OPTIONS EVALUATION REPORT (OER)

Various Location Steelwork Renewal

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Approvals

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Date submitted for approval	9 December 2016	

Change history

Revision	Date	Amendment
0	21 June 2016	Initial issue
1	22 June 2016	No change
2	28 October 2016	Included description of HD bolt risk mitigation, Capex, scope, risk values, NPV, ALARP methodology and breakdown of figures for each site included throughout
3	9 December 2016	Update to format

1. Need/opportunity

Corrosion of substation gantry steelwork has been identified as an emerging issue and investigations have been undertaken to quantify the work required and the hazards associated with corroded steelwork approaching its end of life. Detailed condition assessments have been undertaken at the following sites which have confirmed that the corrosion of the holding down bolts, base plates and gantry steelwork at these sites must be addressed in order to ensure that the risk of failure is kept to an acceptable level.

- Sydney East
- Sydney North (steelwork is excluded, other than earth wire peaks)
- Sydney South
- Albury
- Dapto
- Tomago
- Hume
- Wagga 132kV (only steelwork not previously addressed)
- Upper Tumut (also includes gantry footing works)

2. Related Needs/opportunities

Separate programs for other substation assets are being developed and should be considered when packaging work.

3. Options

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

The Options Screening Report outlines the options which were considered to be technically and economically feasible. The option which was not considered to be feasible was the replacement of gantries and footings due to it being estimated as significantly more expensive than the other options, with no corresponding increase in benefit.

Base Case

The Base Case is the do nothing option which would lead to either:

- Catastrophic failure of the gantries
- Requirement to undertake extensive rebuild works due to reaching end of life of the gantries and holding down bolts and requiring new assets to be installed

There is a risk cost of $40.20m pa associated with the Base Case which should be addressed.

Option A — Steelwork treatment in situ and remediation of HD bolts [OFR 1358A, OFS 1358A]

The scope of work associated with this option includes the following.

- Removal of rust via blasting of gantry columns, gantry beams and earth wire peaks
- Painting of all blasted steel with a zinc paint (Zinga or similar)

- Remediation of hold down bolts and base plates
- Replace corroded gantry members (5% of all gantry members)
- Removal of 10% of gantries and treat steel at ground level
- Reinforce upper concrete section gantry footings at Upper Tumut only

The total Capex associated with this option is $43.20m. The effectiveness of the option is discussed in the evaluation below.

Option B — Steelwork treatment in situ and concrete encasement of HD bolts [OFR 1358B, OFS 1358B]

The scope of work associated with this option includes the following.

- Removal of rust via blasting of gantry columns, gantry beams and earth wire peaks
- Painting of all blasted steel with a zinc paint (Zinga or similar)
- Encase gantry column footings in concrete
- Replace corroded gantry members (5% of all gantry members)
- Removal of 10% of gantries and treat steel at ground level
- Reinforce upper concrete section gantry footings at Upper Tumut only

The total Capex associated with this option is $63.40m. The effectiveness of the option is discussed in the evaluation below.

Option C — Steelwork repair at ground level and reattachment of new section of HD bolts [OFR 1358C, OFS 1358C]

The scope of work associated with this option includes the following.

- Removal of 90% of gantries to facilitate repair of the existing hold down bolts and remediation of steelwork at ground level
- Partial demolition of the existing footing to expose a suitable portion of the hold down bolt
- Removal of the corroded portion
- Attach new hold down bolt to the existing bolt
- Reinstate footing
- Removal of rust via blasting of gantry columns, gantry beams and earth wire peaks
- Painting of all blasted steel with a zinc paint (Zinga or similar)
- Replace corroded gantry members (5% of all gantry members)
- Reinforce upper concrete section gantry footings at Upper Tumut only

The total Capex associated with this option is $72.40m. The effectiveness of the option is discussed in the evaluation below.

4. Evaluation

4.1 Commercial evaluation

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

Table 1 — Commercial evaluation ($ million)

Substation	Option	Description	Total capex	Annual opex	Annual post project risk cost	Economic NPV @10%	Rank
Sydney East	Base	Do nothing	N/A	N/A	7.00	N/A	4
	A	In-situ steel and remediate HDB	5.40	-	0.40	34.00	1
	B	In-situ steel and encase HDB	8.10	-	0.40	31.70	2
	C	Ground level steel and attach HDB	8.50	-	0.40	31.40	3
Sydney North	Base	Do nothing	N/A	N/A	0.95	N/A	4
	A	In-situ steel and remediate HDB	3.60	-	0.30	0.70	1
	B	In-situ steel and encase HDB	7.30	-	0.30	(2.40)	2
	C	Ground level steel and attach HDB	9.30	-	0.30	(4.10)	3
Sydney South	Base	Do nothing	N/A	N/A	18.66	N/A	4
	A	In-situ steel and remediate HDB	10.90	-	0.60	95.30	1
	B	In-situ steel and encase HDB	15.60	-	0.60	91.20	2
	C	Ground level steel and attach HDB	18.10	-	0.60	89.00	3
Albury	Base	Do nothing	N/A	N/A	1.69	N/A	4
	A	In-situ steel and remediate HDB	2.50	-	0.10	7.30	1
	B	In-situ steel and encase HDB	3.30	-	0.10	6.60	2
	C	Ground level steel and attach HDB	4.40	-	0.10	5.70	3
Dapto	Base	Do nothing	N/A	N/A	8.71	N/A	4
	A	In-situ steel and remediate HDB	6.30	-	0.30	43.50	1
	B	In-situ steel and encase HDB	9.40	-	0.30	40.90	2
	C	Ground level steel and attach HDB	10.30	-	0.30	40.10	3
Tomago	Base	Do nothing	N/A	N/A	1.40	N/A	4
	A	In-situ steel and remediate HDB	4.60	-	0.10	4.00	1
	B	In-situ steel and encase HDB	7.60	-	0.10	1.50	2
	C	Ground level steel and attach HDB	7.10	-	0.10	1.90	3
Hume	Base	Do nothing	N/A	N/A	0.19	N/A	4
	A	In-situ steel and remediate HDB	0.90	-	0	0.30	1
	B	In-situ steel and encase HDB	1.20	-	0	0	2
	C	Ground level steel and attach HDB	1.60	-	0	(0.30)	3

Substation	Option	Description	Total capex	Annual opex	Annual post project risk cost	Economic NPV @10%	Rank
Wagga 132kV	Base	Do nothing	N/A	N/A	0.58	N/A	4
	A	In-situ steel and remediate HDB	2.10	-	0.10	1.30	1
	B	In-situ steel and encase HDB	2.70	-	0.10	0.80	2
	C	Ground level steel and attach HDB	3.60	-	0.10	0	3
Upper Tumut	Base	Do nothing	N/A	N/A	1.01	N/A	4
	A	In-situ steel and remediate HDB	6.90	-	0	1.00	1
	B	In-situ steel and encase HDB	8.20	-	0	0.20	2
	C	Ground level steel and attach HDB	9.50	-	0	(0.70)	3

Table 2 — Commercial evaluation - summary ($ million)

Option	Description	Total capex	Annual opex[1]	Annual post project risk cost	Economic NPV @10%	Rank
Base Case	Do nothing and run-to-fail	N/A	N/A	N/A	N/A	4
A	Steelwork treatment in situ and remediation of HD bolts	43.20	-	1.90	187.30	1
B	Steelwork treatment in situ and concrete encasement of HD bolts	63.40	-	1.90	170.50	2
C	Steelwork repair at ground level and reattachment of new section of HD bolts	72.40	-	1.90	163.10	3

Each of the identified options will adequately address the risk associated with the steelwork and holding down bolts and each option will also each achieve a similar extension in asset life of 20 years. This is considering that the solutions included in Option B and C for holding down bolts are only currently at the concept stage and have not been undertaken previously. Also, any additional life beyond 20 years may not be of any benefit since the gantries' footing life may limit the overall life the installation. There is a risk that the level of corrosion on the section of HD bolts below the structure or within the foundation grout (which cannot be assessed without invasive investigations). If this is the case then the solution included in Option B or C may be required. However, the number of gantries in this category is expected to be very limited.

The risk costs have been assumed to be constant for each year in the Net Present Value (NPV) analysis, rather than continuing to increase due to aging. This approach has been taken due to the assumptions and the level of detail achieved within the modelling of steelwork failure probability and calculated yearly risk costs.

[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.

The NPV analysis is based on discounting to June 2019 and with a discount rate of 10%. **Error! Reference source not found.** below provides a sensitivity analysis based on TransGrid's current AER-determined pre-tax real regulatory Weighted Average Cost of Capital (WACC) of 6.75% and an upper bound of 13%.

Table 3 — Discount rate sensitivities ($ million)

Option	Description	Economic NPV @13%	Economic NPV @6.75%
A	Steelwork treatment in situ and remediation of HD bolts	131	281
B	Steelwork treatment in situ and concrete encasement of HD bolts	115	263
C	Steelwork repair at ground level and reattachment of new section of HD bolts	108	255

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 Evaluation

Commercial evaluation

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

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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)

Substation	Option	Description	CAPEX	Expected Life	Annualised CAPEX
Sydney East	A	In-situ steel and remediate HDB	5,400	20 years	270
	B	In-situ steel and encase HDB	8,100	20 years	405
	C	Ground level steel and attach HDB	8,500	20 years	425
Sydney North	A	In-situ steel and remediate HDB	3,600	20 years	180
	B	In-situ steel and encase HDB	7,300	20 years	365
	C	Ground level steel and attach HDB	9,300	20 years	465

Substation	Option	Description	CAPEX	Expected Life	Annualised CAPEX
Sydney South	A	In-situ steel and remediate HDB	10,900	20 years	545
	B	In-situ steel and encase HDB	15,600	20 years	780
	C	Ground level steel and attach HDB	18,100	20 years	905
Albury	A	In-situ steel and remediate HDB	2,500	20 years	125
	B	In-situ steel and encase HDB	3,300	20 years	165
	C	Ground level steel and attach HDB	4,400	20 years	220
Dapto	A	In-situ steel and remediate HDB	6,300	20 years	315
	B	In-situ steel and encase HDB	9,400	20 years	470
	C	Ground level steel and attach HDB	10,300	20 years	515
Tomago	A	In-situ steel and remediate HDB	4,600	20 years	230
	B	In-situ steel and encase HDB	7,600	20 years	380
	C	Ground level steel and attach HDB	7,100	20 years	355
Hume	A	In-situ steel and remediate HDB	900	20 years	45
	B	In-situ steel and encase HDB	1,200	20 years	60
	C	Ground level steel and attach HDB	1,600	20 years	80
Wagga 132kV	A	In-situ steel and remediate HDB	2,100	20 years	105
	B	In-situ steel and encase HDB	2,700	20 years	135
	C	Ground level steel and attach HDB	3,600	20 years	180
Upper Tumut	A	In-situ steel and remediate HDB	6,900	20 years	345
	B	In-situ steel and encase HDB	8,200	20 years	410
	C	Ground level steel and attach HDB	9,500	20 years	475

Table 5 – Annual risk calculations ($ thousand)

Substation	Option	Annual Residual Risk		Annual Risk Savings	
		Safety Risk	Reliability Risk	Safety Risk	Reliability Risk
Sydney East	Base	6	6,597	N/A	N/A
	A	0	334	5	6,262
	B	0	334	5	6,262
	C	0	334	5	6,262

Substation	Option	Annual Residual Risk		Annual Risk Savings	
		Safety Risk	Reliability Risk	Safety Risk	Reliability Risk
Sydney North	Base	1	817	N/A	N/A
	A	0	272	0	545
	B	0	272	0	545
	C	0	272	0	545
Sydney South	Base	11	17,251	N/A	N/A
	A	0	577	11	16,673
	B	0	577	11	16,673
	C	0	577	11	16,673
Albury	Base	3	1,258	N/A	N/A
	A	0	56	3	1,202
	B	0	56	3	1,202
	C	0	56	3	1,202
Dapto	Base	7	7,673	N/A	N/A
	A	0	292	7	7,381
	B	0	292	7	7,381
	C	0	292	7	7,381
Tomago	Base	7	685	N/A	N/A
	A	0	28	6	657
	B	0	28	6	657
	C	0	28	6	657
Hume	Base	1	0	N/A	N/A
	A	0	0	1	0
	B	0	0	1	0
	C	0	0	1	0
Wagga 132kV	Base	0	510	N/A	N/A
	A	0	42	0	468
	B	0	42	0	468
	C	0	42	0	468

Substation	Option	Annual Residual Risk		Annual Risk Savings	
		Safety Risk	Reliability Risk	Safety Risk	Reliability Risk
Upper Tumut	Base	7	2	N/A	N/A
	A	0	0	7	2
	B	0	0	7	2
	C	0	0	7	2

Table 6 – Reasonably practicable test ($ thousand)

Substation	Option	Description	Network Safety Risk Reduction[2]	Annualised CAPEX	Reasonably practicable[3]?
Sydney East	A	In-situ steel and remediate HDB	642	270	Yes
	B	In-situ steel and encase HDB	642	405	Yes
	C	Ground level steel and attach HDB	642	425	Yes
Sydney North	A	In-situ steel and remediate HDB	56	180	No
	B	In-situ steel and encase HDB	56	365	No
	C	Ground level steel and attach HDB	56	465	No
Sydney South	A	In-situ steel and remediate HDB	1,699	545	Yes
	B	In-situ steel and encase HDB	1,699	780	Yes
	C	Ground level steel and attach HDB	1,699	905	Yes
Albury	A	In-situ steel and remediate HDB	129	125	Yes
	B	In-situ steel and encase HDB	129	165	No
	C	Ground level steel and attach HDB	129	220	No
Dapto	A	In-situ steel and remediate HDB	758	315	Yes
	B	In-situ steel and encase HDB	758	470	Yes
	C	Ground level steel and attach HDB	758	515	Yes
Tomago	A	In-situ steel and remediate HDB	85	230	No
	B	In-situ steel and encase HDB	85	380	No
	C	Ground level steel and attach HDB	85	355	No

[2] The 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

Substation	Option	Description	Network Safety Risk Reduction[2]	Annualised CAPEX	Reasonably practicable[3]?
Hume	A	In-situ steel and remediate HDB	3	45	No
	B	In-situ steel and encase HDB	3	60	No
	C	Ground level steel and attach HDB	3	80	No
Wagga 132kV	A	In-situ steel and remediate HDB	47	105	No
	B	In-situ steel and encase HDB	47	135	No
	C	Ground level steel and attach HDB	47	180	No
Upper Tumut	A	In-situ steel and remediate HDB	21	345	No
	B	In-situ steel and encase HDB	21	410	No
	C	Ground level steel and attach HDB	21	475	No

4.3 Preferred option

The outcome of the SFAIRP/ALARP evaluation is that some of the options presented in Table 6 are reasonably practicable for some of the sites and are therefore required to satisfy the organisation's SFAIRP/ALARP obligations.

The preferred option is Option A for all sites based on the SFAIRP/ALARP evaluation (some sites) and the commercial evaluation (all sites).

Capital and operating expenditure

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 Option A be scoped in detail to allow for delivery of the project.