OPTIONS EVALUATION REPORT (OER)

Line 959/92Z 330kV Transmission Line Renewal

OER 000000001346 revision 1.0

Ellipse project no.: P0007959
TRIM file: [TRIM No]

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

Approvals

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Date submitted for approval	2 December 2016	

Change history

Revision	Date	Amendment
0	20 June 2016	Initial issue
1	28 October 2016	Option B Added. Revised for Updated Risk Cost and New SFAIRP/ALARP Methodology
2	2 December 2016	Update to format

1. Need/opportunity

Line 959/92Z is a double circuit 132kV transmission line constructed on modified single circuit 330kV steel towers between Sydney North and Sydney East 330kV substations, with a route length of 23.7km. Line 92Z has a tee to Ausgrid's Mt Colah 132kV Switching Station. The transmission line links generation to the Northern Sydney metropolitan area. This transmission line was constructed in 1965 and consists of 62 structures. The majority of this line passes through National Park with sections in urban areas of Sydney.

Network Asset Condition Assessment (NACA) NACA 1346 performed in January 2016 has identified a number of corrosion related issues with Transmission Line 959/92Z which require rectification in the short – medium term (within the 2018-2023 Regulatory Control Period) to ensure that asset risk levels remain within an acceptable level in the longer term.

In addition to the condition issues identified, the modified single circuit 330kV transmission line structures used on Line 959/92Z are known to contain particular deficiencies due to the design philosophies used at the time of its installation. Although the structures were designed to the standards at that time, following a number of structure failures in extreme wind events, investigations found that the towers were designed to a lower set of criteria with inadequacies in the governing load combinations when compared to more recent design philosophies and standards. A program to strengthen structures with utilisation over 85% at road crossings and public areas has occurred; however, not all structures have been strengthened. Due to this, it is considered essential that condition issues on these towers be addressed so that their capacity, and as a consequence, the security of supply, are not further reduced.

2. Related Needs/opportunities

No related Needs/opportunities have been identified.

3. Options

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

Base Case

Network Asset Condition Assessment (NACA) NACA 1346 has identified existing issues with the line which require rectification. A summary of these can be found in Need/Opportunity Statement (NOS) NS 1346.

Under a Base Case 'run-to-fail' option, the associated risk cost from the issues identified in Table 1 is $0.38m per annum. 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
Financial	0.02
Operational/Compliance	0
People (Safety)	0.18
Environment	0.17
Reputation	0

Risk Category	Annual Risk Cost
Total	**0.38**

It can be seen from Table 1 that the categories with the highest risk costs are 'people (safety)' and 'environment', mainly due to the significant consequences of a bushfire event resulting from conductor drop and risks associated with compromised earthing.

The risk cost per kilometre of line is $0.016m per annum.

Option A — Line Refurbishment [OFR 1346A, OFS 1346A]

This option involves the refurbishment of Line 959/92Z preventing corrosion to tower steelwork which could lead to asset failure and replacement of components which have reached end of life due to corrosion. The scope of this option is summarised in Table 2.

Table 2 – Transmission Line 959/92Z Option A scope of works

Issue	Qty	Remediation
Buried concrete foundations	3 towers	> Assume 2 towers – dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint, establish drainage channel where feasible or concrete encase legs to prevent future corrosion > Assume 1 tower – dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint, concrete scabbling and installation of double plate, establish drainage channel where feasible or concrete encase legs to prevent future corrosion
Corrosion of earth straps	3 towers	> Replacement of earth straps in line with current standard
Corrosion of tower steel members	5 towers	> Replacement of corroded minor members > Assume 5% of members per tower
Corrosion of fasteners	11 towers	> Replacement of fasteners > Assume 10% of fasteners per tower
Corrosion of conductor attachment fittings	39 fittings	> Replacement of hot and cold end fittings
Corrosion of earthwire attachment fittings	32 fittings	> Replacement of earthwire fittings
Corrosion of earthwire	24 km of earthwire (12km of route length)	> Like for like replacement of SC/GZ earthwire
Damaged conductor vibration dampers	10% of line	> Replacement of Stockbridge vibration dampers

Issue	Qty	Remediation
	144 dampers	> Assumed 4 vibration dampers per full tension span per phase

It is estimated that the capital expenditure associated with the refurbishment outlined in this option is $1.44m ±25%. Details can be found in Section 6 of Option Feasibility Study (OFS) OFS 1346A.

Following the refurbishment under this option, the risk cost associated with the remediated line is $0.23m per annum. A breakdown of the Option A risk cost by category is shown in Table 3.

Table 3 – Option A Risk cost by category (million $)

Risk Category	Annual Risk Cost
Reliability (System)	0
Financial	0.01
Operational/Compliance	0
People (Safety)	0.07
Environment	0.15
Reputation	0
Total	**0.23**

The total projected risk reduction as a result of implementing Option A is $0.15m per annum. It can be seen from Table 3 that main components in risk cost reductions would come from the 'environment' and 'people (safety)' categories, with the associated reduction in the likelihood of conductor drop failure and faulty earthing risks.

The total projected risk reduction per kilometre of line is $0.006m per annum.

Option B — Line Refurbishment with OPGW Retrofitting [OFR 1346B, OFS 1346B]

As with Option A, this option involves the refurbishment of Line 17 by the replacement of components which have reached end of life due to corrosion. However, given the significant proportion of earthwire identified with corrosion related issues, this option proposes to replace one earthwire with OPGW Type A between Sydney North and Sydney East. Sections of the other earthwire with identified corrosion related issues will be replaced like for like with SC/GZ earthwire.

With the proposed installation of OPGW, the requisite secondary systems modifications and fibre termination works has been included. The scope of this option is summarised in Table 4.

Table 4 – Transmission Line 959/92Z Option B scope of works

Issue	Qty	Remediation
Buried concrete foundations	3 towers	> Assume 2 towers – dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint, establish drainage channel where feasible or concrete encase legs to prevent future corrosion

Issue	Qty	Remediation
		> Assume 1 tower – dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint, concrete scabbling and installation of double plate, establish drainage channel where feasible or concrete encase legs to prevent future corrosion
Corrosion of earth straps	3 towers	> Replacement of earth straps in line with current standard
Corrosion of tower steel members	5 towers	> Replacement of corroded minor members > Assume 5% of members per tower
Corrosion of fasteners	11 towers	> Replacement of fasteners > Assume 10% of fasteners per tower
Corrosion of conductor attachment fittings	39 fittings	> Replacement of hot and cold end fittings
Corrosion of earthwire attachment fittings	32 fittings	> Replacement of earthwire fittings
Corrosion of earthwire	12 km of earthwire	> Like for like replacement of SC/GZ earthwire
Corrosion of earthwire	24 km of earthwire	> Replacement with OPGW Type A
Damaged conductor vibration dampers	10% of line 144 dampers	> Replacement of Stockbridge vibration dampers > Assumed 4 vibration dampers per full tension span per phase
Sydney North Substation works		> Termination of OPGW into non-metallic conductor at substation gantry. Non-metallic conductor run to cable trench system in buried conduit and then run in conduit to the communications room to be terminated onto new optical distribution frame.
Sydney East Substation works		> Termination of OPGW into non-metallic conductor at substation gantry. Non-metallic conductor run to cable trench system in buried conduit and then run in conduit to the communications room to be terminated onto new optical distribution frame.

It is estimated that the capital expenditure associated with the refurbishment outlined in this option is $2.51m ±25%. Details can be found in Section 6 of OFS 1346B.

Following the refurbishment and OPGW replacement works under this option, it is expected that the risk cost associated with the retrofitted line will be the same as that under Option A at $0.23 per annum. The total projected

risk reduction as a result of implementing Option B is $0.15m per annum, a total reduction per kilometre of line of $0.006m per annum.

The replacement of an earthwire with OPGW will improve the communications system by bringing fibre to Sydney East, allowing for duplicated paths between Sydney North and Sydney East (one fibre and one Ausgrid fibre). The additional benefits of this option arise from reduced OPEX through maintenance and licensing saving, with an expected quantified benefit of $0.03m per annum and an additional efficiency savings benefit specific to the Sydney East site of $0.02m per annum. It is noted that other organisation benefits have not been taken into account.

All of the options mentioned in Section 3 are considered to be technically feasible[1].

4. Evaluation

4.1 Commercial evaluation

The commercial evaluation of the technically feasible options is set out in Table 5. Details of the Net Present Value (NPV) calculations for both Options A and B are provided in Attachment 1.

Table 5 — 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	0.38	N/A	N/A	3
A	Line refurbishment	1.44	-	0.23	(0.17)	(0.17)	2
B	Line refurbishment with OPGW Retrofitting	2.51	(0.05)	0.23	(0.12)	(0.12)	1

The commercial evaluation is based on:

- A 10% discount rate
- A life of the investment of 20 years and a corresponding residual/terminal value
- An allowance for CAPEX avoidance for the required end of life secondary systems and earthwire 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 6.

Table 6 — Discount rate sensitivities ($ million)

Option	Description	Economic NPV @13%	Economic NPV @6.75%
A	Line refurbishment	(0.33)	0.13

[1] 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.

Option	Description	Economic NPV @13%	Economic NPV @6.75%
B	Line refurbishment with OPGW Retrofitting	(0.38)	0.35

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
- Uncontrolled discharge or contact with electricity (faulty earthing)

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 7.

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)
- Uncontrolled discharge or contact with electricity (faulty earthing) – 6 times the environment (bushfire) risk, 6 times the safety risk and 10% of the reliability risk (applicable to safety)

Table 7 – Feasible options ($ thousand)

Option	Description	CAPEX	Expected Life	Annualised CAPEX
Base	Run-to-fail	N/A	N/A	N/A
A	Line refurbishment	1,440	20 years	72
B	Line refurbishment with OPGW Retrofitting	2,510	20 years	126

Table 8 – Annual risk calculations ($ thousand)

Option	Annual Residual Risk			Annual Risk Savings		
	Safety Risk	Reliability Risk	Bushfire Risk	Safety Risk	Reliability Risk	Bushfire Risk
Base	184	0	171	N/A	N/A	N/A
A	68	0	147	116	0	24
B	68	0	147	116	0	24

Table 9 – Reasonably practicable test ($ thousand)

Option	Network Safety Risk Reduction[2]	Annualised CAPEX	Reasonably practicable[3]?
A	842	72	Yes
B	842	126	Yes

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

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 the same 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. Neither Option A nor Option B is commercially viable at a discount rate of 10%. However both options return positive NPV at discount rate of 6.75% (see sensitivities in Table 6 above). Option B at 6.75% discount rate provides higher return than Option A.

Option B, due to its newer technology, is expected to provide further future efficiency savings which have not been quantified at this stage. In addition, the improvement to the communications system with the addition of fibre will provide greater visibility and interrogation of assets at the site and is foreseen to improve asset management and maintenance practices. It also meets the telecommunications development strategy of retiring the microwave network and associated assets by 2028.

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

Capital and operating expenditure

The estimated capital expenditure associated with the refurbishment outlined under Option A is $1.44m ±25%. Under Option B, the capital expenditure estimate for the refurbishment and OPGW retrofitting is $2.51m ±25%, with an expected quantified OPEX saving of $0.05m per annum. In both instances, the vast majority of the capital expenditure is proposed to be carried out in 2018-2019.

It is expected that should works not occur by the Need date, under both Options A and B, an increase in corrective maintenance and subsequent operating expenditure is expected.

Regulatory Investment Test

No Regulatory Investment Test for Transmission (RIT-T) analysis is required for Option A as the works are condition based. Under Option B, no RIT-T analysis is required as the estimated CAPEX comes under the $5m threshold.

5. Recommendation

Under the SFAIRP/ALARP evaluation, both Options A and B are considered to be reasonably practicable and are required, at a minimum, to be undertaken in order to satisfy the organisation's SFAIRP/ALARP obligations. Neither option is considered to be commercially viable at a discount rate of 10%, but both return positive NPV at discount rate of 6.75%. As Option B is foreseen to significantly improve asset management and maintenance practices, it is recommended that detailed scoping for the refurbishment of Line 959/92Z including OPGW retrofitting as outlined under Option B is undertaken. Furthermore, deploying Option B provides a technically superior option that will meet TransGrid's increasing telecommunications requirements into the foreseeable future and provide a link in a

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

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

robust optical fibre backbone that will be established (in accordance with the Telecommunications Infrastructure Renewal and Maintenance Strategy) to facilitate the withdrawal of microwave infrastructure from the network.

Attachment 1 – Commercial evaluation report

Option A NPV calculation

Project_Option Name	Line 959/92Z Refurbishment

1. Financial Evaluation (excludes VCR benefits)

NPV @ standard discount rate	10.00%	-$0.17m	*NPV / Capital (Ratio)*	*-0.12*
NPV @ upper bound rate	13.00%	-$0.33m	*Pay Back Period (Yrs)*	*0.08 Yrs*
NPV @ lower bound rate (WACC)	6.75%	$0.13m	*IRR%*	*7.98%*

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%	-$0.16m	*NPV / Capital (Ratio)*	*0.05*
NPV @ upper bound rate	13.00%	-$0.33m	*Pay Back Period (Yrs)*	*9.85 Yrs*
NPV @ lower bound rate (WACC)	6.75%	$0.13m	*IRR%*	*7.99%*

Benefits

Risk cost	As Is	To Be	Benefit
Systems (reliability)	*$0.00m*	*$0.00m*	*$0.00m*
Financial	*$0.02m*	*$0.01m*	*$0.00m*
Operational/compliance	*$0.00m*	*$0.00m*	*$0.00m*
People (safety)	*$0.18m*	*$0.07m*	*$0.12m*
Environment	*$0.17m*	*$0.15m*	*$0.02m*
Reputation	*$0.00m*	*$0.00m*	*$0.00m*
Total Risk benefits	$0.37m	$0.23m	$0.15m
Cost savings and other benefits			$0.00m
Total Benefits			$0.15m

VCR Benefit	*$0.00m*
ENS Penalty	*$0.00m*
All other risk benefits	*$0.15m*
Total Risk benefits	$0.15m
Benefits in the financial NPV* *excludes VCR benefits	$0.15m
Benefits in the economic NPV** **excludes ENS penalty	$0.15m

Other Financial Drivers

Incremental opex cost pa (no depreciation)	$0.00m	Write-off cost	$0.00m
Capital - initial $m	-$1.44m	Major Asset Life (Yrs)	20.00 Yrs
Residual Value - initial investment	$0.07m	Re-investment capital	$0.00m
Capitalisation period	3.00 Yrs	Start of the re-investment period	0.00 Yrs

Option B NPV calculation

Project_Option Name	Line 959/92Z Refurbishment with OPGW Retrofit

1. Financial Evaluation (excludes VCR benefits)				
NPV @ standard discount rate	10.00%	-$0.12m	*NPV / Capital (Ratio)*	*-0.06*
NPV @ upper bound rate	13.00%	-$0.39m	*Pay Back Period (Yrs)*	*0.09 Yrs*
NPV @ lower bound rate (WACC)	6.75%	$0.35m	*IRR%*	*9.02%*

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%	-$0.12m	*NPV / Capital (Ratio)*	*0.04*
NPV @ upper bound rate	13.00%	-$0.38m	*Pay Back Period (Yrs)*	*7.93 Yrs*
NPV @ lower bound rate (WACC)	6.75%	$0.35m	*IRR%*	*9.03%*

Benefits					
Risk cost	As Is	To Be	Benefit	*VCR Benefit*	*$0.00m*
Systems (reliability)	*$0.00m*	*$0.00m*	*$0.00m*	*ENS Penalty*	*$0.00m*
Financial	*$0.02m*	*$0.01m*	*$0.00m*	*All other risk benefits*	*$0.15m*
Operational/compliance	*$0.00m*	*$0.00m*	*$0.00m*	Total Risk benefits	$0.15m
People (safety)	*$0.18m*	*$0.07m*	*$0.12m*		
Environment	*$0.17m*	*$0.15m*	*$0.02m*	Benefits in the financial NPV*	$0.20m
Reputation	*$0.00m*	*$0.00m*	*$0.00m*	**excludes VCR benefits*	
Total Risk benefits	$0.37m	$0.23m	$0.15m		
Cost savings and other benefits			$0.05m	Benefits in the economic NPV**	$0.20m
Total Benefits			$0.20m	***excludes ENS penalty*	

Other Financial Drivers			
Incremental opex cost pa (no depreciation)	$0.00m	Write-off cost	$0.00m
Capital - initial $m	-$2.08m	Major Asset Life (Yrs)	20.00 Yrs
Residual Value - initial investment	$0.00m	Re-investment capital	$0.67m
Capitalisation period	3.00 Yrs	Start of the re-investment period	2021-22