

OPTIONS EVALUATION REPORT (OER)

Transformer Renewal 2018 – 2023

OER 000000001354 revision 1.0



Ellipse project no.: P0007976

TRIM file: [TRIM No]

Project reason: Capability – Improve Asset Management

Project category: Prescribed - Asset Renewal Strategies

Approvals

Author	Evan Lamplough	Substations Asset Strategist
Endorsed	Tony Gray	Substations Asset Manager
	Azil Khan	Investment Analysis Manager
Approved	Lance Wee	Manager, Asset Strategy
Date submitted for approval	9 December 2016	

Change history

Revision	Date	Amendment
0	1 July 2016	Initial issue
1	28 October 2016	Updated risk costs, Capex, SFAIRP/ALARP methodology, figures and wording throughout.
2	9 December 2016	Update to format

1. Need/opportunity

This transformer renewal program is being considered as a result of a review of TransGrid's aging transformer population.

Detailed condition assessments have been conducted on 14 transformers (including 6 single phase units at Kemps Creek 500kV Substation), and have identified issues including insulation, leaks, diverter switch and bushings. Refer to the Need/Opportunity Statement (NOS) [NS 1354](#).

There is an increasing risk cost associated with each of the identified transformers and methods to reduce this risk should be considered.

2. Related Needs/opportunities

Programs for other substation assets are being developed and should be considered when packaging work for delivery, however it is unlikely that these will be closely related.

3. Options

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

Base Case

The Base Case is the 'do nothing option' whereby the transformers will be run-to-failure. This option leads to ongoing increases in the probability of failure due to the continual degradation in asset condition.

The total pre-investment risk for the transformers identified is \$2.58m (per annum in 2021).

Option A — Refurbish Transformers [[OFR 1354A](#), [OFS 1354A](#)]

This option consists of refurbishing the transformers according to the individual condition issues in order to extend their lives, as per the requirements stated in Options Feasibility Request (OFR) OFR 1354A.

The estimated capex associated with the refurbishments is \$12.397m.

The post-investment risk cost is \$1.25m, which is a risk reduction of \$1.33m.

The risk savings from this option are through a decrease in the probability of failure due to the refurbishment of the transformers in order to extend their life, which is modelled through a reduction in the effective age of the transformer. The amount of risk reduction is dependent on the condition issues of each transformer and the effectiveness of the available treatments.

Option B — Replace Transformers [[OFR 1354B](#), [OFS 1354B](#)]

This option consists of replacing transformers like for like.

The estimated Capex associated with the replacement of all of the identified transformers is \$94.4m.

The post-investment risk cost is essentially zero (due to the low probability of failure of brand new asset), which is a risk reduction of \$2.58m. The asset life is assumed to be 45 years for new transformers.

Other Options

No feasible non-network options were identified for the included transformers.

4. Evaluation

Both options proposed in section 3 are technically feasible and evaluation of the 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.

The transformer risk increases over time as the age of the transformer increases. For most transformers this increase in risk is based on TransGrid's transformer probability of failure model. Where the detailed condition assessment has identified the transformer bushings as needing to be replaced and this is the primary issue to be addressed, the bushing asset probability of failure curve along, with its actual age, has been used to model the overall increasing risk to the transformer. This probability of failure was derived from the transformer probability of failure curve and is sufficient to describe the overall transformer risk.

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)

Transformer	Option	Description	Total capex	Annual opex	Annual post project risk cost	Economic NPV @10%	Rank
Ingleburn No.1	Base Case	Do nothing	-	-	0.29	-	-
	A	Refurbishment	0.73	-	0.16	0.79	1
	B	Replacement	6.00	0	0.00	(1.24)	2
Kemps Creek No.2	Base Case	Do nothing	-	-	0.43	-	-
	A	Refurbishment	1.55	-	0.24	0.83	1
	B	Replacement	17.10	0	0	(8.52)	2
Kemps Creek No.3	Base Case	Do nothing	-	-	0.46	-	-
	A	Refurbishment	1.55	-	0.24	0.83	1
	B	Replacement	17.10	0	0	(8.52)	2
Liverpool No.1	Base Case	Do nothing	-	-	0.15	-	-
	A	Refurbishment	0.81	-	0.03	0.26	1
	B	Replacement	6.50	0	0	(3.34)	2
Liverpool No.2	Base Case	Do nothing	-	-	0.07	-	-
	A	Refurbishment	0.42	-	0.04	0.02	1
	B	Replacement	6.50	0	0	(4.19)	2
Moree No.1	Base Case	Do nothing	-	-	0.09	-	-
	A	Refurbishment	0.54	-	0.05	0.05	1
	B	Replacement	4.10	0	0	(2.15)	2

Transformer	Option	Description	Total capex	Annual opex	Annual post project risk cost	Economic NPV @10%	Rank
Moree No.2	Base Case	Do nothing	-	-	0.17	-	-
	A	Refurbishment	0.44	-	0.10	0.32	1
	B	Replacement	4.70	0	0	(1.87)	2
Murray No.1	Base Case	Do nothing	-	-	0.09	-	-
	A	Refurbishment	0.80	-	0.06	0.43	1
	B	Replacement	3.00	0	0	(1.40)	2
Murray No.2	Base Case	Do nothing	-	-	0.07	-	-
	A	Refurbishment	0.49	-	0.03	(0.02)	1
	B	Replacement	3.00	0	0	(1.62)	2
Murrumburrah No.1	Base Case	Do nothing	-	-	0.15	-	-
	A	Refurbishment	0.69	-	0.09	0.11	1
	B	Replacement	4.00	0	0	(1.48)	2
Panorama No.1	Base Case	Do nothing	-	-	0.21	-	-
	A	Refurbishment	1.03	-	0.06	0.64	1
	B	Replacement	4.70	0	0	(1.33)	2
Panorama No.2	Base Case	Do nothing	-	-	0.22	-	-
	A	Refurbishment	0.93	-	0.08	0.62	1
	B	Replacement	4.70	0	0	(1.17)	2
Sydney North No.3	Base Case	Do nothing	-	-	0.08	-	-
	A	Refurbishment	1.23	-	0.03	0.05	1
	B	Replacement	6.50	0	0	(4.13)	2
Sydney North No.4	Base Case	Do nothing	-	-	0.11	-	-
	A	Refurbishment	1.23	-	0.04	0.05	1
	B	Replacement	6.50	0	0	(3.87)	2

The economic evaluation is based on a 10% discount over a 30 year analysis period, including the 5 year investment period during next regulatory period. There is a small estimated Opex reduction due to reduced maintenance and defects in the case of the transformer replacement and this has been included. There may be small reductions in defect Opex following transformer but this is not significant and has been excluded from the analysis.

The results of the economic evaluation are:

- > Refurbishment is the preferred option over replacement for all transformers
- > Refurbishment has a positive NPV for all transformers except for Murray No.2 transformer, which is slightly negative NPV at 10% discount rate.

The negative Net Present Value (NPV) for the Murray No.2 transformer should be reviewed in light of other considerations. The IRR is 9.38% which is closer to the 10% discount rate. A sensitivity analysis shows that the NPV would be positive if the assessed age in 2021 is 2 years older, or a Weighted Average Cost of Capital (WACC) of 6.75%. The cost estimates for the transformer program include an appropriate allowance for construction and scope risk which may eventuate, however it is not possible to determine which individual ones may incur these risks, and therefore the actual achieved NPV of each individual transformer. Based on these considerations it is recommended that the Murray No.2 transformer still be included in the transformer refurbishment program.

A summary of the options for all of the transformers is provided in Table 2.

Table 2 — Commercial evaluation - summary (\$ million)

Option	Description	Total capex	Annual opex ¹	Annual post project risk cost	Economic NPV @10%	Rank
Base Case	Run to fail	N/A	N/A	2.58	N/A	3
A	Refurbishment	12.40	-	1.25	4.99	1
B	Replacement	94.40	(0.03)	0	(44.80)	2

The table below outlines provides 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 positive NPV for the preferred option for the range of discount rates considered.

Table 3 — Discount rate sensitivities (\$ million)

Option	Description	Economic NPV @13%	Economic NPV @6.75%
A	Refurbishment	1.03	12.74
B	Replacement	(52.68)	(26.61)

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 4.

¹ No Opex savings are included in the economic NPV analysis, since there is no significant change in maintenance between the existing and renewed assets.

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 High Voltage (HV) equipment - 10% of the reliability risk (applicable to safety)

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

Table 4 – Feasible options (\$ thousand)

Transformer	Option	Description	CAPEX	Expected Life	Annualised CAPEX
Ingleburn No.1	A	Refurbishment	728	13 years	56
	B	Replacement	6,000	45 years	133
Kemps Creek No.2	A	Refurbishment	1,545	9 years	172
	B	Replacement	17,100	45 years	380
Kemps Creek No.3	A	Refurbishment	1,545	9 years	172
	B	Replacement	17,100	45 years	380
Liverpool No.1	A	Refurbishment	809	17 years	48
	B	Replacement	6,500	45 years	144
Liverpool No.2	A	Refurbishment	416	20 years	21
	B	Replacement	6,500	45 years	144
Moree No.1	A	Refurbishment	535	15 years	36
	B	Replacement	4,100	45 years	91
Moree No.2	A	Refurbishment	440	8 years	55
	B	Replacement	4,700	45 years	104
Murray No.1	A	Refurbishment	798	8 years	100
	B	Replacement	3,000	45 years	67
Murray No.2	A	Refurbishment	485	13 years	37
	B	Replacement	3,000	45 years	67
Murrumburrah No.1	A	Refurbishment	688	10 years	69
	B	Replacement	4,000	45 years	89

Transformer	Option	Description	CAPEX	Expected Life	Annualised CAPEX
Panorama No.1	A	Refurbishment	1,028	17 years	60
	B	Replacement	4,700	45 years	104
Panorama No.2	A	Refurbishment	928	14 years	66
	B	Replacement	4,700	45 years	104
Sydney North No.3	A	Refurbishment	1,226	22 years	56
	B	Replacement	6,500	45 years	144
Sydney North No.4	A	Refurbishment	1,226	19 years	65
	B	Replacement	6,500	45 years	144

Table 5 – Annual risk calculations (\$ thousand)

Transformer	Option	Annual Residual Risk		Annual Risk Savings	
		Safety Risk	Reliability Risk	Safety Risk	Reliability Risk
Ingleburn No.1	Base	4	183	N/A	N/A
	A	2	97	2	86
	B	0	0	4	183
Kemps Creek No.2	Base	7	4	N/A	N/A
	A	4	2	3	2
	B	0	0	7	4
Kemps Creek No.3	Base	7	4	N/A	N/A
	A	4	2	3	2
	B	0	0	7	4
Liverpool No.1	Base	2	49	N/A	N/A
	A	0	9	2	39
	B	0	0	2	49
Liverpool No.2	Base	1	22	N/A	N/A
	A	1	14	0	8
	B	0	0	1	22
Moree No.1	Base	2	30	N/A	N/A
	A	1	16	1	13
	B	0	0	2	30
Moree No.2	Base	4	56	N/A	N/A
	A	2	32	2	24
	B	0	0	4	56
Murray No.1	Base	6	6	N/A	N/A
	A	4	4	2	2
	B	0	0	6	6

Transformer	Option	Annual Residual Risk		Annual Risk Savings	
		Safety Risk	Reliability Risk	Safety Risk	Reliability Risk
Murray No.2	Base	5	5	N/A	N/A
	A	3	3	2	2
	B	0	0	5	5
Murrumburrah No.1	Base	3	59	N/A	N/A
	A	2	36	1	23
	B	0	0	3	59
Panorama No.1	Base	3	105	N/A	N/A
	A	1	31	2	74
	B	0	0	3	105
Panorama No.2	Base	3	113	N/A	N/A
	A	1	43	2	70
	B	0	0	3	113
Sydney North No.3	Base	3	8	N/A	N/A
	A	1	3	2	6
	B	0	0	3	8
Sydney North No.4	Base	4	11	N/A	N/A
	A	2	4	3	7
	B	0	0	4	11

Table 6 – Reasonably practicable test (\$ thousand)

Transformer	Option	Description	Network Safety Risk Reduction ²	Annualised CAPEX	Reasonably practicable ³ ?
Ingleburn No.1	A	Refurbishment	14	56	No
	B	Replacement	29	133	No
Kemps Creek No.2	A	Refurbishment	11	172	No
	B	Replacement	22	380	No
Kemps Creek No.3	A	Refurbishment	11	172	No
	B	Replacement	22	380	No
Liverpool No.1	A	Refurbishment	9	48	No
	B	Replacement	11	144	No

² Network Safety Risk Reduction is calculated as 3 x Safety Risk Reduction + 0.1 x Reliability Risk Reduction. No bushfire risk is applicable for the consequences considered.

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

Transformer	Option	Description	Network Safety Risk Reduction ²	Annualised CAPEX	Reasonably practicable ³ ?
Liverpool No.2	A	Refurbishment	2	21	No
	B	Replacement	5	144	No
Moree No.1	A	Refurbishment	4	36	No
	B	Replacement	9	91	No
Moree No.2	A	Refurbishment	7	55	No
	B	Replacement	18	104	No
Murray No.1	A	Refurbishment	8	100	No
	B	Replacement	20	67	No
Murray No.2	A	Refurbishment	7	37	No
	B	Replacement	15	67	No
Murrumburrah No.1	A	Refurbishment	6	69	No
	B	Replacement	16	89	No
Panorama No.1	A	Refurbishment	13	60	No
	B	Replacement	19	104	No
Panorama No.2	A	Refurbishment	13	66	No
	B	Replacement	21	104	No
Sydney North No.3	A	Refurbishment	7	56	No
	B	Replacement	11	144	No
Sydney North No.4	A	Refurbishment	9	65	No
	B	Replacement	14	144	No

4.3 Preferred option

The outcome of the SFAIRP/ALARP evaluation is that neither of the options presented in Table 4 are reasonably practicable for any of the included transformers and are therefore not required to satisfy the organisation's SFAIRP/ALARP obligations.

The preferred option is Option A (transformer refurbishment) based on the commercial evaluation.

Capital and operating expenditure

There are no other Capex or Opex considerations beyond those already included above.

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 Project Approval Documents be prepared to implement Option A.