

# OPTIONS EVALUATION REPORT (OER)



Protection - Transformer Diff Condition

OER 000000001386 revision 4.0

**Ellipse project no.:** P0008045

**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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<b>Date submitted for approval</b>	16 December 2016	

## Change history

Revision	Date	Amendment
0	24 June 2016	Initial issue
1	31 October 2016	Update to 2016/17 dollars and SFAIRP/ALARP data
2	17 November 2016	Update to format
3	14 December 2016	Minor amendment – consistent option names
4	16 December 2016	Minor amendment – correct NPV labels

## 1. Need/opportunity

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The assets raised within this Need have been identified to address their end of life condition. Manufacturer support for all models has ceased and spares currently held by TransGrid are exhausted or expected to be exhausted for all models. These assets have higher costs associated with managing and maintaining spares, and the continuing maintenance capability required for obsolete models with a small population.

The use of duplicated protection schemes across all transformers are a continuing requirement of the Australian Energy Regulator (AER) as outlined in the National Electricity Rules (NER). These protection schemes are required into the foreseeable future.

## 2. Related Needs/opportunities

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The following Needs address parts of the omitted relays covered by this Need:

- > Need ID 1180 – Wagga 330kV Secondary Systems Renewal
- > Need ID 1186 – Murrumburrah Secondary Systems Renewal
- > Need ID 1191 – Deniliquin Secondary Systems Renewal
- > Need ID 1192 – Lower Tumut Secondary Systems Renewal
- > Need ID 1193 – Broken Hill Secondary Systems Renewal
- > Need ID 1194 – Tenterfield Secondary Systems Renewal
- > Need ID 1196 – Coleambally Secondary Systems Renewal
- > Need ID 1243 – Tamworth 330kV Secondary Systems Renewal
- > Need ID 1244 – Wallerawang 330kV Secondary Systems Renewal
- > Need ID 1246 – Panorama Secondary Systems Renewal
- > Need ID 1247 – Muswellbrook Secondary Systems Renewal
- > Need ID 1252 – Cowra Secondary Systems Renewal
- > Need ID 1253 – Darlington Point Secondary Systems Renewal
- > Need ID 1255 – Ingleburn Secondary Systems Renewal
- > Need ID 1258 – Regentville Secondary Systems Renewal
- > Need ID 1263 – Tuggerah Secondary Systems Renewal
- > Need ID 1266 – Marulan Secondary Systems Renewal
- > Need ID 1267 – Molong Secondary Systems Renewal
- > Need ID 1599 – Liverpool Secondary Systems Renewal

### 3. Options

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

#### Base Case

The Base Case for this Need is to run these assets to failure. This approach does not address the increasing failure rates or the risk cost associated with the Need. At \$458k per annum, the risks are significant and foreseen to increase as the probability of failure of the assets will also likely increase. Key drivers for this risk cost are:

- > Consequence assumes black start for assets protecting primary plant at 330kV and above with “N-1” redundancy. The restoration time has been set as 8 hours with an assumed 1,296MW of load interrupted to mixed customers (residential, commercial, and agricultural) to model a number of potential network scenarios based on this consequence.
- > The population of this asset group is 23 units across all voltage levels and sites within the network.

Increasing the maintenance for the assets cannot reduce the probability of failure in order to reduce the risk cost.

#### Option A — Replacement of Individual Assets [[OFR 1386A](#), [OFS 1386A](#)]

This option covers the replacement of assets in a “like for like” manner. This involves removing the panel and replacing it with a new relay panel utilising the same features currently in use. This option doesn’t include any upgrade of systems to maximise the utilisation of available technology.

Operating costs have been estimated at \$2.4k per annum for this option based on current maintenance plan settings.

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<sup>1</sup>.

The expected total capital cost to replace every asset identified under this Need is \$3.06m. This costing is estimated using TransGrid’s “Success” estimating system. This cost has been adjusted to \$1.73m for analysis in this OER to account for the reduction of 10 assets that will be replaced under Secondary Systems Renewal Needs or are utilised on negotiated services. This adjustment has been carried out using the unit costs provided in the Option Feasibility Study (OFS).

The residual risk associated with this option upon completion of the project amounts to \$50.7k per annum (base case risk cost = \$458k). The risk reduction is realised through the reduction in the probability of failure for all assets.

The assets under investigation have been categorised into three broad categories:

#### Assets protecting primary assets <330kV and <150MW

This configuration covers only replacing the assets protecting primary assets where the peak load at risk is less than 150MW and service voltage is less than 330kV.

The expected capital cost to replace this category of assets is \$665k. This costing was estimated using the unit costs provided under OFS 1386A and applying them to those assets that would be replaced. These costs are broken down in Table 1.

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<sup>1</sup> Refer SSA Strategy - Renewal and Maintenance - Secondary Systems Site Installations

**Table 1 – Expected costs for assets protecting primary assets <330kV and <150MW (\$ thousand)**

Item	Unit Cost, Including Labour	Quantity	Total Cost
KBCH ≤132kV	133	2	266,000
MBCH ≤132kV	133	1	133,000
MBCH12 ≤132kV	133	2	266,000
<b>Total estimated cost</b>			<b>665,000</b>

The residual risk associated with this portion of assets upon completion of the project amounts to \$9.42k per annum (base case risk cost component = \$51.9k). The risk reduction is realised through the reduction in the probability of failure for the affected assets.

#### **Assets protecting primary assets <330kV and >150MW**

This configuration covers only replacing the assets classified as protecting primary assets where the peak load at risk is greater than 150MW and service voltage is less than 330kV.

No assets within this Need fall under this configuration.

#### **Assets protecting primary assets ≥330kV**

This configuration covers only replacing the assets classified as protecting primary assets operating at 330kV and above.

The expected capital cost is \$1.06m. This costing was estimated using the unit costs provided under OFS 1386A and applying them to those assets that would be replaced. These costs are broken down in Table 2.

**Table 2 – Expected costs for assets protecting primary assets ≥330kV (\$ thousand)**

Item	Unit Cost, Including Labour	Quantity	Total Cost
KBCH ≥330kV	133.04	3	399,000
MBCH ≥330kV	133.04	5	665,000
MBCH12 ≥330kV	133.04	0	0
<b>Total estimated cost</b>			<b>1,060</b>

The residual risk associated with this portion of upon completion of the project amounts to \$41.2k per annum (base case risk cost component = \$406k). The risk reduction is realised through the reduction in the probability of failure for the affected assets.

## **4. Evaluation**

Evaluation of the proposed options has been completed using the SFAIRP/ALARP (as low as reasonably practical) 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 options is summarised in the Table 3.

**Table 3 – 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	NA	0.002	0.458	NA	NA	2
<b>A</b>	Replace individual Assets	1.73	0.002	0.0507	0.60	(0.96)	1 <sup>2</sup>
<b>i)</b>	Replace <150MW Assets	0.665	0.001	0.00942	(0.31)	(0.39)	-
<b>ii)</b>	Replace >150MW Assets	-	-	-	-	-	-
<b>iii)</b>	Replace >=330kV Assets	1.06	0.002	0.0412	0.91	(0.55)	-

The commercial evaluation is based on:

- > Economic life of the assets is assumed 15 years, hence this assessment period has been applied
- > Write-offs have not been estimated
- > Capital cost is not escalated and it does not include capitalised interest

Sensitivities on economic Net Present Value (NPV) for the options with changing discount rates are shown in Table 4.

**Table 4 – Discount rate sensitivities (\$ million)**

Option	Description	Economic NPV @13%	Economic NPV @6.75%
<b>A</b>	Replace individual Assets	0.20	1.27
<b>i)</b>	Replace <150MW Assets	(0.32)	(0.27)
<b>ii)</b>	Replace >150MW Assets	-	-
<b>iii)</b>	Replace >=330kV Assets	0.53	1.55

## 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 5.

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:

<sup>2</sup> This option is ranked 1 only for those categories of assets that provide a positive NPV.

- > 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 are summarised in the tables below.

**Table 5 – Feasible options (\$ thousand)**

Option	Description	CAPEX	Expected Life	Annualised CAPEX
Base	Run-to-fail	N/A	N/A	N/A
A	Replace individual Assets	1,730	15 years	120

**Table 6 – Annual risk calculations (\$ thousand)**

Option	Annual Residual Risk			Annual Risk Savings		
	Safety Risk	Reliability Risk	Bushfire Risk	Safety Risk	Reliability Risk	Bushfire Risk
Base	0	355	0	N/A	N/A	N/A
A	0	30	0	0	325	0

**Table 7 – Reasonably practicable test (\$ thousand)**

Option	Network Safety Risk Reduction <sup>3</sup>	Annualised CAPEX	Reasonably practicable <sup>4</sup> ?
A	33	120	No

Option A is not reasonably practicable.

### 4.3 Preferred option

The outcome of the SFAIRP/ALARP evaluation is that none of the options presented in Table 5 are reasonably practicable, and are therefore not required to satisfy the organisation's SFAIRP/ALARP obligations.

The preferred option to address the condition of the identified assets is Option A (iii) – Replacement of Assets ≥330kV.

This option has been selected due to its technical viability and reduction in reliability risk. This option provides significant technical benefits and provides the greatest positive NPV.

Refer to Attachment 1 for details of the assets to be replaced under this Need.

#### Capital and operating expenditure

There is negligible difference in predicted ongoing operational expenditure between the option and base case. Implementing Option A (iii) will reduce callouts to address defects and this benefit has been captured in the risk assessment. These have been captured as benefits for delivering the project.

<sup>3</sup> The Network Safety Risk Reduction is calculated as 6 x Bushfire Risk Reduction + 3 x Safety Risk Reduction + 0.1 x Reliability Risk Reduction

<sup>4</sup> Reasonably practicable is defined as whether the annualised CAPEX is less than the Network Safety Risk Reduction

## 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

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It is recommended to proceed with the replacement of 8 identified relays protecting assets  $\geq 330\text{kV}$ .

## Attachment 1 – Assets for replacement

### A.1 Assets protecting $\geq 330\text{kV}$

**Table 8 – KBCH**

EQUIP_NO	EQUIP_CLASS	PLANT_NO	ITEM_NAME_1	EQUIP_LOCATION
000000076705	PT	NNPMN1CR1271AF31	NO3 330/132/11KV TRANSFORMER NO1 PROT	MN1
000000009946	PT	CMPSYSCR4221D1	NO5 330/132/11KV TRANSFORMER NO1 PROT	SYS
000000009949	PT	CMPSYSCR4181F1	NO6 330/132/11KV TRANSFORMER NO1 PROT	SYS

**Table 9 – MBCH**

EQUIP_NO	EQUIP_CLASS	PLANT_NO	ITEM_NAME_1	EQUIP_LOCATION
000000048720	PT	NTPAR1CR66B1C2	NO3 330/132/11KV TRANSFORMER NO2 PROT	AR1
000000053798	PT	NTPLSMCRA061A1	NO1 330/132/11KV TRANSFORMER NO1 PROT	LSM
000000053801	PT	NTPLSMCRA101B1	NO2 330/132/11KV TRANSFORMER NO1 PROT	LSM
000000048726	PT	NTPAR1CR70B1A2	NO6 330/132/11KV TRANSFORMER NO2 PROT	AR1
000000076465	PT	NTPAR1CREP21M2	NO1 STATIC VAR COMPENSATOR NO2 PROT	AR1

## Attachment 2 – Commercial evaluation report

### Option A NPV calculation

Project_Option Name		Option A - Individual Asset Replacements - All Assets			
<b>1. Financial Evaluation</b> (excludes VCR benefits)					
NPV @ standard discount rate	10.00%	-\$0.96m	NPV / Capital (Ratio)	-0.55	
NPV @ upper bound rate	13.00%	-\$0.96m	Pay Back Period (Yrs)	-0.04 Yrs	
NPV @ lower bound rate (WACC)	6.75%	-\$0.93m	IRR%	-4.19%	
<b>2. Economic Evaluation</b> (includes VCR benefits but excludes tax benefits from non-cash transactions, ENS penalty and overall tax cost)					
NPV @ standard discount rate	10.00%	\$0.60m	NPV / Capital (Ratio)	0.35	
NPV @ upper bound rate	13.00%	\$0.20m	Pay Back Period (Yrs)	4.27 Yrs	
NPV @ lower bound rate (WACC)	6.75%	\$1.27m	IRR%	15.21%	
<b>Benefits</b>					
Risk cost	As Is	To Be	Benefit	VCR Benefit	\$0.33m
Systems (reliability)	\$0.36m	\$0.03m	\$0.33m	ENS Penalty	\$0.00m
Financial	\$0.10m	\$0.02m	\$0.08m	All other risk benefits	\$0.08m
Operational/compliance	\$0.00m	\$0.00m	\$0.00m	Total Risk benefits	\$0.41m
People (safety)	\$0.00m	\$0.00m	\$0.00m	Benefits in the financial NPV*	\$0.08m
Environment	\$0.00m	\$0.00m	\$0.00m	*excludes VCR benefits	
Reputation	\$0.00m	\$0.00m	\$0.00m	Benefits in the economic NPV**	\$0.41m
Total Risk benefits	\$0.46m	\$0.05m	\$0.41m	**excludes ENS penalty	
Cost savings and other benefits			\$0.00m		
Total Benefits			\$0.41m		
<b>Other Financial Drivers</b>					
Incremental opex cost pa (no depreciation)			-\$0.00m	Write-off cost	\$0.00m
Capital - initial \$m			-\$1.73m	Major Asset Life (Yrs)	15.00 Yrs
Residual Value - initial investment			\$0.00m	Re-investment capital	\$0.00m
Capitalisation period			5.00 Yrs	Start of the re-investment period	0.00 Yrs

## Option A(i) NPV calculation

Project_Option Name			Option A - Individual Asset Replacements - Less than 150MW		
<b>1. Financial Evaluation</b> (excludes VCR benefits)					
NPV @ standard discount rate	10.00%	-\$0.39m	NPV / Capital (Ratio)	-0.58	
NPV @ upper bound rate	13.00%	-\$0.38m	Pay Back Period (Yrs)	-0.05 Yrs	
NPV @ lower bound rate (WACC)	6.75%	-\$0.38m	IRR%	-5.37%	
<b>2. Economic Evaluation</b> (includes VCR benefits but excludes tax benefits from non-cash transactions, ENS penalty and overall tax cost)					
NPV @ standard discount rate	10.00%	-\$0.31m	NPV / Capital (Ratio)	-0.47	
NPV @ upper bound rate	13.00%	-\$0.32m	Pay Back Period (Yrs)	Not measurable	
NPV @ lower bound rate (WACC)	6.75%	-\$0.27m	IRR%	-0.75%	
<b>Benefits</b>					
Risk cost	As Is	To Be	Benefit	VCR Benefit	\$0.02m
Systems (reliability)	\$0.02m	\$0.00m	\$0.02m	ENS Penalty	\$0.00m
Financial	\$0.03m	\$0.01m	\$0.03m	All other risk benefits	\$0.03m
Operational/compliance	\$0.00m	\$0.00m	\$0.00m	Total Risk benefits	\$0.04m
People (safety)	\$0.00m	\$0.00m	\$0.00m	Benefits in the financial NPV*	\$0.03m
Environment	\$0.00m	\$0.00m	\$0.00m	*excludes VCR benefits	
Reputation	\$0.00m	\$0.00m	\$0.00m	Benefits in the economic NPV**	\$0.04m
Total Risk benefits	\$0.05m	\$0.01m	\$0.04m	**excludes ENS penalty	
Cost savings and other benefits			\$0.00m		
Total Benefits			\$0.04m		
<b>Other Financial Drivers</b>					
Incremental opex cost pa (no depreciation)			-\$0.00m	Write-off cost	\$0.00m
Capital - initial \$m			-\$0.67m	Major Asset Life (Yrs)	15.00 Yrs
Residual Value - initial investment			\$0.00m	Re-investment capital	\$0.00m
Capitalisation period			5.00 Yrs	Start of the re-investment period	0.00 Yrs

## Option A(iii) NPV calculation

Project\_Option Name

Option A - Individual Asset Replacements - >=330kV

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

NPV @ standard discount rate	10.00%	-\$0.55m	NPV / Capital (Ratio)	-0.52
NPV @ upper bound rate	13.00%	-\$0.56m	Pay Back Period (Yrs)	-0.03 Yrs
NPV @ lower bound rate (WACC)	6.75%	-\$0.52m	IRR%	-2.70%

### 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%	\$0.91m	NPV / Capital (Ratio)	0.86
NPV @ upper bound rate	13.00%	\$0.53m	Pay Back Period (Yrs)	2.91 Yrs
NPV @ lower bound rate (WACC)	6.75%	\$1.55m	IRR%	21.23%

### Benefits

Risk cost	As Is	To Be	Benefit		
<i>Systems (reliability)</i>	\$0.34m	\$0.03m	\$0.31m	VCR Benefit	\$0.31m
<i>Financial</i>	\$0.07m	\$0.01m	\$0.06m	ENS Penalty	\$0.00m
<i>Operational/compliance</i>	\$0.00m	\$0.00m	\$0.00m	All other risk benefits	\$0.06m
<i>People (safety)</i>	\$0.00m	\$0.00m	\$0.00m	Total Risk benefits	\$0.37m
<i>Environment</i>	\$0.00m	\$0.00m	\$0.00m	Benefits in the financial NPV*	\$0.06m
<i>Reputation</i>	\$0.00m	\$0.00m	\$0.00m	*excludes VCR benefits	
Total Risk benefits	\$0.41m	\$0.04m	\$0.37m	Benefits in the economic NPV**	\$0.37m
Cost savings and other benefits			\$0.00m	**excludes ENS penalty	
Total Benefits			\$0.37m		

### Other Financial Drivers

Incremental opex cost pa (no depreciation)	-\$0.00m	Write-off cost	\$0.00m
Capital - initial \$m	-\$1.06m	Major Asset Life (Yrs)	15.00 Yrs
Residual Value - initial investment	\$0.00m	Re-investment capital	\$0.00m
Capitalisation period	5.00 Yrs	Start of the re-investment period	0.00 Yrs