OPTIONS EVALUATION REPORT (OER)

Broken Hill Secondary Systems Renewal

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

Approvals

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Date submitted for approval	24 November 2016	

Change history

Revision	Date	Amendment
0	28 June 2016	Initial issue
1	31 October 2016	Update to 2016/17 dollars and SFAIRP/ALARP data
2	15 November 2016	Update to format
3	24 November 2016	Added OSR reference

1. Need/opportunity

Broken Hill 220/22kV Substation comprises 2×220kV feeders, 2×220kV reactors, 2×220/22kV transformers, 8×22kV feeders, 3×22kV capacitor banks and 2×22kV SVCs. The site was established in 1979, and the secondary systems assets have install dates between 1979 (electro-mechanical type with 40 years average nominal asset life) and 2015 (microprocessor with 15 years average nominal asset life).

The Secondary Systems assets have been identified as reaching end of life and require addressing at the site. Additionally, there is an opportunity to improve the operational capacity of the site by modernising the automation philosophy to current design standards and practices

2. Related Needs/opportunities

The assets proposed to be replaced under this Secondary System Replacement were identified in the following Needs:

- Need ID 605 – Replacement of Quadramho Protection Relays
- Need ID 606 – Replacement of THR Protection Relays
- Need ID 610 – Replacement of EDMI MK3 Energy Meters
- Need ID 621 – Replacement of DB Series Protection Relays
- Need ID 1368 – Replacement of Feeder OC Protection Relays
- Need ID 1387 – Replacement of Capacitor Protection Relays
- Need ID 1388 – Replacement of SVC Protection Relays
- Need ID 1338 – Various Locations CT Renewal Program
- Need ID 1442 – Various Locations VT Renewal Program
- Need ID 541 – Magrini Galileo MGE 33kV Circuit Breakers

3. Options

The options scoped for this need were identified as per the Options Screening Report – Secondary System Renewal.

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

Base Case

The Base Case for this Need is to continue with TransGrid's operation and maintenance (O&M) for the site. This approach does not address the technological obsolescence, spares unavailability, manufacturer non-support, component deterioration of the secondary systems and the risk cost associated with the Need. The risk cost associated with all secondary system at Broken Hill Substation of $5.75m per annum will increase due to:

- the probability of failure increasing as the assets move further past their expected life; and
- TransGrid's means of mitigating and repairing these failures being almost exhausted.

Broken Hill Substation is a customer connection point supplying Essential Energy's 22kV networks in the area inclusive of Broken Hill Mines and Cockburn. Broken Hill Substation is also a customer connection point for the AGL Solar Farms in the area. Key drivers for this risk cost are:

- All the relays protecting assets at this site have either reached or will reach by 2023 their end of life, with limited spares and no manufacturer support. This increases the likelihood of a hazardous event occurring and decreases TransGrid's ability to react to mitigate or repair any failures.

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

Option A – Complete Replacement with SSBs [OFR 1193A, OFS 1193A]

Option A is to carry out the complete upgrade and renewal of secondary systems at Broken Hill Substation by using modular Secondary Systems Building (SSBs) and installing new cable throughout the substation. This option will modernise the automation philosophy to current design standards and practices and will provide additional operational benefits.

This option assumes that the new secondary systems will be designed to be accommodated within a similar panel arrangement as the existing installation. Redundant panels and tunnel boards in the ASB relay room will need to be progressively decommissioned and removed as the new secondary systems are cut-over and commissioned.

The expected capital costs for this option total $10.80m. This costing is estimated using TransGrid's 'Success' estimating system. No capital expenditure would be required over the 15 year life cycle of this option through to 2038 as this involves complete replacement of the existing secondary systems.

Operating costs have been estimated at $6k per annum for this option based on current maintenance schedule.

A benefit figure of $88k per annum has been calculated for this option in accordance with TransGrid's Renewal and Maintenance Strategy for Secondary Systems Site Installations.

The residual risk associated with this option upon completion of the project amounts to $2.43m per annum (base case risk cost = $5.75m). The risk reduction is realised through the reduction in the probability of failure for all assets and the reduction in likelihood of a hazardous event due to the installation of self-checking relays.

Option B – In-Situ Replacement [OFR 1193B, OFS 1193B]

Option B is to carry out the complete upgrade and renewal of the secondary systems at Broken Hill Substation by reusing the existing building, tunnel boards and where practicable, the cabling. This option will modernise the automation philosophy to current design standards and practices and will provide additional operational benefits.

This option assumes that the new secondary systems will be designed to be accommodated within a similar panel arrangement as the existing installation. Redundant panels and tunnel boards in the ASB relay room will need to be progressively decommissioned and removed as the new secondary systems are cut-over and commissioned.

The expected capital costs for this option total $5.90m. This costing is estimated using TransGrid's 'Success' estimating system. No capital expenditure would be required over the 15 year life cycle of this option through to 2038 as this is a complete in-situ replacement option.

Operating costs have been estimated at $6k per annum for this option based on current maintenance schedule.

A benefit figure of $35.4k per annum has been calculated for this option in accordance with TransGrid's Renewal and Maintenance Strategy for Secondary Systems Site Installations.

The residual risk associated with this option upon completion of the project amounts to $2.67m per annum (base case risk cost = $5.75m). The risk reduction is realised through the reduction in the probability of failure for all assets and the reduction in likelihood of a hazardous event due to the installation of self-checking relays.

Option C – Strategic Asset Replacement [OFR 1193C, OFS 1193C]

Option C is to carry out the replacement of individual secondary system assets at Broken Hill Substation that are in need of renewal during the 2018-2023 regulatory period. This option involves replacing the old assets "like for like" with a modern equivalent asset by utilising the existing building, tunnel boards and where practicable, the cabling. This option excludes additional system modification or delivery of additional functionality.

The expected capital cost for this option total $3.80m. This costing is estimated using TransGrid's 'Success' estimating system. A further $1.48m of capital expenditure would be required over the 15 year life cycle of this option through to 2038 to replace the remaining secondary systems asset.

Operating costs have been estimated at $6k per annum for this option based on current maintenance schedules.

Due to the "like for like" nature of this option, no benefit has been calculated in accordance with TransGrid's Renewal and Maintenance Strategy for Secondary Systems Site Installations[1].

The residual risk associated with this option upon completion of the project amounts to $3.99m per annum (base case risk cost = $5.75m). The risk reduction is realised through the reduction in the probability of failure for all assets and reduction in likelihood of a hazardous event due to the installation of self-checking relays.

Option D – 22kV Switch Room and 220kV Secondary System Building [OFR 1193D, OFS 1193D]

Option D is to carry out the complete upgrade and renewal of secondary systems at the Broken Hill Substation by using modular Secondary Systems Building (SSBs), new metal clad 22kV switchgear, and installing new cable throughout. This option will modernise the automation philosophy to current design standards and practices and will provide additional operational benefits.

This option assumes that the new secondary systems will be designed to be accommodated within a similar panel arrangement as the existing installation. Redundant panels and tunnel boards in the ASB relay room will need to be progressively decommissioned and removed as the new secondary systems are cut-over and commissioned.

The expected capital costs for this option total $12.30m. This costing is estimated using TransGrid's 'Success' estimating system. No capital expenditure would be required over the 15 year life cycle of this option through to 2038 as this involves complete replacement of the existing secondary systems.

Operating costs have been estimated at $6k per annum for this option based on current maintenance schedule.

A benefit figure of $88k per annum has been calculated for this option in accordance with TransGrid's Renewal and Maintenance Strategy for Secondary Systems Site Installations.

The residual risk associated with this option upon completion of the project amounts to $1.13m per annum (base case risk cost = $5.75m). The risk reduction is realised through the reduction in the probability of failure for all assets and the reduction in likelihood of a hazardous event due to the installation of self-checking relays.

[1] Refer SSA Strategy - Renewal and Maintenance - Secondary Systems Site Installations

4. Evaluation

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

4.1 Commercial evaluation

The result of commercial evaluation for each of the 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
Base Case	'Run-to-fail' (O&M continues)	-	0.006	5.75	-	-	5
A	Complete Replacement with SSBs	10.80	0.006	2.43	9.78	(1.76)	3
B	In-Situ Replacement	5.90	0.006	2.67	12.07	0.53	2
C	Strategic Asset Replacement	3.80	0.006	3.99	4.54	(1.97)	4
D	22kV Switch Room and 220kV Secondary System Building	12.30	0.006	1.13	15.92	(2.31)	1

The commercial evaluation is based on:

- Economic life of assets is assumed 15 years. Therefore the Net Present Value (NPV) assessment period is also 15 years.
- Write-offs have been evaluated from the fixed asset register at $92.8k in June 2023 for Option A, B, D as these three options retire few assets before the end of their financial lives.
- Capex excludes interest during construction.

Sensitivities on all options with changing discount rate are shown in Table 2.

Table 2 – Discount rate sensitivities ($ million)

Option	Description	Economic NPV @13%	Economic NPV @6.75%
A	Complete Replacement with SSBs	6.21	15.45
B	In-Situ Replacement	8.63	17.43
C	Strategic Asset Replacement	2.83	7.41
D	22kV Switch Room and 220kV Secondary System Building	10.83	23.91

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 below.

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:

> Conductor drop/structure failure - 6 times the bushfire risk, 3 times the safety risk and 10% of the reliability risk (applicable to safety)

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

Table 3 – Feasible options ($ thousand)

Option	Description	CAPEX	Expected Life	Annualised CAPEX
Base	Do nothing	N/A	N/A	N/A
A	Complete Replacement with SSBs	10,800	15 years	720
B	In-Situ Replacement	5,900	15 years	390
C	Strategic Asset Replacement	3,800	15 years	250
D	22kV Switch Room and 220kV Secondary System Building	12,300	15 years	820

Table 4 – Annual risk calculations ($ thousand)

Option	Annual Residual Risk			Annual Risk Savings		
	Safety Risk	Reliability Risk	Bushfire Risk	Safety Risk	Reliability Risk	Bushfire Risk
Base	336	4,521	30	N/A	N/A	N/A
A	90	2,130	15	246	2,391	15
B	330	2,130	15	6	2,391	15
C	330	2,900	20	6	1,621	10
D	0	970	20	336	3,551	10

Table 5 - Reasonably practicable test ($ thousand)

Option	Network Safety Risk Reduction[2]	Annualised CAPEX	Reasonably practicable[3]?
A	1,067	720	Yes
B	347	390	No
C	240	250	No
D	1,423	820	Yes

4.3 Preferred option

The outcome of the SFAIRP/ALARP evaluation is that only Option A and D are reasonably practicable and Option D provides the highest network risk reductions.

The preferred option to address the condition of the secondary systems is Option D – 22kV Switch Room and 220kV Secondary System Building.

This option has been selected due to its technical viability and reduction in network safety risk. This option provides significant technical benefits and provides a positive NPV.

Capital and operating expenditure

There is negligible difference in predicted ongoing operational expenditure between the two options and the Base Case. Deploying the Complete Replacement with SSBs will provide benefits in terms of remote monitoring, control and interrogation, responding to faults more efficiently and phasing out of obsolete legacy systems. These have been captured as benefits for delivering the 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 the recommendation that Option D - 22kV Switch Room and 220kV Secondary System Building.

[2] The Network Safety Risk Reduction is calculated as 6 x Bushfire Risk Reduction + 3 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

Option A NPV calculation

Project_Option Name	Broken Hill Secondary System Renewal - Option A (Commercia

1. Financial Evaluation (excludes VCR benefits)

NPV @ standard discount rate	10.00%	-$1.76m	*NPV / Capital (Ratio)*	*-0.16*
NPV @ upper bound rate	13.00%	-$2.84m	*Pay Back Period (Yrs)*	*0.07 Yrs*
NPV @ lower bound rate (WACC)	6.75%	$0.08m	*IRR%*	*6.87%*

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%	$9.78m	*NPV / Capital (Ratio)*	*0.91*
NPV @ upper bound rate	13.00%	$6.21m	*Pay Back Period (Yrs)*	*3.37 Yrs*
NPV @ lower bound rate (WACC)	6.75%	$15.45m	*IRR%*	*23.74%*

Benefits

Risk cost	As Is	To Be	Benefit		
Systems (reliability)	*$4.52m*	*$2.13m*	*$2.39m*	*VCR Benefit*	*$2.18m*
Financial	*$0.74m*	*$0.14m*	*$0.60m*	*ENS Penalty*	*$0.16m*
Operational/compliance	*$0.00m*	*$0.00m*	*$0.00m*	*All other risk benefits*	*$0.98m*
People (safety)	*$0.34m*	*$0.09m*	*$0.25m*	Total Risk benefits	$3.32m
Environment	*$0.03m*	*$0.02m*	*$0.02m*		
Reputation	*$0.12m*	*$0.06m*	*$0.07m*	Benefits in the financial NPV*	$1.23m
Total Risk benefits	$5.75m	$2.43m	$3.32m	**excludes VCR benefits*	
Cost savings and other benefits			$0.09m	Benefits in the economic NPV**	$3.25m
Total Benefits			$3.41m	***excludes ENS penalty*	

Other Financial Drivers

Incremental opex cost pa (no depreciation)	-$0.01m	Write-off cost	-$0.09m
Capital - initial $m	-$10.80m	Major Asset Life (Yrs)	15.00 Yrs
Residual Value - initial investment	$1.46m	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	Broken Hill Secondary System Renewal - Option B (Commercia

1. Financial Evaluation (excludes VCR benefits)

NPV @ standard discount rate	10.00%	$0.53m	*NPV / Capital (Ratio)*	*0.09*
NPV @ upper bound rate	13.00%	-$0.41m	*Pay Back Period (Yrs)*	*0.12 Yrs*
NPV @ lower bound rate (WACC)	6.75%	$2.06m	*IRR%*	*11.53%*

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%	$12.07m	*NPV / Capital (Ratio)*	*2.05*
NPV @ upper bound rate	13.00%	$8.63m	*Pay Back Period (Yrs)*	*2.00 Yrs*
NPV @ lower bound rate (WACC)	6.75%	$17.43m	*IRR%*	*35.50%*

Benefits

Risk cost	As Is	To Be	Benefit		
Systems (reliability)	*$4.52m*	*$2.13m*	*$2.39m*	*VCR Benefit*	*$2.18m*
Financial	*$0.74m*	*$0.14m*	*$0.60m*	*ENS Penalty*	*$0.16m*
Operational/compliance	*$0.00m*	*$0.00m*	*$0.00m*	*All other risk benefits*	*$0.74m*
People (safety)	*$0.34m*	*$0.33m*	*$0.01m*	Total Risk benefits	$3.08m
Environment	*$0.03m*	*$0.02m*	*$0.01m*	Benefits in the financial NPV*	$0.93m
Reputation	*$0.12m*	*$0.06m*	*$0.07m*	**excludes VCR benefits*	
Total Risk benefits	$5.75m	$2.67m	$3.08m		
Cost savings and other benefits			$0.04m	Benefits in the economic NPV**	$2.95m
Total Benefits			$3.11m	***excludes ENS penalty*	

Other Financial Drivers

Incremental opex cost pa (no depreciation)	-$0.01m	Write-off cost	-$0.09m
Capital - initial $m	-$5.90m	Major Asset Life (Yrs)	15.00 Yrs
Residual Value - initial investment	$0.39m	Re-investment capital	$0.00m
Capitalisation period	3.00 Yrs	Start of the re-investment period	0.00 Yrs

Option C NPV calculation

Project_Option Name	Broken Hill Secondary System Renewal - Option C (Commercia

1. Financial Evaluation (excludes VCR benefits)				
NPV @ standard discount rate	10.00%	-$1.97m	*NPV / Capital (Ratio)*	*-0.52*
NPV @ upper bound rate	13.00%	-$2.01m	*Pay Back Period (Yrs)*	*-0.01 Yrs*
NPV @ lower bound rate (WACC)	6.75%	-$1.81m	*IRR%*	*-0.95%*

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%	$4.54m	*NPV / Capital (Ratio)*	*1.20*
NPV @ upper bound rate	13.00%	$2.83m	*Pay Back Period (Yrs)*	*2.35 Yrs*
NPV @ lower bound rate (WACC)	6.75%	$7.41m	*IRR%*	*24.43%*

Benefits					
Risk cost	As Is	To Be	Benefit	*VCR Benefit*	*$1.50m*
Systems (reliability)	*$4.52m*	*$2.90m*	*$1.62m*	*ENS Penalty*	*$0.12m*
Financial	*$0.74m*	*$0.66m*	*$0.08m*	*All other risk benefits*	*$0.14m*
Operational/compliance	*$0.00m*	*$0.00m*	*$0.00m*	Total Risk benefits	$1.76m
People (safety)	*$0.34m*	*$0.33m*	*$0.01m*		
Environment	*$0.03m*	*$0.02m*	*$0.01m*	Benefits in the financial NPV*	$0.26m
Reputation	*$0.12m*	*$0.08m*	*$0.04m*	**excludes VCR benefits*	
Total Risk benefits	$5.75m	$3.99m	$1.76m		
Cost savings and other benefits			$0.00m	Benefits in the economic NPV**	$1.64m
Total Benefits			$1.76m	***excludes ENS penalty*	

Other Financial Drivers			
Incremental opex cost pa (no depreciation)	-$0.01m	Write-off cost	$0.00m
Capital - initial $m	-$3.80m	Major Asset Life (Yrs)	15.00 Yrs
Residual Value - initial investment	$0.00m	Re-investment capital	-$1.48m
Capitalisation period	5.00 Yrs	Start of the re-investment period	2025-26

Option D NPV calculation

Project_Option Name	Broken Hill Secondary System Renewal - Option A (Commercia

1. Financial Evaluation (excludes VCR benefits)

NPV @ standard discount rate	10.00%	-$2.31m	*NPV / Capital (Ratio)*	*-0.19*
NPV @ upper bound rate	13.00%	-$3.45m	*Pay Back Period (Yrs)*	*0.06 Yrs*
NPV @ lower bound rate (WACC)	6.75%	-$0.36m	*IRR%*	*6.29%*

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%	$15.92m	*NPV / Capital (Ratio)*	*1.29*
NPV @ upper bound rate	13.00%	$10.84m	*Pay Back Period (Yrs)*	*2.72 Yrs*
NPV @ lower bound rate (WACC)	6.75%	$23.91m	*IRR%*	*28.67%*

Benefits

Risk cost	As Is	To Be	Benefit		
Systems (reliability)	*$4.52m*	*$0.97m*	*$3.55m*	*VCR Benefit*	*$3.34m*
Financial	*$0.74m*	*$0.08m*	*$0.66m*	*ENS Penalty*	*$0.15m*
Operational/compliance	*$0.00m*	*$0.00m*	*$0.00m*	*All other risk benefits*	*$1.13m*
People (safety)	*$0.34m*	*$0.00m*	*$0.34m*	Total Risk benefits	$4.62m
Environment	*$0.03m*	*$0.02m*	*$0.01m*	Benefits in the financial NPV*	$1.37m
Reputation	*$0.12m*	*$0.06m*	*$0.06m*	**excludes VCR benefits*	
Total Risk benefits	$5.75m	$1.13m	$4.62m		
Cost savings and other benefits			$0.09m	Benefits in the economic NPV**	$4.56m
Total Benefits			$4.71m	***excludes ENS penalty*	

Other Financial Drivers

Incremental opex cost pa (no depreciation)	-$0.01m	Write-off cost	-$0.09m
Capital - initial $m	-$12.30m	Major Asset Life (Yrs)	15.00 Yrs
Residual Value - initial investment	$0.82m	Re-investment capital	$0.00m
Capitalisation period	4.00 Yrs	Start of the re-investment period	0.00 Yrs