lives. Some deterioration of insulation resistance has occurred – the line also has a number of structures with pre-1965 porcelain insulators where laboratory testing has indicated deterioration of insulation resistance and the manufacturer recommending their replacement. Failure of an insulator may result in a fallen conductor which was recently experienced on another 132kV transmission line.
- Flying angle and tension structures with the structure type BD, D, EB, and EL have the insulators connected to the pole via eyebolts. Where timber is defective, these bolts are known to “pull through” the pole – there have been three failure incidents resulting in conductor drop since 1998. There are 20 structures on Line 977/1 which are impacted, and the eyebolts are to be replaced with pole bands.
- Deterioration in the steel crossarms due to corrosion, which can compromise structural integrity and potentially result in a fallen conductor.
- Deterioration of guys and anchors – failure of these components can potentially compromise structural integrity.
- Low Span on 977/1

  According to its original design parameters, Line 977/1 was intended to have a maximum operating temperature of 85°C, with a statutory design clearance at that time of 6.7 m. The line has the following conductor sections:

  - Goat conductor (0.3” SCA) from Canberra to Spring Flat
  - Panther conductor (0.2” SCA) from Spring Flat to Queanbeyan

  Current advice from Network Planning indicates that the original design rating and associated maximum operating temperature of the line is now required.

  Following the first aerial laser surveys of the line, it became apparent that these statutory clearances would be encroached at well below these design temperatures. Accordingly, based on the line loading scenarios at the time, Line 977/1 was assessed by Network Planning to require a capacity of 89 MVA (deterministic rating), which corresponded to at a temperature of 65°C on the Goat section and 70°C on the Panther section.An earlier low span remediation project to address spans assessed at the lower conductor temperatures was undertaken on this line and completed in FY2019. The low spans that remain at the design temperature on this line are to be remediated in accordance to the requirements set out in the Low Spans Risk Assessment Methodology. Any remediation is required to meet clearances as specified in AS/NZS 7000 at the required rating of the line.

There is a need to remediate these issues 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'; and

- Provide economic benefit to consumers through reduction in safety and bushfire risks.

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 avoided cost savings from reduced in bushfire and safety risk, and maintenance costs that would otherwise occur without refurbishment.

Appendix B provides a summary of the number of structures with condition issues within each asset component category. The figures are based on the Transmission Line Refurbishment Criteria document.

2. Related needs/opportunities

- Need N2480: Line 976/1 Refurbishment
- Need N2612: Line 976/2 Refurbishment
- Need N2613: Line 976/3 Refurbishment
- Need N2550: FY24-28 OPGW Rollouts. There is a need to install OPGW on Line 977/1 to address existing network communications reliability risk.
- Panther Conductor: The section from Spring Flat to Queanbeyan is strung with Panther conductor. 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. TransGrid has experienced two failures of this conductor type, and the subsequent investigations both attributed the failure to the aforementioned issue. TransGrid has work practice limitations in place for Panther conductor.

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, two remediation options have been considered. Option A involves a targeted program to address components which have experienced the greatest deterioration. Option B involves addressing all identified low spans on the 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 — Remediate all identified condition issues on the line as per the Transmission Line Refurbishment Criteria, and remediate low spans.

Detail of scope can be found in Appendix B.

It is estimated that this option would cost $8.74 million ± 25% in $2020-21. This project is expected to be completed within 32 months following DG1.

Option B — Remediate all identified low spans.

It is estimated that this option would cost $1.00 million ± 25% in $2020-21. This option will only address the low span and not the asset condition issues. Hence, this option is not progressed further.

This project is expected to be completed within 21 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
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.
New transmission line	Due to significant costs of this option, a single 132kV transmission line is not considered commercially 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 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 Inputs

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

Parameters used in this commercial evaluation:

Table 4 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 4.3 for details.

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	6.94	52.49	22.09	109.39	59.12	1
Option B	0.72	-0.60	-0.69	-0.45	-0.58	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]

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

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	1.87	0.46	Y
B	0.00	0.05	N

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 2025/2026 based on an optimal timing analysis (see Section 5).

Capital and Operating Expenditure

The capital cost expected is $8.74 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 2025/2026.

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 32 months in the OFS.

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

[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.

The results of optimal timing analysis is:

- Optimal commissioning year: 2025/2026.
- Commissioning year annual benefit: $2.23 million.
- Annualised cost: $0.46 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 $8.74 million including an amount of $0.5 million to progress the project from DG1 to DG2.

Appendix A – Option Summaries[6]

Project Description	Line 977/1 Refurbishment		
Option Description	Option A - Refurbish all asset components that have been identified as having condition issues		
Project Summary			
Option Rank	*1*	Investment Assessment Period	*25*
Asset Life	*50*	NPV Year	2021
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, $m)	52.49	Annualised CAPEX @ Central Benefit Scenario ($m)	Annualised Capex - Standard (Business Case) 0.46
NPV @ Lower Bound Scenario (PV, $m)	22.09	Network Safety Risk Reduction ($m)	Network Safety Risk Reduction 1.87
NPV @ Higher Bound Scenario (PV, $m)	109.39	ALARP	ALARP Compliant? Yes
NPV Weighted (PV, $m)	59.12	Optimal Timing	Optimal timing (Business Case) 2026
Cost (Central Scenario)			
Total Capex ($m)	8.74	Cost Capex (PV,$m)	6.94
Terminal Value ($m)	4.37	Terminal Value (PV,$m)	1.12
Risk (Central Scenario)	**Pre**	**Post**	**Benefit**
Reliability (PV,$m)	Reliability Risk (Pre) 0.85	Reliability Risk (Post) 0.07	Pre – Post 0.78
Financial (PV,$m)	Financial Risk (Pre) 9.02	Financial Risk (Post) 0.81	Pre – Post 8.21
Operational/Compliance (PV,$m)	Operational Risk (Pre) 0.00	Operational Risk (Post) 0.00	Pre – Post 0.00
Safety (PV,$m)	Safety Risk (Pre) 0.00	Safety Risk (Post) 0.00	Pre – Post 0.00
Environmental (PV,$m)	Environmental Risk (Pre) 53.61	Environmental Risk (Post) 5.25	Pre – Post 48.36
Reputational ($m)	Reputational Risk (Pre) 1.07	Reputational Risk (Post) 0.10	Pre – Post 0.97
Total Risk (PV,$m)	Total Risk (Pre) 64.55	Total Risk (Post) 6.24	Pre – Post 58.31
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 58.31

Commissioning year annual benefit ($k): 2226.63

[6] Figures have been rounded for simplicity.

Project Description	Line 977/1 Refurbishment		
Option Description	Option B - Remediate all identified low spans in accordance with the Low Spans Risk Assessment Methodology		
Project Summary			
Option Rank	*2*	Investment Assessment Period	*25*
Asset Life	*50*	NPV Year	2021
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, $m)	-0.60	Annualised CAPEX @ Central Benefit Scenario ($m)	Annualised Capex - Standard (Business Case) 0.05
NPV @ Lower Bound Scenario (PV, $m)	-0.69	Network Safety Risk Reduction ($m)	Network Safety Risk Reduction #N/A
NPV @ Higher Bound Scenario (PV, $m)	-0.45	ALARP	ALARP Compliant? #N/A
NPV Weighted (PV, $m)	-0.58	Optimal Timing	Optimal timing (Business Case) -1
Cost (Central Scenario)			
Total Capex ($m)	1.00	Cost Capex (PV,$m)	0.72
Terminal Value ($m)	0.48	Terminal Value (PV,$m)	0.12
Risk (Central Scenario)	**Pre**	**Post**	**Benefit**
Reliability (PV,$m)	Reliability Risk (Pre) 0.85	Reliability Risk (Post) 0.85	Pre – Post 0.00
Financial (PV,$m)	Financial Risk (Pre) 9.02	Financial Risk (Post) 9.02	Pre – Post 0.00
Operational/Compliance (PV,$m)	Operational Risk (Pre) 0.00	Operational Risk (Post) 0.00	Pre – Post 0.00
Safety (PV,$m)	Safety Risk (Pre) 0.00	Safety Risk (Post) 0.00	Pre – Post 0.00
Environmental (PV,$m)	Environmental Risk (Pre) 53.61	Environmental Risk (Post) 53.61	Pre – Post 0.00
Reputational ($m)	Reputational Risk (Pre) 1.07	Reputational Risk (Post) 1.07	Pre – Post 0.00
Total Risk (PV,$m)	Total Risk (Pre) 64.55	Total Risk (Post) 64.55	Pre – Post 0.00
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 0.00

Commissioning year annual benefit ($k): **#N/A**

Appendix B Asset Condition

Asset Component Category	Cause	Effect	Consequence	No. of Structures with Condition Issues
Conductor Fittings	Flying angle eyebolts, which can pull through degraded/decayed timber.	Fallen conductor	Bushfire resulting in potential loss of property and/or life Safety incident resulting in potential injury or death Line outage with potential network reliability impacts	20
Earthwire Dampers	Dampers are drooping, reducing effectiveness. Ineffective vibration damping can lead to accelerated conductor fatigue.	Fallen conductor	Bushfire resulting in potential loss of property and/or life Safety incident resulting in potential injury or death Line outage with potential network reliability impacts	1
Earthwire Fittings	Connection needs to be secured.	Fallen conductor	Bushfire resulting in potential loss of property and/or life Safety incident resulting in potential injury or death Line outage with potential network reliability impacts	1
Guy and Anchor	Deteriorated guys and damaged guy sleeves.	Fallen structure and conductor	Bushfire resulting in potential loss of property and/or life Safety incident resulting in potential injury or death Line outage with potential network reliability impacts	9
Insulator	Porcelain insulators have reached end of serviceable life. Some insulators out of alignment and/or rusty.	Fallen conductor	Bushfire resulting in potential loss of property and/or life Safety incident resulting in potential injury or death Line outage with potential network reliability impacts	200
Public Safety – Aerial Marker Balls	Deteriorated.	Unauthorised access	Safety incident resulting in potential injury or death Line outage with potential network reliability impacts	1

Asset Component Category	Cause	Effect	Consequence	No. of Structures with Condition Issues
Public Safety – Structure ID Signs	Deteriorated.	Unauthorised access	Safety incident resulting in potential injury or death Line outage with potential network reliability impacts	206
Steel Crossarm	Corrosion of crossarm. This can compromise structural integrity.	Fallen conductor	Bushfire resulting in potential loss of property and/or life Safety incident resulting in potential injury or death Line outage with potential network reliability impacts	48
Structure Earthing	Poor connection.	Possible transfer potential, earth current and voltage gradient issues	Safety incident resulting in potential injury or death	3
Wood Pole	Deterioration of ground line wood condition. Leaning structures. This can compromise structural integrity.	Fallen structure and conductor	Bushfire resulting in potential loss of property and/or life Safety incident resulting in potential injury or death Line outage with potential network reliability impacts	16