

# OPTIONS EVALUATION REPORT (OER)

Sydney East No.1,2,3 Transformer Condition

OER DCN548 revision 1.0



**Ellipse project no.:** P0008869

**TRIM file:** [TRIM No]

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

**Project category:** Prescribed - Replacement

## Approvals

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Date submitted for approval	16 December 2016	

## Change history

Revision	Date	Amendment
0	27 June 2016	Initial issue
1	28 October 2016	Update to 2016/17 dollars and SFAIRP/ALARP data
2	16 December 2016	Update to format

## 1. Need/opportunity

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The Sydney East Substation has four 330/132 kV transformers. No. 1, 2 and 3 transformers are approaching the end of their serviceable lives. These are single phase units commissioned in 1974.

The detailed condition assessment has been conducted on No. 1, 2 and 3 transformers and has confirmed the issues with insulation, leaks, diverter switch and bushings. Results indicate carbon contamination in the main tank due to leaky diverter switch. Transformers are installed with D type diverter switches which have the history of leaking in to the main tank causing carbon contamination.

Overall condition of the transformers presents an unacceptable and increasing risk of failure. Refer Need/Opportunity Statement (NOS) [DCN548](#).

The associated (and increasing) total risk cost of No. 1, 2 and 3 Transformer is \$1.30m, \$2.40m and \$1.60m per annum respectively over the 2018-2023 regulatory period. Exposure to these increasing risks should be addressed.

## 2. Related Needs/opportunities

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Need ID 1337 - The 330 kV circuit breakers (CB) associated with these three transformers are included in the CB renewal program for the next regulatory period (2018-23). CB replacement will need to be coordinated with this transformer renewal project.

This Need DCN 548 includes renewal of transformer protection and control system and establishing Low Voltage (LV) supply from No. 4 Transformer.

## 3. Options

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

The Options Screening Report ([OSR DCN548](#)) outlines the options considered to address this Need. All options include retiring and scrapping one transformer.

### Base Case (Option A)

The Base Case is the 'do nothing option' whereby the transformers will be run to failure. This option leads to large increases in the probability of failure as the assets move further past their expected life. The risk costs (per annum) associated with this option:

- > No. 1 Transformer: \$1.30m
- > No. 2 Transformer: \$2.40m
- > No. 3 Transformer: \$1.60m

Total pre-investment risk at Sydney East 330 kV Substation: **\$5.20m**

Increasing maintenance on the equipment cannot reduce the probability of failure in order to reduce the risk cost.

### Option B — Replace only bushings on two transformers

This option is excluded in the Options Screening Report (OSR).

### **Option C — Refurbish No. 1 and No. 3 transformers and decommission No.2 transformer [[OFR DCN548C](#), [OFS DCN548C](#)]**

This option consists of

- > Onsite oil treatment and degassing to remove moisture and gases.
- > Replace High Voltage (HV) and Low Voltage (LV) bushings with new ones.
- > Fixing oil leaks and removing stains.
- > Replacement of the B phase of No. 3 transformer with a spare single phase transformer.

Estimated CAPEX = **\$2.90m**. OFS DCN548C estimates capital spend of \$3.70m, however this has been adjusted to exclude 330 kV CBs worth \$0.80m.

Risk savings from this option is \$0.30m, driven by decrease in the probability of failure due to the refurbishment and new bushings.

### **Option D — Replace No. 2 and 3 transformers and associated secondary systems and decommission No.1 transformer [[OFR DCN548D](#), [OFS DCN548D](#)]**

This option consists of replacing No. 2 and 3 transformers with new 3 phase 375 MVA transformers and no changes to existing single phase spare transformer.

Estimated CAPEX = **\$15.50m**. OFS DCN548D estimates capital spend of \$16.30m, however this has been adjusted to exclude 330 kV CBs worth \$0.80m.

Risk savings from this option is \$4.10m, driven by reliability risk improvements as the option considers installing new transformers.

Asset life is assumed 45 years.

### **Option E — Replace No. 2 transformer, refurbish No. 1 transformer and replace associated secondary systems and decommission No.3 transformer [[OFR DCN548E](#), [OFS DCN548E](#)]**

This option consists of

- > Replacing No. 2 transformer with a new one, and
- > Onsite refurbishment of No. 1 transformer, which includes -
  - Oil treatment and degassing to remove moisture and gases.
  - Replace High Voltage (HV) and Low Voltage (LV) bushings with new ones.
  - Fixing oil leaks and removing stains.

Estimated CAPEX = **\$9.20m**. OFS DCN548E estimates capital spend of \$10.00m, however this has been adjusted to exclude 330 kV CBs worth \$0.80m.

Risk savings from this option is \$2.70m, driven by reliability risk improvements and reduced probability of failure.

Asset life is assumed 45 for new and gained 2 years for the refurbished transformer.

### **Other options**

No feasible non-network options were identified for the Sydney East 330 kV transformers renewal project.

## 4. Evaluation

Evaluation of the proposed options has been completed using the ALARP (As Low as Reasonably Practicable) regulatory requirements and economic considerations. The results of this evaluation are outlined below.

### 4.1 Commercial evaluation

The result of commercial evaluation for each of the technically feasible options is summarised in Table 1.

**Table 1 – Commercial evaluation (\$ million)**

Option	Description	Total capex	Annual opex	Annual post project risk cost	Economic NPV @10%	Financial NPV @10%	Rank
<b>Base Case</b>	Run-to-fail	N/A	N/A	No.1 Transformer 1.30 No.2 Transformer 2.40 No.3 Transformer 1.60	N/A	4	N/A
<b>C</b>	Refurbish No. 1 and 3 Transformer	2.90	0	2.50	0.77	3	2.90
<b>D</b>	Replace No. 2 and 3 Transformer and associated secondary systems	15.50	0	0.01	33.30	1	15.50
<b>E</b>	Replace No.2 Transformer, refurbish No. 1 Transformer and replace associated secondary systems	9.20	0	1.08	21.60	2	9.20

The economic evaluation is based on:

- > a 10% discount with sensitivities based on TransGrid's current AER-determined pre-tax real regulatory Weighted Average Cost of Capital (WACC) of [X per cent] and 13% for the upper bound, and
- > Increase in failure risk due to age.

Table 2 outlines a sensitivity analysis based on TransGrid's current AER-determined pre-tax real regulatory WACC of 6.75% and an upper bound of 13%. The sensitivity analysis demonstrates a strongly positive Net Present Value (NPV) for the range of discount rates considered, however the number of individual asset replacements which are NPV positive reduces with the higher discount rate and increases with the lower discount rate.

**Table 2 – Discount rate sensitivities (\$ million)**

Option	Description	Economic NPV @13%	Economic NPV @6.75%
<b>C</b>	Refurbish No. 1 and 3 Transformers	0.09	2.15
<b>D</b>	Replace No. 2 and 3 Transformers and associated secondary systems	20.20	58.70
<b>E</b>	Replace No.2 Transformer, refurbish No. 1 Transformer and replace associated secondary systems	13.30	37.5

## 4.2 SFAIRP/ALARP evaluation

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 3.

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:

- > Catastrophic failure of asset/uncontrolled discharge or contact with electricity/ unauthorised access to site - 3 times the safety risk and 10% of the reliability risk (applicable to safety)
- > Unplanned outage of HV equipment - 10% of the reliability risk (applicable to safety)

The results of this evaluation is summarised in the tables below.

**Table 3 – Feasible options (\$ thousand)**

Option	Description	CAPEX	Expected Life	Annualised CAPEX
<b>Base</b>	Run-to-fail	N/A	N/A	N/A
<b>C</b>	Refurbish No. 1 and 3 Transformers	2.90	2-6 years	0.73
<b>D</b>	Replace No. 2 and 3 Transformers and associated secondary systems	15.50	45 years	0.34
<b>E</b>	Replace No.2 Transformer, refurbish No. 1 Transformer and replace associated secondary systems	9.20	6-45 years	0.36

**Table 4 – Annual risk calculations (\$ thousand)**

Option	Annual Residual Risk		Annual Risk Savings	
	Safety Risk	Reliability Risk	Safety Risk	Reliability Risk
<b>Base</b>	25	4,509	N/A	N/A
<b>C</b>	12	2,197	13	2,312
<b>D</b>	0	0	25	4,509
<b>E</b>	5	929	20	3,580

**Table 5 – Reasonably practicable test (\$ thousand)**

Option	Network Safety Risk Reduction <sup>1</sup>	Annualised CAPEX	Reasonably practicable <sup>2</sup> ?
<b>C</b>	Refurbish No. 1 and 3 Transformers	725	No

<sup>1</sup> The Network Safety Risk Reduction is calculated as 3 x Bushfire Risk Reduction + 3 x Safety Risk Reduction + 0.1 x Reliability Risk Reduction. No bushfire risk is applicable for the consequences considered.

<sup>2</sup> Reasonably practicable is defined as whether the annualised CAPEX is less than the Network Safety Risk Reduction

Option	Network Safety Risk Reduction <sup>1</sup>	Annualised CAPEX	Reasonably practicable <sup>2</sup> ?
<b>D</b>	Replace No. 2 and 3 Transformers and associated secondary systems	344	Yes
<b>E</b>	Replace No.2 Transformer, refurbish No. 1 Transformer and replace associated secondary systems	361	Yes

### 4.3 Preferred option

NPV with Option D is the highest. Replacing two transformers proposed in Option D as part of one project can potentially deliver more benefits with savings in project delivery.

In addition to project execution efficiencies and higher NPV with Option D, the ALARP evaluation clearly indicates that the Option D offers highest safety risk savings.

Therefore, the preferred option is Option D, i.e. replace No. 2 and No. 3 Transformer with new transformers and replace the associated secondary systems.

#### Capital and operating expenditure

The operational savings associated with decreased defect costs of the new assets has been included. There are no other ongoing capital expenditure considerations beyond the initial asset replacement project.

#### Regulatory Investment Test

A Regulatory Investment Test for Transmission (RIT-T) is not required as this is an asset replacement project with no augmentation component.

## 5. Recommendation

It is recommended that the project be scoped in detail and Project Approval Documents be prepared to implement Option D.