OPTIONS EVALUATION REPORT (OER)

Line 16 - Marulan - Avon - Tower Refurb

OER- 000000001353 revision 1.0

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Approvals

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Change history

Revision	Date	Amendment
0	21/09/2021	Initial Issues
1	13/11/2021	Minor Formatting

Executive summary

Line 16 is a 330kV, steel tower transmission line that connects Marulan 330kV and Avon 330kV Substations, with a route length of 70.5km. The transmission line is a key part of the link between Snowy Hydro and wind generation, and the Illawarra and Sydney metropolitan regions. There are 159 structures on the line, which traverses bushland and rural agricultural areas between Marulan and Avon.

Detailed analysis of asset condition information has identified that 156 of the 159 structures on line 16 have several condition issues on the line which require refurbishment to address asset health and maintain appropriate risk levels across the network.

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	Remediate all identified condition issues for line components which have experienced greater deterioration and/or reached the end of their functional lives	7.46	0.70	8.16	14.65	2
Option B	Remediate all identified condition issues on the line	8.17	0.77	8.94	16.79	1

The preferred option is Option B, as it has the highest weighted NPV result of the technically and commercially feasible options which were considered. It is therefore recommended that Option B 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.

[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.

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

1. Need/opportunity

Line 16 is a 330kV, steel tower transmission line that connects Marulan 330kV and Avon 330kV Substations, with a route length of 70.5km. The transmission line is a key part of the link between Snowy Hydro and wind generation, and the Illawarra and Sydney metropolitan regions. There are 159 structures on the line, which traverses bushland and rural agricultural areas between Marulan and Avon.

Detailed analysis of asset condition information has identified that 156 of the 159 structures on line 16 have several condition issues on the line which require refurbishment to address asset health and maintain appropriate risk levels across the network.

The most significant element of concern is that the insulators have reached the end of their expected lives. The majority of the line is installed with pre-1965 porcelain insulators, and lab testing on the insulator type has indicated deterioration of insulation performance. The porcelain formula mixture used in this type of insulators is no longer in use, and the manufacturer has recommended their replacement. Failure of an insulator may result in a fallen conductor – there was a recently recorded instance in 2011 of an insulator failure resulting in a conductor drop event. Since that time, it is noted that the replacement of insulators has been included as part of a wider line refurbishment programme.

Other issues on the line include:

- Deterioration of conductor fittings, earthwire fittings and corona rings due to corrosion – failure of the fitting attachment can result in a fallen conductor
- Deterioration of foundations and steel members, primarily due to corrosion – these members are difficult to replace, and if not remediated their failure can compromise structural integrity
- Deterioration on asset components relating to public safety such as climbing deterrents and signage

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.’
- Provide an economic benefit to consumers through reductions in safety and bushfire risks. 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 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 for each (Option A and Option B) are based on the Transmission Line Refurbishment Criteria document.

2. Related needs/opportunities

- Need N2524: Line 4 Refurbishment

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 refurbishment options have been considered.

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 identified condition issues for line components that have experienced greater deterioration and/or reached the end of their functional lives. [NOSA-1353,OFS-1353A].

It is estimated that this option would cost $8.16 million ± 25% in $2020-21.

This project is expected to be completed within 30 months following DG1.

Option B — Remediate all identified condition issues on the line. [NOSA-1353, OFS-1353B].

It is estimated that this option would cost $8.94 million ± 25% in $2020-21. Option B will provide efficiency in delivery by addressing all identified condition issues for line components in a single mobilisation whilst reducing bushfire risks on the line that may arise from conductor drop due to asset failure.

This project is expected to be completed within 31 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 new double circuit 330 kV 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 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 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 benefit	100%	75%	125%
Scenario weighting	**50%**	**25%**	**25%**

Parameters used in this commercial evaluation:

Table 4 Model 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
Expected asset life	Period of depreciation of the asset	35 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	6.48	12.23	1.88	32.27	14.65	2
Option B	7.10	14.04	2.34	36.75	16.79	1

Based on the commercial analysis, Option B 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 factor4, 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	**0.73**	**0.49**	**Y**
B	**0.80**	**0.53**	**Y**

The result of the ALARP evaluation is that both options meet the ALARP threshold.

4.4 Preferred option

[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.

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

The preferred option is Option B, as it has the highest weighted NPV result of all the technically and commercially feasible options considered as part of this need. Option B 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 for Option B is $8.94 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 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: 2025/2026
- Commissioning year annual benefit: $0.83 million
- Annualised cost: $0.53 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 B, 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 $8.94 million including an amount of $0.5 million to progress the project from DG1 to DG2.

Appendix A – Option Summaries[6]

Project Description	Line 16 Refurbishment		
Option Description	Option A - Refurbish components that meet primary condition criteria only		
Project Summary			
Option Rank	*2*	Investment Assessment Period	*25*
Asset Life	*35*	NPV Year	2021
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, $m)	12.23	Annualised CAPEX @ Central Benefit Scenario ($m)	Annualised Capex - Standard (Business Case) 0.49
NPV @ Lower Bound Scenario (PV, $m)	1.88	Network Safety Risk Reduction ($m)	Network Safety Risk Reduction 0.73
NPV @ Higher Bound Scenario (PV, $m)	32.27	ALARP	ALARP Compliant? Yes
NPV Weighted (PV, $m)	14.65	Optimal Timing	Optimal timing (Business Case) 2026
Cost (Central Scenario)			
Total Capex ($m)	8.16	Cost Capex (PV,$m)	6.48
Terminal Value ($m)	2.10	Terminal Value (PV,$m)	0.51
Risk (Central Scenario)	**Pre**	**Post**	**Benefit**
Reliability (PV,$m)	Reliability Risk (Pre) 0.00	Reliability Risk (Post) 0.00	Pre – Post 0.00
Financial (PV,$m)	Financial Risk (Pre) 1.06	Financial Risk (Post) 0.41	Pre – Post 0.65
Operational/Compliance (PV,$m)	Operational Risk (Pre) 0.00	Operational Risk (Post) 0.00	Pre – Post 0.00
Safety (PV,$m)	Safety Risk (Pre) 0.01	Safety Risk (Post) 0.00	Pre – Post 0.01
Environmental (PV,$m)	Environmental Risk (Pre) 23.69	Environmental Risk (Post) 6.22	Pre – Post 17.47
Reputational ($m)	Reputational Risk (Pre) 0.12	Reputational Risk (Post) 0.05	Pre – Post 0.07
Total Risk (PV,$m)	Total Risk (Pre) 24.88	Total Risk (Post) 6.68	Pre – Post 18.20
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 18.20

Commissioning year annual benefit ($k): 752.98

[6] Figures may not add due to rounding

Project Description	Line 16 Refurbishment		
Option Description	Option B - Refurbish all asset components identified as having condition issues		
Project Summary			
Option Rank	*1*	Investment Assessment Period	*25*
Asset Life	*35*	NPV Year	2021
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, $m)	14.04	Annualised CAPEX @ Central Benefit Scenario ($m)	Annualised Capex - Standard (Business Case) 0.53
NPV @ Lower Bound Scenario (PV, $m)	2.34	Network Safety Risk Reduction ($m)	Network Safety Risk Reduction 0.80
NPV @ Higher Bound Scenario (PV, $m)	36.75	ALARP	ALARP Compliant? Yes
NPV Weighted (PV, $m)	16.79	Optimal Timing	Optimal timing (Business Case) 2026
Cost (Central Scenario)			
Total Capex ($m)	8.94	Cost Capex (PV,$m)	7.10
Terminal Value ($m)	2.30	Terminal Value (PV,$m)	0.56
Risk (Central Scenario)	**Pre**	**Post**	**Benefit**
Reliability (PV,$m)	Reliability Risk (Pre) 0.00	Reliability Risk (Post) 0.00	Pre – Post 0.00
Financial (PV,$m)	Financial Risk (Pre) 1.06	Financial Risk (Post) 0.17	Pre – Post 0.89
Operational/Compliance (PV,$m)	Operational Risk (Pre) 0.00	Operational Risk (Post) 0.00	Pre – Post 0.00
Safety (PV,$m)	Safety Risk (Pre) 0.01	Safety Risk (Post) 0.00	Pre – Post 0.01
Environmental (PV,$m)	Environmental Risk (Pre) 23.69	Environmental Risk (Post) 4.11	Pre – Post 19.58
Reputational ($m)	Reputational Risk (Pre) 0.12	Reputational Risk (Post) 0.02	Pre – Post 0.10
Total Risk (PV,$m)	Total Risk (Pre) 24.88	Total Risk (Post) 4.30	Pre – Post 20.58
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 20.58

Commissioning year annual benefit ($k): 832.96

Appendix B Asset Condition

Asset Component Category	Cause	Effect	Consequence	No. of Structures with condition issues	
				Option A	Option B
Conductor Dampers	Dampers are drooping.	Damaged 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	1
Conductor Fittings	Corrosion of fittings.	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	39	48
Conductor Spacers	Corrosion of spacers.	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	10	22
Corona Rings	Corrosion of corona rings.	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	5
Earthwire	Deteriorated earthwire due to corrosion.	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	0	5
Earthwire Bonding	Poor connection and bird caging.	Possible transfer potential, earth current and voltage gradient issues	Safety incident resulting in potential injury or death	5	5

Asset Component Category	Cause	Effect	Consequence	No. of Structures with condition issues	
				Option A	Option B
Earthwire Dampers	Damaged/loose dampers. Ineffective vibration damping can lead to accelerated conductor fatigue.	Damaged earthwire	Line outage with potential network reliability impacts	1	1
Earthwire Fittings	Corrosion of fittings.	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	17	23
Foundations	Structure legs covered with soil. Failure of critical members 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	30	30
Groundline Steel	Rust on steel at groundline. Failure of critical members 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	17	17
Insulator	Porcelain insulators deteriorated at end of life. Insulators deteriorated due to corona effect.	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	127	153
Public Safety – Aerial Marker Balls	Faded.	Aircraft collision with conductor.	Safety incident resulting in potential injury or death Line outage with potential network reliability impacts	8	8
Public Safety – Climbing Deterrents	Deteriorated.	Unauthorised access	Safety incident resulting in potential injury or death Line outage with potential network reliability impacts	48	48

Asset Component Category	Cause	Effect	Consequence	No. of Structures with condition issues	
				Option A	Option B
Public Safety – Danger Signs	Deteriorated.	Unauthorised access	Safety incident resulting in potential injury or death Line outage with potential network reliability impacts	62	62
Public Safety – Structure ID Signs	Deteriorated.	Unauthorised access	Safety incident resulting in potential injury or death Line outage with potential network reliability impacts	39	39
Tower Base	Corrosion of tower members. Failure of critical members 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	3	4
Tower Body	Corrosion of tower members. Failure of critical members 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	1	2
Tower Fasteners	Corroded fasteners. 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	0	2