OPTIONS EVALUATION REPORT (OER)

Line 86 330kV Transmission Line Renewal

OER- 000000001555 revision 2.0

Ellipse project no.: P0009029
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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	27 October 2016	Initial issue
1	9 December 2016	Update to format
2	15 December 2016	Minor editorial changes

1. Need/opportunity

Transmission Line 86 is a 330kV transmission line which runs between Tamworth and Armidale. The line is 111km in length and comprises 416 structures. The line was constructed in 1982 using mostly composite wood pole structures – a short section of the line outside Tamworth is constructed on steel towers. Wood rot beneath the composite pole joint sleeve is prevalent throughout the line, and 22 structures have been replaced with concrete poles since 2011 due to condition related issues.

Line 86 is the only 330kV line in TransGrid's network that was not constructed with steel towers. Due to its composite wood pole construction, Line 86 was designed and constructed to a lower set of criteria more comparable to other TransGrid wood pole lines than the criteria used on the 330kV steel towers and is considered to be less secure. As a result, its construction utilises shorter span lengths and a smaller lighter weight twin Lime ACSR conductor (compared to typical conductors used on TransGrid 330kV lines), which in turn reduces the rating of the line. Its original design temperature was 85°C but has since been upgraded to a design temperature of 100°C, its maximum feasible capability and has no further capacity improvement available.

Current proposals indicate that there is 553MW of new renewable generation already committed in the northern NSW New England area (Moree Solar Farm, Sapphire Wind Farm and White Rock Wind Farm), with a potential of growing to over 1000MW. In addition, the proposed retirement of Liddell in 2022/2023 increases the likelihood of power flows in the direction from Queensland to NSW, placing a greater importance on securing supply to NSW.

The changing generation scenario sees a significant quantity of generation shifting from the Hunter Region to northern NSW in the form of new renewable generation. This places an increasing importance on the security both transmission lines between Armidale and Tamworth (Lines 85 and 86). Both line routes are located within a similar proximity geographically, and it is not inconceivable that one high wind event could adversely impact both lines. There has been one structure failure incident on Line 86 since its construction due to extreme weather conditions. In the event where both Lines 85 and 86 were out of service, Queensland and northern NSW (north of Tamworth) will operate as an island separated from mainland NEM.

Further, an increase in new northern NSW renewable generation, and in the circumstance where power is imported to NSW from Queensland, there is a higher likelihood of both Lines 85 and 86 being constrained. There is a proposal to upgrade Line 85 from a design temperature of 85°C to 100°C, which would leave Line 86 being the constraint in the event of trip of Line 85. With this likely future constraint, an opportunity exists to improve the rating of the line. An upgrade to the transmission network between Armidale and Tamworth would enable access to new wind/solar generation from northern NSW in the event of allowable market conditions and provide better security of supply to NSW.

2. Related Needs/opportunities

> Need ID 1529 – Reinforcement of Northern Network

3. Options

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

Base Case

A defect analysis conducted on Line 86 has consistently identified issues with wood decay beneath the composite pole joint sleeve. In 2011, 22 structures were identified to be defective and required replacement due to condition related issues, with another 14 identified as defective requiring remediation. Further, recent experience from Field Services has indicated an emerging issue with the crossarm bracing, with corrosion of the thimble leading to failures of the brace wiring and possible subsequent failure of the crossarm. A summary of these can be found in Need/Opportunity Statement (NOS) NS 1555.

Under a Base Case 'run-to-fail' option, the associated risk cost from the issues identified in Table 1 is $1.92m 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)	0.66
Financial	0.05
Operational/Compliance	0
People (Safety)	0.11
Environment	1.09
Reputation	0
Total	**1.92**

It can be seen from Table 1 that the category with the highest risk cost is 'environment', mainly due to the significant consequences of a bushfire event resulting from conductor drop. The other considerable contributor to the overall risk cost is the 'reliability (system)' category, due to the criticality of the line.

The risk cost per kilometre of line is $0.017m per annum.

Option A — Wood Pole Replacement with Concrete Pole [OFR 1555A, OFS 1555A]

This option covers progressive replacement of the existing wood pole transmission line with a concrete pole transmission line, reusing the existing conductor. As part of the rebuild, span lengths are to be optimised wherever possible.

It is estimated that the capital expenditure associated with the wood pole replacement outlined in this option is $53.40m ±25%. Details can be found in Section 6 of Option Feasibility Study (OFS) OFS 1555A.

With the replacement of poles with concrete pole structures, a reduction in maintenance costs is expected from savings on underground inspections (UGIs), totalling $0.03m per annum for the total of 391 structures. In addition, savings from the replacement of the composite wood pole structures as defect maintenance at a cost of $0.10m per structure are also anticipated. The current defect rate of 1.39% equates to 5.7 structures per annum.

Following the wood pole replacement under this option, the risk cost associated with the remediated line is $0.17m per annum. A breakdown of the Option A risk cost by category is shown in Table 2.

Table 2 – Base Case risk cost by category ($ million)

Risk Category	Annual Risk Cost
Reliability (System)	0.04
Financial	0.01
Operational/Compliance	0
People (Safety)	0.01
Environment	0.10
Reputation	0

Risk Category	Annual Risk Cost
Total	**0.17**

The total projected risk reduction as a result of implementing Option A is $1.75m per annum. It can be seen from Table 2 that the largest component of the reduction is in the 'environment' category, due to the reduced likelihood of conductor drop failure. Reductions in risk cost in the 'reliability (system)' category are also expected.

The total projected risk reduction per kilometre of line is $0.016m per annum.

Option B — Line Rebuild with New Concrete Poles and New Conductor [OFR 1555B, OFS 1555B]

This option covers rebuild of the existing transmission line with new structures and new conductor. The scope of work includes the replacement of composite wood pole structures with concrete pole structures. The new conductor is to be twin Olive ACSR/GZ with a design temperature of 120°C. The expected rating of the new line is 1290MVA, an increase in capacity of 301MVA compared with the existing line. The route of the new line will be the same as the existing and as part of the rebuild, span lengths are to be optimised wherever possible.

It is estimated that the capital expenditure associated with the wood pole replacement outlined in this option is $66.20m ±25%. Details can be found in Section 6 of OFS 1555B.

As with Option A, the replacement of poles with concrete pole structures is expected to result in a reduction in maintenance costs due to savings on underground inspections (UGIs), totalling $0.03m per annum for the total of 391 structures. In addition, savings from the replacement of the composite wood pole structures as defect maintenance at a cost of $0.10m per structure are also anticipated. The current defect rate of 1.39% equates to 5.7 structures per annum.

The rebuild of Line 86 to provide a higher rating is expected to produce benefits, estimated to be $1.65m per annum. This is based on the following:

- Based on historical power flow data and the potential renewable generation in the New England area, it is estimated that Line 86 will be the constraint on importing power from north 5% of the time
- An assumption of average generation cost of $25/MWh for thermal generation compared to renewable generation with a load factor of 0.5
- Option Benefit = Value of Extra Renewable Generation Available to NSW/NEM per year
  = (Time Line 85+86 Flow Exceeds Present Rating) x (Extra Capacity) x (Load Factor) x (Market Benefit/MWh) x (Hrs Per Year)
  = 0.05 x 301 x 0.5 x 25 x 24 x 365
  = $1.65m/year

Following the line rebuild under this option, the risk cost associated with the remediated line is $0.08m per annum. A breakdown of the Option B risk cost by category is shown in Table 3.

Table 3 – Base Case risk cost by category ($ million)

Risk Category	Annual Risk Cost
Reliability (System)	0.02
Financial	0
Operational/Compliance	0
People (Safety)	0.01
Environment	0.05

Risk Category	Annual Risk Cost
Reputation	0
Total	**0.08**

The total projected risk reduction as a result of implementing Option B is $1.84m per annum. It can be seen from Table 3 that the largest component of the reduction is in the 'environment' category, due to the reduced likelihood of conductor drop failure. Reductions in risk cost in the 'reliability (system)' category are also expected.

The total projected risk reduction per kilometre of line is $0.02m per annum.

All options detailed in Section 3 above 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 4. Details of the Net Present Value (NPV) calculations for Options A and B are provided in Attachment 1.

Table 4 — Commercial evaluation ($ million)

Option	Description	Total capex	Annual opex	Annual post project risk cost	Economic NPV @10%	Financial NPV @10%	Economic IRR[2]	Rank
Base Case	Run-to-fail	N/A	N/A	1.92	N/A	N/A	N/A	3
A	Wood Pole Replacement with Concrete Pole	53.40	(0.60)	0.17	(23.26)	(27.11)	2.92%	2
B	Line Rebuild with New Concrete Poles and New Conductor	66.20	(0.60)	0.08	(21.55)	(25.57)	4.87%	1

The commercial evaluation is based on:

- A 10% discount rate
- A life of the investment of 50 years and a corresponding residual/terminal value
- An allowance for a reduction in OPEX costs from savings on UGIs, totalling $0.03m per annum for the 391 structures following the implementation of both Options A and B (ongoing incremental operating expenditure)
- An allowance for a reduction in OPEX costs for future defect pole replacements at a rate of 1.39% (5.7 structures) per year following the implementation of both Options A and B (ongoing incremental operating expenditure)

[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.

[2] The Economic Investment Rate of Return (IRR) has been included to assessment as another measure of the expected financial performance of the proposed options

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 5.

Table 5 — Discount rate sensitivities ($ million)

Option	Description	Economic NPV @13%	Economic NPV @6.75%
A	Wood Pole Replacement with Concrete Pole	(24.97)	(17.82)
B	Line Rebuild with New Concrete Poles and New Conductor	(25.70)	(11.21)

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 6.

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 6 – Feasible options ($ thousand)

Option	Description	CAPEX	Expected Life	Annualised CAPEX
Base	Run-to-fail	N/A	N/A	N/A
A	Wood Pole Replacement with Concrete Pole	53,400	50 years	1,068
B	Line Rebuild with New Concrete Poles and New Conductor	66,200	50 years	1,324

Table 7 – Annual risk calculations ($ thousand)

Option	Annual Residual Risk			Annual Risk Savings		
	Safety Risk	Reliability Risk	Bushfire Risk	Safety Risk	Reliability Risk	Bushfire Risk
Base	110	658	1,091	N/A	N/A	N/A

Option	Annual Residual Risk			Annual Risk Savings		
	Safety Risk	Reliability Risk	Bushfire Risk	Safety Risk	Reliability Risk	Bushfire Risk
A	13	43	103	96	616	988
B	5	16	52	105	642	1,039

Table 8 – Reasonably practicable test ($ thousand)

Option	Network Safety Risk Reduction[3]	Annualised CAPEX	Reasonably practicable[4]?
A	6,567	1,068	Yes
B	6,930	1,324	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 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. Neither Option A nor Option B is considered to be commercially viable (as per the commercial evaluation), although Option B can be considered more beneficial with a better NPV value and has an IRR close to the lower bound AER-determined pre-tax real regulatory WACC of 6.75%.

Of the two options, Option B and its associated line upgrade has greater potential future benefits by enabling the increase of power flows through the northern NSW region which have not been quantified at this stage. For this reason, it is the preferred option and it is proposed that Option B be scoped in further detail.

Capital and operating expenditure

The estimated capital expenditure associated with Option A is $53.40m ±25%. The vast majority of this expenditure is proposed to be carried out in 2021-2022.

The estimated capital expenditure associated with Option B is $66.20m ±25%. The vast majority of this expenditure is proposed to be carried out in 2021-2022.

Under both Options A and B, the anticipated reduction in ongoing operational expenditure due to savings on UGIs and the replacement of the composite wood pole structures as defect maintenance is $0.60m per annum. This is based on UGI savings for the 391 total structures and defect replacement at the current rate of 1.39%, or 5.7 poles, per annum. With Option B and the line upgrade, the benefits as a result of improving power flows are estimated to be $1.65m per annum.

Should neither Option A nor Option B works occur by the Need date, it is likely that there will be an increase in corrective maintenance and subsequent operating expenditure as a result of further deterioration of composite wood pole condition leading to an increase in defect rates.

[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

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, a RIT-T analysis is required as the estimated CAPEX is over the $5.00m threshold. It is anticipated that the RIT-T analysis be completed by December 2019.

5. Recommendation

From the above SFAIRP/ALARP evaluation in accordance with the regulatory requirements, it is required that one option be undertaken to remediate the condition issues with Line 86. Of the two options, Option B and its associated line upgrade is considered to be more commercially beneficial than Option A in the longer term. Option B has an IRR close to the lower bound AER-determined pre-tax real regulatory Weighted Average Cost of Capital (WACC) of 6.75%.

It is recommended that detailed scoping for the Line 86 replacement with new twin Olive ACSR/GZ conductor as outlined under Option B is undertaken. Further, a RIT-T analysis for Option B is to be undertaken and completed by December 2019.

Attachment 1 – Commercial evaluation report

Option A NPV calculation

Project_Option Name	Line 86 Option A - Wood Pole Replacement

1. Financial Evaluation (excludes VCR benefits)

NPV @ standard discount rate	10.00%	-$27.11m	*NPV / Capital (Ratio)*	*-0.51*
NPV @ upper bound rate	13.00%	-$27.75m	*Pay Back Period (Yrs)*	*0.02 Yrs*
NPV @ lower bound rate (WACC)	6.75%	-$23.56m	*IRR%*	*1.56%*

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%	-$23.26m	*NPV / Capital (Ratio)*	*5.82*
NPV @ upper bound rate	13.00%	-$24.97m	*Pay Back Period (Yrs)*	*22.67 Yrs*
NPV @ lower bound rate (WACC)	6.75%	-$17.82m	*IRR%*	*2.92%*

Benefits

Risk cost	As Is	To Be	Benefit
Systems (reliability)	*$0.66m*	*$0.04m*	*$0.62m*
Financial	*$0.05m*	*$0.00m*	*$0.05m*
Operational/compliance	*$0.00m*	*$0.00m*	*$0.00m*
People (safety)	*$0.11m*	*$0.01m*	*$0.10m*
Environment	*$1.09m*	*$0.10m*	*$0.99m*
Reputation	*$0.00m*	*$0.00m*	*$0.00m*
Total Risk benefits	$1.92m	$0.16m	$1.75m
Cost savings and other benefits			$0.60m
Total Benefits			$2.36m

VCR Benefit	*$0.62m*
ENS Penalty	*$0.00m*
All other risk benefits	*$1.14m*
Total Risk benefits	$1.75m
Benefits in the financial NPV*	$1.74m
**excludes VCR benefits*	
Benefits in the economic NPV**	$2.36m
***excludes ENS penalty*	

Other Financial Drivers

Incremental opex cost pa (no depreciation)	$0.00m	Write-off cost	$0.00m
Capital - initial $m	-$53.40m	Major Asset Life (Yrs)	50.00 Yrs
Residual Value - initial investment	$25.63m	Re-investment capital	$0.00m
Capitalisation period	4.00 Yrs	Start of the re-investment period	0.00 Yrs

Option B NPV calculation

Project_Option Name	Line 86 Option B - Wood Pole Replacement with New Conducto

1. Financial Evaluation (excludes VCR benefits)				
NPV @ standard discount rate	10.00%	-$25.57m	*NPV / Capital (Ratio)*	*-0.39*
NPV @ upper bound rate	13.00%	-$28.60m	*Pay Back Period (Yrs)*	*0.04 Yrs*
NPV @ lower bound rate (WACC)	6.75%	-$17.20m	*IRR%*	*3.81%*

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%	-$21.55m	*NPV / Capital (Ratio)*	*5.39*
NPV @ upper bound rate	13.00%	-$25.70m	*Pay Back Period (Yrs)*	*16.19 Yrs*
NPV @ lower bound rate (WACC)	6.75%	-$11.21m	*IRR%*	*4.87%*

Benefits					
Risk cost	As Is	To Be	Benefit	*VCR Benefit*	*$0.64m*
Systems (reliability)	*$0.66m*	*$0.02m*	*$0.64m*	*ENS Penalty*	*$0.00m*
Financial	*$0.05m*	*$0.00m*	*$0.05m*	*All other risk benefits*	*$1.20m*
Operational/compliance	*$0.00m*	*$0.00m*	*$0.00m*	Total Risk benefits	$1.84m
People (safety)	*$0.11m*	*$0.01m*	*$0.10m*		
Environment	*$1.09m*	*$0.05m*	*$1.04m*	Benefits in the financial NPV*	$3.45m
Reputation	*$0.00m*	*$0.00m*	*$0.00m*	**excludes VCR benefits*	
Total Risk benefits	$1.92m	$0.07m	$1.84m		
Cost savings and other benefits			$2.25m	Benefits in the economic NPV**	$4.09m
Total Benefits			$4.09m	***excludes ENS penalty*	

Other Financial Drivers			
Incremental opex cost pa (no depreciation)	$0.00m	Write-off cost	$0.00m
Capital - initial $m	-$66.30m	Major Asset Life (Yrs)	50.00 Yrs
Residual Value - initial investment	$31.82m	Re-investment capital	$0.00m
Capitalisation period	4.00 Yrs	Start of the re-investment period	0.00 Yrs