OPTIONS EVALUATION REPORT (OER)

TL Grillage Condition

OER- 000000001523 revision 1.0

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

Author	Edward Luk	Transmission Lines and Cables Analyst
Endorsed	Steve Stavropoulos	Transmission Lines and Cables Asset Manager
	Azil Khan	Investment Analysis Manager
Approved	Lance Wee	Manager/Asset Strategy
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Change history

Revision	Date	Amendment
0	28 October 2016	Initial issue
1	8 December 2016	Update to format

1. Need/opportunity

A considerable number of TransGrid's earliest transmission towers have been installed with grillage foundations where the footings are constructed from hot-dip galvanised steel members extending from the tower body above ground as a continuous member below ground, formed into a grill and direct buried.

This type of foundation did not use any concrete relying on the steel frame and the encapsulated soil as the foundation support for the tower superstructure. These towers are approximately 50 to 60 years old. Sacrificial anodes have been installed at various times on these towers to provide galvanic cathodic protection as a mitigation measure against footing corrosion. Grillage footings on 26 structures in the Dapto area were concrete encased in 1988. This was largely to address grillage steelwork corrosion issues.

A field assessment of the cathodic protection system and grillage condition on a sample of towers conducted in April 2016 has concluded that the installed sacrificial anodes are no longer providing sufficient protection against tower footing steelwork corrosion[1]. It is expected that these anodes have been consumed while providing sacrificial protection to the buried tower foundations and therefore have reached the end of their useful life. Furthermore, metal loss of the footings is expected in areas of aggressive soil. Buried wooden grillages also exist on 97K line, which are expected to be in poor condition.

2. Related Needs/opportunities

A number of transmission lines impacted by grillage condition issues also require remediation to extend their economic lives. The remediation works include abrasive blasting of the tower steelwork and application of paint, and the replacement of insulators, conductor/earthwire fittings and earthwires which have been affected by corrosion. These projects may have outage clashes and require coordination, and there may be an advantage in combining the work packages. A list of related projects is provided below.

- Need ID 1353 – 16 330kV Transmission Line Renewal
- Need ID 1352 – 17 330kV Transmission Line Renewal
- Need ID 1351 – 18 330kV Transmission Line Renewal
- Need ID 1333 – 21 TGH - SYN 330kV Line Renewal
- Need ID 1348 – 24 330kV Transmission Line Renewal
- Need ID 1411 – 2M 330kV Transmission Line Renewal
- Need ID 1341 – 8 MRN - DPT 330kV Line Renewal
- Need ID 1317 – 88 330kV Transmission Line Renewal
- Need ID 1347 – 90 330kV Transmission Line Renewal
- Need ID 1590 – TL Silmalec Fitting Condition Phase 2

3. Options

All dollar values in this document are expressed in un-escalated 2016/17 dollars.

[1] Refer to Grillage Foundations Investigation Report – on TransGrid's Project Document Governance System (PDGS).

Base Case

Corrosion of buried steelwork is coupled to the soil exposure classification, as described in AS2159, which determines the rate at which buried steel is expected to corrode in various ground and environmental conditions. Each structure with grillage foundations in TransGrid's network has been independently assessed by a Subject Matter Expert using the following inputs to estimate soil aggressiveness:

- Australian Soil Classification
- Acid Sulphate Soils
- Proximity of Estuary/Watercourse
- Salinity

Condition assessments were carried out on three grillage footings on three separate structures, all located in areas with a mild soil aggressiveness ranking, by excavating the grillage, inspecting for corrosion and backfilling with concrete. Significant steel loss on the major grillage member was identified on one footing, despite the mild soil aggressiveness ranking. It is suspected that this was due to the fact that no sacrificial anode had been installed on the structure. The other two footings investigated had sacrificial anodes in the past and exhibited only minor rusting consistent with their soil aggressiveness classification. Note that metal loss in excess of 1mm is considered to be significant and compromises the integrity of the member.

Based on the above classifications, and the results of the April 2016 field assessment, it is expected that the currently installed sacrificial anodes have depleted and are no longer providing protection against corrosion of buried steelwork. Across the network, a total of 2,361 towers are affected. Further detail can be found in Need/Opportunity Statement (NOS) NS 1523.

Under a Base Case 'run-to-fail' option, the associated risk cost from the issues identified in Table 1 is $15.84m per year. A breakdown of the Base Case risk cost by category is shown in Table 1.

Table 1 – Base Case risk cost by category ($ million)

Risk Category	Annual Risk Cost
Reliability (System)	0.46
Financial	1.42
Operational/Compliance	0
People (Safety)	1.66
Environment	12.27
Reputation	0.03
Total	**15.84**

It can be seen from Table 1 that the category with the highest risk cost is 'environment', mainly due to the considerable consequences of a bushfire event resulting from structure failure. Other significant contributors to the overall risk cost are the 'people (safety)' and 'financial' categories.

Option A — Anode Replacement and Foundation Concrete Encasement [OFR 1523A, OFS 1523A]

This option involves the replacement of sacrificial anodes which have reached end of life for structures which have been classified as located in non-aggressive soils. The new anodes are expected to provide 10 to 15 years of protection against further corrosion of the buried steelwork. Structures which have been classified as located in areas of aggressive soils are to have the grillage foundation dug out, and the footing steel work repaired, or reinstated where required, then concrete encased.

Of the 2,361 total towers affected across the network, 2,048 tower locations soil profiles have been classified as non-aggressive and 313 classified as aggressive. Further details of the scope in this option can be found in Options Feasibility Request (OFR) OFR 1523A.

It is estimated that the capital expenditure associated with the refurbishment outlined in this option is $62.2m ±25%. Details can be found in Section 6 of Option Feasibility Study (OFS) OFS 1523A.

Following the anode replacement and foundation concrete encasement of all affected structures under this option, the risk cost associated with the remediated foundations and new anodes is $6.40m per annum. A breakdown of the Option A risk cost by category is shown in Table 2.

Table 2 – Option A risk cost by category ($ million)

Risk Category	Annual Risk Cost
Reliability (System)	0.28
Financial	0.53
Operational/Compliance	0
People (Safety)	0.68
Environment	4.91
Reputation	0.01
Total	**6.40**

The total projected risk reduction as a result of implementing Option A is $9.44m per annum. It can be seen from Table 2 that the largest component of the risk reduction is in the 'environment' category, due to the reduced likelihood of structure failure and conductor drop events.

Option B — Anode Replacement and Structure Replacement [OFR 1523B, OFS 1523B]

This option involves the replacement of sacrificial anodes which have reached end of life for structures which have been classified as located in non-aggressive soils, as with Option A. Structures which have been classified as located in areas of aggressive soils are to be replaced.

The same classification to determine the soil profiles of the 2,361 affected structures has been applied in Option B also. Further details of the scope in this option can be found in OFR 1523B.

It is estimated that the capital expenditure associated with the refurbishment outlined in this option is $100.60m ±25%. Details can be found in Section 6 of OFS 1523B.

As with Option A, the risk cost associated with the new replaced structures and anodes is $6.40m per annum, with the same projected risk reduction of $9.44m per annum. The breakdown of the risk cost by category is expected to be the same as that shown in Table 2, with the largest component of the risk reduction expected in the 'environment' category.

All options detailed in Section 3 above are considered to be technically feasible[2].

[2] An option is technically feasible if TransGrid reasonably considers that there is a high likelihood that the option, if developed, will provide the relevant service while complying with all relevant laws.

4. Evaluation

4.1 Commercial evaluation

The commercial evaluation of the technically feasible options is set out in Table 3. Details of the Net Present Value (NPV) calculations for Options A and B are provided in Attachment 1.

Table 3 — Commercial evaluation ($ million)

Option	Description	Total capex	Annual opex	Annual post project risk cost	Economic NPV @10%	Financial NPV @10%	Rank
Base Case	Run-to-fail	N/A	N/A	15.84	N/A	N/A	3
A	Anode Replacement and Foundation Concrete Encasement	62.20	-	6.40	4.41	3.52	1
B	Anode Replacement and Structure Replacement	100.60	-	6.40	(15.91)	(16.84)	2

The commercial evaluation is based on:

- A 10% discount rate
- A life of the investment of 15 years and a corresponding residual/terminal value for CAPEX associated with anode replacement under both options
- A life of the investment of 20 years and a corresponding residual/terminal value for CAPEX associated with foundation concrete encasement under Option A
- A life of the investment of 50 years and a corresponding residual/terminal value for CAPEX associated with structure replacement under Option B

Discount rate sensitivities based on TransGrid's current AER-determined pre-tax real regulatory Weighted Average Cost of Capital (WACC) of 6.75% and 13% appear in Table 4.

Table 4 — Discount rate sensitivities ($ million)

Option	Description	Economic NPV @13%	Economic NPV @6.75%
A	Anode Replacement and Foundation Concrete Encasement	(4.65)	22.28
B	Anode Replacement and Structure Replacement	(24.89)	5.36

4.2 SFAIRP/ALARP evaluation

In the context of the Network Asset Risk Assessment Methodology, the SFAIRP (So Far As Is Reasonably Practicable)/ALARP (As Low As Reasonably Practical) principle is applicable to the following Key Hazardous Events:

- Structure failure
- Conductor / earthwire drop

Options to reduce the network safety risk as per the risk treatment hierarchy have been considered in other lifecycle stages of the asset, and it has been determined that no reasonably practicable options exist to reduce the risk further than those capital investment options listed in Table 5.

Evaluation of the proposed options has been completed against the SFAIRP (So Far As Is Reasonably Practicable)/ALARP (As Low As Reasonably Practical) obligation, as required by the Electricity Supply (Safety and Network Management) Regulation 2014 and the Work Health and Safety Act 2011. The Key Hazardous Events and the disproportionality multipliers considered in the evaluation are as follows:

- Structure failure – 6 times the environment (bushfire) risk, 6 times the safety risk and 10% of the reliability risk (applicable to safety)
- Conductor / earthwire drop – 6 times the environment (bushfire) risk, 6 times the safety risk and 10% of the reliability risk (applicable to safety)

Table 5 – Feasible options ($ thousand)

Option	Description	CAPEX	Expected Life	Annualised CAPEX
Base	Run-to-fail	N/A	N/A	N/A
A	Anode Replacement and Foundation Concrete Encasement	62,200	15 or 20 years	3,427
B	Anode Replacement and Structure Replacement	100,600	15 or 20 years	2.899

Table 6 – Annual risk calculations ($ thousand)

Option	Annual Residual Risk			Annual Risk Savings		
	Safety Risk	Reliability Risk	Bushfire Risk	Safety Risk	Reliability Risk	Bushfire Risk
Base	1,661	460	12,270	N/A	N/A	N/A
A	675	276	4,905	985	184	7,365
B	675	276	4,905	985	184	7,365

Table 7 – Reasonably practicable test ($ thousand)

Option	Network Safety Risk Reduction[3]	Annualised CAPEX	Reasonably practicable[4]?
A	50,119	3,427	Yes
B	50,119	2,899	Yes

From the above evaluation, it is considered that both Options A and B are reasonably practicable.

[3] The Network Safety Risk Reduction is calculated as 6 x Bushfire Risk Reduction + 6 x Safety Risk Reduction + 0.1 x Reliability Risk Reduction

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

4.3 Preferred option

From the SFAIRP/ALARP evaluation, it is considered that both Options A and B are reasonably practicable and both options provide a similar level of network safety risk reduction. In order to satisfy the organisation's SFAIRP/ALARP obligations, one of these options is required to be undertaken. Only Option A is considered to be commercially viable (as per the commercial evaluation).

For the aforementioned reasons, it is proposed that Option A be scoped in further detail.

Capital and operating expenditure

The estimated capital expenditure associated with Option A is $62.2m ±25%. The estimated capital expenditure associated with Option B is $100.6m ±25%. Under both options, the vast majority of this expenditure is proposed to be carried out in 2022-2023.

Should the works under either Option A or Option B not occur by the Need date, an increase in future corrective maintenance and subsequent operating expenditure is expected as the condition of the grillage foundations deteriorates further.

Regulatory Investment Test

No Regulatory Investment Test for Transmission (RIT-T) analysis is required for both Options A and B as the works are condition based.

5. Recommendation

From the above SFAIRP/ALARP evaluation in accordance with the regulatory requirements, and the commercial and technical evaluation of the available options, it is recommended that detailed scoping for the anode replacement and foundation concrete encasement of affected grillage structures, as outlined under Option A, is undertaken.

Option A NPV calculation

Project_Option Name	Grillage Foundations Option A

1. Financial Evaluation (excludes VCR benefits)

NPV @ standard discount rate	10.00%	$3.52m	*NPV / Capital (Ratio)*	*0.06*
NPV @ upper bound rate	13.00%	-$5.27m	*Pay Back Period (Yrs)*	*0.11 Yrs*
NPV @ lower bound rate (WACC)	6.75%	$20.93m	*IRR%*	*11.00%*

2. Economic Evaluation (includes VCR benefits but excludes tax benefits from non-cash transactions, ENS penalty and overall tax cost)

NPV @ standard discount rate	10.00%	$4.41m	*NPV / Capital (Ratio)*	*-0.73*
NPV @ upper bound rate	13.00%	-$4.65m	*Pay Back Period (Yrs)*	*6.59 Yrs*
NPV @ lower bound rate (WACC)	6.75%	$22.28m	*IRR%*	*11.25%*

Benefits

Risk cost	As Is	To Be	Benefit
Systems (reliability)	*$0.46m*	*$0.28m*	*$0.18m*
Financial	*$1.42m*	*$0.53m*	*$0.89m*
Operational/compliance	*$0.00m*	*$0.00m*	*$0.00m*
People (safety)	*$1.66m*	*$0.68m*	*$0.99m*
Environment	*$12.27m*	*$4.90m*	*$7.37m*
Reputation	*$0.03m*	*$0.01m*	*$0.02m*
Total Risk benefits	$15.84m	$6.40m	$9.44m
Cost savings and other benefits			$0.00m
Total Benefits			$9.44m

VCR Benefit	*$0.18m*
ENS Penalty	*$0.00m*
All other risk benefits	*$9.26m*
Total Risk benefits	$9.44m
Benefits in the financial NPV*	$9.26m
**excludes VCR benefits*	
Benefits in the economic NPV**	$9.44m
***excludes ENS penalty*	

Other Financial Drivers

Incremental opex cost pa (no depreciation)	$0.00m	Write-off cost	$0.00m
Capital - initial $m	-$62.20m	Major Asset Life (Yrs)	20.00 Yrs
Residual Value - initial investment	$0.00m	Re-investment capital	$0.00m
Capitalisation period	6.00 Yrs	Start of the re-investment period	0.00 Yrs

Option B NPV calculation

Project_Option Name	Grillage Foundations Option B

1. Financial Evaluation (excludes VCR benefits)				
NPV @ standard discount rate	10.00%	-$16.84m	*NPV / Capital (Ratio)*	*-0.17*
NPV @ upper bound rate	13.00%	-$25.53m	*Pay Back Period (Yrs)*	*0.07 Yrs*
NPV @ lower bound rate (WACC)	6.75%	$3.91m	*IRR%*	*7.20%*

2. Economic Evaluation (includes VCR benefits but excludes tax benefits from non-cash transactions, ENS penalty and overall tax cost)				
NPV @ standard discount rate	10.00%	-$15.91m	*NPV / Capital (Ratio)*	*2.65*
NPV @ upper bound rate	13.00%	-$24.89m	*Pay Back Period (Yrs)*	*10.66 Yrs*
NPV @ lower bound rate (WACC)	6.75%	$5.36m	*IRR%*	*7.36%*

Benefits					
Risk cost	As Is	To Be	Benefit	*VCR Benefit*	*$0.18m*
Systems (reliability)	*$0.46m*	*$0.28m*	*$0.18m*	*ENS Penalty*	*$0.00m*
Financial	*$1.42m*	*$0.53m*	*$0.89m*	*All other risk benefits*	*$9.26m*
Operational/compliance	*$0.00m*	*$0.00m*	*$0.00m*	Total Risk benefits	$9.44m
People (safety)	*$1.66m*	*$0.68m*	*$0.99m*		
Environment	*$12.27m*	*$4.90m*	*$7.37m*	Benefits in the financial NPV*	$9.26m
Reputation	*$0.03m*	*$0.01m*	*$0.02m*	*excludes VCR benefits	
Total Risk benefits	$15.84m	$6.40m	$9.44m		
Cost savings and other benefits			$0.00m	Benefits in the economic NPV**	$9.44m
Total Benefits			$9.44m	**excludes ENS penalty	

Other Financial Drivers			
Incremental opex cost pa (no depreciation)	$0.00m	Write-off cost	$0.00m
Capital - initial $m	-$100.60m	Major Asset Life (Yrs)	50.00 Yrs
Residual Value - initial investment	$42.43m	Re-investment capital	$0.00m
Capitalisation period	6.00 Yrs	Start of the re-investment period	0.00 Yrs