# OPTIONS EVALUATION REPORT (OER)

Line 17 330kV Transmission Line Renewal

OER 000000001352 revision 3.0

**Ellipse project no.:** P0007971
**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** | 14 December 2016 | |

**Change history**

| Revision | Date | Amendment |
|---|---|---|
| 0 | 20 June 2016 | Initial issue |
| 1 | 20 October 2016 | Option B Added. Revised for Updated Risk Cost and New SFAIRP/ALARP Methodology |
| 2 | 6 December 2016 | Update to format |
| 3 | 14 December 2016 | Minor editorial changes |

# 1. Need/opportunity

Line 17 is a single circuit steel tower 330kV transmission line between Avon and Macarthur 330kV Substations, with a route length of 41 km. The transmission line is a key link between the Wollongong region and the Sydney metropolitan area. This transmission line was constructed in 1964 as the Dapto to Sydney West 330kV line and consists of 101 structures. The southern section of the transmission line mainly traverses through forested areas, with a significant section located in land belonging to the Sydney Catchment Authority. There are large numbers of residences and populated areas in the northern half of the line from Appin through to Macarthur. The Campbelltown area is rapidly expanding, with suburban developments likely to build up next to the line in the near future.

Network Asset Condition Assessment (NACA) NACA 1352 performed in March 2016 has identified a number of condition related issues with Line 17 which require rectification in the short – medium term (in 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 single circuit transmission line structures used on Line 17 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

> Need 1575 – Line 10 Earthwire Condition

# 3. Options

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

**Base Case**

Network Asset Condition Assessment (NACA) NACA 1352 has identified existing issues with the line which require rectification. A summary of these can be found in Need/Opportunity Statement (NOS) NS 1352.

Under a Base Case 'run-to-fail' option, the associated risk cost from the issues identified in Table 1 is $1.22m 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) | 0.24 |
| Financial | 0.03 |
| Operational/Compliance | 0 |
| People (Safety) | 0.10 |
| Environment | 0.85 |
| Reputation | 0 |

| Risk Category | Annual Risk Cost |
|---|---|
| **Total** | **1.22** |

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 substantial contributor to the overall risk cost is the 'reliability (system)' from the associated outage.

The risk cost per kilometre of line is $0.030m per annum.

**Option A — Line Refurbishment [OFR 1352A, OFS 1352A]**

This option involves the refurbishment of Line 17 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 17 Option A scope of works**

| Issue | Qty | | Remediation |
|---|---|---|---|
| Ground line corrosion of steel at footing | 15 towers | > | Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and concrete encasement to prevent future corrosion |
| Buried concrete foundations | 20 towers | > | Dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and establishment of drainage channel |
| Corrosion of tower fasteners | 35 towers | > | Replacement of fasteners |
| | | > | Assume 5% of fasteners per tower |
| Insulator pin corrosion – suspension insulators | 212 insulator strings | > | Replacement with composite longrod insulators |
| Corrosion of conductor fittings | 27 fittings | > | Replacement of hot and cold end fittings |
| Corrosion of earthwire fittings | 12 fittings | > | Replacement of earthwire fittings |
| Corrosion of earthwire | 50km (25km of route length) | > | Like for like replacement of SC/GZ earthwire |
| Damaged conductor vibration dampers | 10% of line | > | Replacement of Stockbridge vibration dampers |
| | 240 dampers | > | Assumed 8 vibration dampers per full tension span per phase |

It is estimated that the capital expenditure associated with the refurbishment outlined in this option is $2.81m ±25%. Details can be found in Section 6 of Option Feasibility Study (OFS) OFS 1352A.

Following the refurbishment under this option, the risk cost associated with the remediated line is $0.12m 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) | 0.04 |
| Financial | 0.01 |
| Operational/Compliance | 0 |
| People (Safety) | 0.01 |
| Environment | 0.07 |
| Reputation | 0 |
| **Total** | **$0.12** |

The total projected risk reduction as a result of implementing Option A is $1.10m 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. Considerable reductions in risk cost in the 'reliability (system)' and 'people (safety)' categories are also expected.

The total projected risk reduction per kilometre of line is $0.027m per annum.

**Option B — Line Refurbishment with OPGW Retrofitting (OFR 1352B, OFS 1352B)**

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 Avon and Macarthur. 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 17 Option B scope of works**

| Issue | Qty | Remediation |
|---|---|---|
| Ground line corrosion of steel at footing | 15 towers | > Abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and concrete encasement to prevent future corrosion |
| Buried concrete foundations | 20 towers | > Dig out tower legs, abrasive blast cleaning of steelwork to remove any corrosion product, application of Zinga paint and establishment of drainage channel |
| Corrosion of tower fasteners | 35 towers | > Replacement of fasteners<br>> Assume 5% of fasteners per tower |
| Insulator pin corrosion – suspension insulators | 212 insulator strings | > Replacement with composite longrod insulators |
| Corrosion of conductor fittings | 27 fittings | > Replacement of hot and cold end fittings |

| Issue | Qty | | Remediation |
|---|---|---|---|
| Corrosion of earthwire fittings | 12 fittings | > | Replacement of earthwire fittings |
| Corrosion of earthwire | 25km | > | Like for like replacement of SC/GZ earthwire |
| Corrosion of earthwire | 50km | > | Replacement with OPGW Type A |
| Damaged conductor vibration dampers | 10% of line | > | Replacement of Stockbridge vibration dampers |
| | 240 dampers | > | Assumed 8 vibration dampers per full tension span per phase |
| Avon Substation works for OPGW termination | | > | Termination of OPGW into non-metallic conductor at substation gantry. Non-metallic conductor run to communications room in buried conduit and terminated onto new optical distribution frame. |
| Macarthur Substation works for OPGW termination | | > | 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 $3.84m ±25%. Details can be found in Section 6 of OFS 1352B.

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 $0.12 per annum. The total projected risk reduction as a result of implementing Option B is $1.10m per annum, a total reduction per kilometre of line of $0.027m per annum.

Installation of OPGW on both Lines 17 and 10, as currently proposed, will improve the communications system by bringing fibre to Avon and providing duplicated paths to Dapto, Macarthur and Marulan. The benefits of this opportunity come as a result of reduced OPEX through maintenance and licensing savings, and should OPGW be installed on both lines, the expected quantified benefit is $0.04m per annum, with an additional efficiency savings benefit specific to the Avon site of $0.006m 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].

[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.

# 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 | 1.22 | N/A | N/A | 3 |
| A | Line refurbishment | 2.81 | - | 0.12 | 4.88 | 3.58 | 1 |
| B | Line refurbishment with OPGW retrofitting | 3.84 | (0.04) | 0.12 | 4.85 | 3.55 | 2 |

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 microwave 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 | 3.36 | 7.41 |
| B | Line refurbishment with OPGW retrofitting | 3.25 | 7.54 |

## 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 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)

**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 | 2,810 | 20 years | 141 |
| **B** | Line refurbishment with OPGW retrofitting | 3,840 | 20 years | 192 |

**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** | 99 | 241 | 848 | N/A | N/A | N/A |
| **A** | 10 | 39 | 65 | 89 | 202 | 782 |
| **B** | 10 | 10 | 10 | 89 | 202 | 782 |

**Table 9 – Reasonably practicable test ($ thousand)**

| Option | Network Safety Risk Reduction[2] | Annualised CAPEX | Reasonably practicable[3]? |
|---|---|---|---|
| **A** | 5,251 | 141 | Yes |
| **B** | 5,251 | 192 | 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. Both Options A and B are commercially viable (as per the commercial evaluation), and whilst Option A is more beneficial, the NPV values of both options are very similar ($4.85m and $4.88m).

[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

However, 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 these 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 in this option is $2.81m ±25%. Under Option B, the capital expenditure estimate for the refurbishment and OPGW retrofitting is $3.84m ±25%, with a total expected quantified OPEX saving of $0.04m per annum. In both instances, the vast majority of the capital expenditure is proposed to be carried out in 2022-2023.

It is expected that should works not occur by the Need date, under either 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

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 refurbishment of Line 17 including the 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 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 17 Refurbishment |
|---|---|

**1. Financial Evaluation** (excludes VCR benefits)

| | | | | |
|---|---|---|---|---|
| NPV @ standard discount rate | 10.00% | $3.58m | *NPV / Capital (Ratio)* | *1.28* |
| NPV @ upper bound rate | 13.00% | $2.38m | *Pay Back Period (Yrs)* | *0.30 Yrs* |
| NPV @ lower bound rate (WACC) | 6.75% | $5.62m | *IRR%* | *30.45%* |

**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% | $4.88m | *NPV / Capital (Ratio)* | *-1.63* |
| NPV @ upper bound rate | 13.00% | $3.36m | *Pay Back Period (Yrs)* | *2.56 Yrs* |
| NPV @ lower bound rate (WACC) | 6.75% | $7.41m | *IRR%* | *37.12%* |

**Benefits**

| Risk cost | As Is | To Be | Benefit |
|---|---|---|---|
| *Systems (reliability)* | *$0.24m* | *$0.04m* | *$0.20m* |
| *Financial* | *$0.03m* | *$0.00m* | *$0.02m* |
| *Operational/compliance* | *$0.00m* | *$0.00m* | *$0.00m* |
| *People (safety)* | *$0.10m* | *$0.01m* | *$0.09m* |
| *Environment* | *$0.85m* | *$0.07m* | *$0.78m* |
| *Reputation* | *$0.00m* | *$0.00m* | *$0.00m* |
| Total Risk benefits | $1.22m | $0.12m | $1.10m |
| Cost savings and other benefits | | | $0.00m |
| Total Benefits | | | $1.10m |

| | |
|---|---|
| *VCR Benefit* | *$0.20m* |
| *ENS Penalty* | *$0.00m* |
| *All other risk benefits* | *$0.89m* |
| Total Risk benefits | $1.10m |
| Benefits in the financial NPV* | $0.89m |
| **excludes VCR benefits* | |
| Benefits in the economic NPV** | $1.10m |
| ***excludes ENS penalty* | |

**Other Financial Drivers**

| | | | |
|---|---|---|---|
| Incremental opex cost pa (no depreciation) | $0.00m | Write-off cost | $0.00m |
| Capital - initial $m | -$2.81m | Major Asset Life (Yrs) | 20.00 Yrs |
| Residual Value - initial investment | $0.00m | 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 17 Refurbishment with OPGW Retrofit |
|---|---|

### 1. Financial Evaluation (excludes VCR benefits)

| | | | | |
|---|---|---|---|---|
| NPV @ standard discount rate | 10.00% | $3.55m | *NPV / Capital (Ratio)* | *1.02* |
| NPV @ upper bound rate | 13.00% | $2.26m | *Pay Back Period (Yrs)* | *0.27 Yrs* |
| NPV @ lower bound rate (WACC) | 6.75% | $5.74m | *IRR%* | *26.86%* |

### 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% | $4.85m | *NPV / Capital (Ratio)* | *-1.62* |
| NPV @ upper bound rate | 13.00% | $3.25m | *Pay Back Period (Yrs)* | *3.04 Yrs* |
| NPV @ lower bound rate (WACC) | 6.75% | $7.54m | *IRR%* | *32.61%* |

### Benefits

| Risk cost | As Is | To Be | Benefit | | |
|---|---|---|---|---|---|
| *Systems (reliability)* | *$0.24m* | *$0.04m* | *$0.20m* | *VCR Benefit* | *$0.20m* |
| *Financial* | *$0.03m* | *$0.00m* | *$0.02m* | *ENS Penalty* | *$0.00m* |
| *Operational/compliance* | *$0.00m* | *$0.00m* | *$0.00m* | *All other risk benefits* | *$0.89m* |
| *People (safety)* | *$0.10m* | *$0.01m* | *$0.09m* | Total Risk benefits | $1.10m |
| *Environment* | *$0.85m* | *$0.07m* | *$0.78m* | Benefits in the financial NPV* | $0.94m |
| *Reputation* | *$0.00m* | *$0.00m* | *$0.00m* | **excludes VCR benefits* | |
| Total Risk benefits | $1.22m | $0.12m | $1.10m | | |
| Cost savings and other benefits | | | $0.04m | Benefits in the economic NPV** | $1.14m |
| Total Benefits | | | $1.14m | ***excludes ENS penalty* | |

### Other Financial Drivers

| | | | |
|---|---|---|---|
| Incremental opex cost pa (no depreciation) | $0.00m | Write-off cost | $0.00m |
| Capital - initial $m | -$3.47m | Major Asset Life (Yrs) | 20.00 Yrs |
| Residual Value - initial investment | $0.19m | Re-investment capital | $0.67m |
| Capitalisation period | 3.00 Yrs | Start of the re-investment period | 2021-22 |