OPTIONS EVALUATION REPORT (OER)

Line 23 - Vales Pt - Munmorah - Refurb

OER- 000000001408 revision 1.0

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

Project reason: Capability - Asset Replacement for end of life condition
Project category: Prescribed - Replacement

Approvals

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Change history

Revision	Date	Amendment
0	07/10/2021	Initial Issues
1	14/11/2021	Minor Formatting

Executive summary

Line 23 is a 330kV, steel tower transmission line that connects Munmorah and Vales Point Substations, with a route length of 7km. Constructed in 1965, there are 24 structures on this single circuit line:

- 12 suspension towers
- 11 tension towers
- 1 wood pole suspension structure

The line is a key link in the Central Coast region, and its route traverses rural areas near the power stations and Lake Macquarie, and also crosses the Pacific Highway at Doyalson North.

Detailed analysis of asset condition information has identified that 23 of the 24 structures on line 23 have several condition issues on the line which require refurbishment to address asset health and maintain appropriate risk levels across the network.

In addition, all 12 suspension towers on Line 23 have been identified as having condition issues, based on the criteria set out in the latest Transmission Line Refurbishment Criteria document. There is also one non-standard wood pole structure designed to assist in any future line re-arrangements at the substation. This wood pole is proposed to be replaced to align with the standard design.

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 all suspension structures identified as having priority condition issues with concrete or steel poles Replace the wood pole structure with a concrete or steel pole Refurbish the line components on the tension structures that have been identified as having	6.60	0.49	7.09	59.35	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
	condition issues					
Option B	Replace all suspension structures with concrete or steel poles Replace the wood pole structure with a concrete or steel pole Refurbish the line components on the tension structures that have been identified as having condition issues	9.08	0.46	9.54	72.51	3
Option C	Replace all suspension structures with concrete or steel poles Replace the wood pole structure with a concrete or steel pole Replace all conductor and earthwire including associated components, hardware, fittings and insulators	11.38	0.86	12.24	125.54	1

The preferred option is Option C, as it has the highest weighted NPV result among all the technically and commercially feasible options considered in this business case. It is therefore recommended that Option C 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 23 is a 330kV, steel tower transmission line that connects Munmorah and Vales Point Substations, with a route length of 7km. Constructed in 1965, there are 24 structures on this single circuit line:

- 12 suspension towers
- 11 tension towers
- 1 wood pole suspension structure

The line is a key link in the Central Coast region, and its route traverses rural areas near the power stations and Lake Macquarie, and also crosses the Pacific Highway at Doyalson North.

Detailed analysis of asset condition information has identified that 23 of the 24 structures on Line 23 have condition issues which require rectification. Moreover, the remaining wood pole structure on Line 23 is a non-standard structure, and remediation is required in order to bring it in line with the latest standards.

All 12 suspension towers on Line 23 have been identified as having condition issues, based on the criteria set out in the latest Transmission Line Refurbishment Criteria document. Of these, eight of the towers have been identified has having priority condition issues, that is, the tower has one or more members that have been identified as having a condition issue with the worst possible rating. There is also one non-standard wood pole structure designed to assist in any future line re-arrangements at the substation. This wood pole is proposed to be replaced to align with the standard design.

No condition issues have been identified on the tension towers on Line 23. Condition issues, however, have been identified on other line components on these tension towers, where these have reached the end of their serviceable lives. Other issues on the line include, but are not limited to:

- A number of these structures have pre-1965 porcelain insulators, and laboratory testing has indicated deterioration of insulation performance. These insulators have a porcelain mixture formula that is no longer in use and the manufacturer has recommended their replacement. Further, given the coastal location of the line and proximity to coal generation, the insulator pins are also identified as being affected by corrosion. Failure of an insulator may result in a fallen conductor which was most recently experienced on another 132kV transmission line in 2018. The replacement of insulators has been included as part of a wider line refurbishment programme;
- Condition of conductor and earthwire fittings;
- Condition of conductor.
  Material testing of conductor samples from the locations identified above confirmed the following:
  - Aluminium and zinc oxides were contained within the white surface product, partial loss of the galvanising layer on the steel strands and reduction in cross section of the inner aluminium strands was observed when the samples were dismantled;
  - Loss of tensile strength at the locations where strands were out of lay; and
  - Migration of the conductor grease away from the inner at locations where surface deposits and discolouration was observed.

  In consideration of the refurbishment works proposed under this need, there may be advantages in performing the works under a combined package, and accordingly, options have been considered under this need to address the conductor condition issues.

The options have been developed in accordance with TransGrid's steel tower remediation strategy, where suspension towers in higher corrosion zones are replaced at end of life. Tension structures, being more costly and difficult to replace, are remediated prior to end of life and subject to ongoing tower refurbishment.

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 are based on the Transmission Line Refurbishment Criteria document.

2. Related needs/opportunities

- Need 000000001350 – Line 26 Refurbishment
- Need N2595 – Various Lines Conductor Condition
- Need N2609 – Main Grid Low Spans

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 remediation options have been considered which are discussed in Section 3.2.

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 – Replacement of all suspension structures on the line that have been identified as having priority condition issues with concrete or steel pole structures including the non-standard wood pole structure. Remediate line components on tension structures that have identified condition issues based on the latest Transmission Line Refurbishment Criteria document. [NOSA N1408, OFS N1408A]

The number of suspension structures to be replaced under this option are 9. It is estimated that this option would cost $7.09 million ± 25% in $2020-21. This project is expected to be completed within the 2024 – 2028 regulatory period and within 24 months following DG1.

Option B – Replacement of all suspension structures on the line with concrete or steel pole structures including the non-standard wood pole structure. Remediate line components on tension structures that have identified condition issues based on the latest Transmission Line Refurbishment Criteria document. [NOSA N1408, OFS N1408B]

The number of suspension structures to be replaced under this option are 13. It is estimated that this option would cost $9.54 million ± 25% in $2020-21. This project is expected to be completed within the 2024 – 2028 regulatory period and within 25 months following DG1.

Option C – Replacement of all suspension structures on the line with concrete or steel pole structures including the non-standard wood pole structure. All phase conductor and earthwires are also to be replaced. [NOSA N1408, OFS N1408C]

The number of suspension structures to be replaced under this option are 13 including 14km of earthwire and 7km of conductor. This option will address all the condition issues on the line and provide efficiency by single mobilisation. It is estimated that this option would cost $12.24 million ± 25% in $2020-21.

This project is expected to be completed within the 2024 – 2028 regulatory period and within 26 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 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	5.62	52.01	21.56	111.82	59.35	2
Option B	7.55	63.56	26.07	136.83	72.51	3
Option C	10.14	110.06	45.93	236.12	125.54	1

Based on the commercial analysis, Option C 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	2.15	0.42	Y
B	2.82	0.57	Y
C	3.20	0.73	Y

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

4.4 Preferred option

The preferred option is Option C, as it has the highest weighted NPV result of all the technically and commercially feasible options considered as part of this need. Option C 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 expected capital expenditure for the project is $11.4 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.

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[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.

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: $3.25 million
- Annualised cost: $0.73 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 C, 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 $11.4 million including an amount of $0.5 million to progress the project from DG1 to DG2.

Appendix A – Option Summaries

Project Description	Line 23 Refurbishment		
Option Description	Option A - Replace all suspension structures on the line that have been identified as having priority condition issues with concrete or steel pole structures Replace the non-standard wood pole structure with a concrete or steel pole structure Remediate line components on tension structures that have identified condition issues based on the latest Transmission Line Refurbishment Criteria document		
Project Summary			
Option Rank	*3*	Investment Assessment Period	*25*
Asset Life	*35*	NPV Year	2021
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, $m)	52.01	Annualised CAPEX @ Central Benefit Scenario ($m)	Annualised Capex - Standard (Business Case) 0.42
NPV @ Lower Bound Scenario (PV, $m)	21.56	Network Safety Risk Reduction ($m)	Network Safety Risk Reduction 2.15
NPV @ Higher Bound Scenario (PV, $m)	111.82	ALARP	ALARP Compliant? Yes
NPV Weighted (PV, $m)	59.35	Optimal Timing	Optimal timing (Business Case) 2026
Cost (Central Scenario)			
Total Capex ($m)	7.09	Cost Capex (PV,$m)	5.62
Terminal Value ($m)	2.03	Terminal Value (PV,$m)	0.52
Risk (Central Scenario)	**Pre**	**Post**	**Benefit**
Reliability (PV,$m)	Reliability Risk (Pre) 0.00	Reliability Risk (Post) 0.00	Pre – Post 0.00
Financial (PV,$m)	Financial Risk (Pre) 1.83	Financial Risk (Post) 1.01	Pre – Post 0.82
Operational/Compliance (PV,$m)	Operational Risk (Pre) 0.00	Operational Risk (Post) 0.00	Pre – Post 0.00
Safety (PV,$m)	Safety Risk (Pre) 0.27	Safety Risk (Post) 0.27	Pre – Post 0.00
Environmental (PV,$m)	Environmental Risk (Pre) 131.58	Environmental Risk (Post) 75.38	Pre – Post 56.20
Reputational ($m)	Reputational Risk (Pre) 0.21	Reputational Risk (Post) 0.12	Pre – Post 0.09
Total Risk (PV,$m)	Total Risk (Pre) 133.89	Total Risk (Post) 76.78	Pre – Post 57.11
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 57.11

Commissioning year annual benefit ($k): **2184.81**

Project Description	Line 23 Refurbishment		
Option Description	Option B - Replace all suspension structures on the line with concrete or steel pole structures Replace the non-standard wood pole structure with a concrete or steel pole structure Remediate line components on tension structures that have identified condition issues based on the latest Transmission Line Refurbishment Criteria document		
Project Summary			
Option Rank	*2*	Investment Assessment Period	*25*
Asset Life	*35*	NPV Year	2021
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, $m)	63.56	Annualised CAPEX @ Central Benefit Scenario ($m)	Annualised Capex - Standard (Business Case) 0.57
NPV @ Lower Bound Scenario (PV, $m)	26.07	Network Safety Risk Reduction ($m)	Network Safety Risk Reduction 2.82
NPV @ Higher Bound Scenario (PV, $m)	136.83	ALARP	ALARP Compliant? Yes
NPV Weighted (PV, $m)	72.51	Optimal Timing	Optimal timing (Business Case) 2026
Cost (Central Scenario)			
Direct Capex ($m)		Network and Corporate Overheads ($m)	
Total Capex ($m)	9.54	Cost Capex (PV,$m)	7.55
Terminal Value ($m)	2.45	Terminal Value (PV,$m)	0.63
Risk (Central Scenario)	**Pre**	**Post**	**Benefit**
Reliability (PV,$m)	Reliability Risk (Pre) 0.00	Reliability Risk (Post) 0.00	Pre – Post 0.00
Financial (PV,$m)	Financial Risk (Pre) 1.83	Financial Risk (Post) 0.84	Pre – Post 0.99
Operational/Compliance (PV,$m)	Operational Risk (Pre) 0.00	Operational Risk (Post) 0.00	Pre – Post 0.00
Safety (PV,$m)	Safety Risk (Pre) 0.27	Safety Risk (Post) 0.20	Pre – Post 0.07
Environmental (PV,$m)	Environmental Risk (Pre) 131.58	Environmental Risk (Post) 62.27	Pre – Post 69.31
Reputational ($m)	Reputational Risk (Pre) 0.21	Reputational Risk (Post) 0.10	Pre – Post 0.11
Total Risk (PV,$m)	Total Risk (Pre) 133.89	Total Risk (Post) 63.40	Pre – Post 70.49
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 70.49

Commissioning year annual benefit ($k): **2866.06**

Project Description	Line 23 Refurbishment		
Option Description	Option C - Replace all suspension structures on the line with concrete or steel pole structures Replace the non-standard wood pole structure with a concrete or steel pole structure Replace all phase conductor and earthwires with equivalent conductor Replace all phase conductor and earthwire components, hardware and fittings, including all insulators.		
Project Summary			
Option Rank	*1*	Investment Assessment Period	*25*
Asset Life	*35*	NPV Year	2021
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, $m)	110.06	Annualised CAPEX @ Central Benefit Scenario ($m)	Annualised Capex - Standard (Business Case) 0.73
NPV @ Lower Bound Scenario (PV, $m)	45.93	Network Safety Risk Reduction ($m)	Network Safety Risk Reduction 3.20
NPV @ Higher Bound Scenario (PV, $m)	236.12	ALARP	ALARP Compliant? Yes
NPV Weighted (PV, $m)	125.54	Optimal Timing	Optimal timing (Business Case) 2026
Cost (Central Scenario)			
Direct Capex ($m)		Network and Corporate Overheads ($m)	
Total Capex ($m)	12.24	Cost Capex (PV,$m)	10.14
Terminal Value ($m)	3.50	Terminal Value (PV,$m)	0.90
Risk (Central Scenario)	**Pre**	**Post**	**Benefit**
Reliability (PV,$m)	Reliability Risk (Pre) 0.00	Reliability Risk (Post) 0.00	Pre – Post 0.00
Financial (PV,$m)	Financial Risk (Pre) 1.83	Financial Risk (Post) 0.21	Pre – Post 1.62
Operational/Compliance (PV,$m)	Operational Risk (Pre) 0.00	Operational Risk (Post) 0.00	Pre – Post 0.00
Safety (PV,$m)	Safety Risk (Pre) 0.27	Safety Risk (Post) 0.02	Pre – Post 0.25
Environmental (PV,$m)	Environmental Risk (Pre) 131.58	Environmental Risk (Post) 14.34	Pre – Post 117.24
Reputational ($m)	Reputational Risk (Pre) 0.21	Reputational Risk (Post) 0.02	Pre – Post 0.19
Total Risk (PV,$m)	Total Risk (Pre) 133.89	Total Risk (Post) 14.59	Pre – Post 119.30
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 119.30

Commissioning year annual benefit ($k): **3253.16**

Appendix B Asset Condition

Asset Component Category	Cause	Effect	Consequence	No. of Structures All Options
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	11
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	11
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	1
Earthwire Bonding	Poor connection and bird caging.	Possible transfer potential, earth current and voltage gradient issues	Safety incident resulting in potential injury or death	4
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	10
Insulator	Porcelain insulators deteriorated and at end of life.	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	11