

# OPTIONS EVALUATION REPORT (OER)



Protection - ABB Relays Condition

OER 000000001377 revision 2.0

**Ellipse project no.:** P0008020

**TRIM file:** [TRIM No]

**Project reason:** Capability - Obsolescence/Manufacturer support withdrawn

**Project category:** Prescribed - Asset Renewal Strategies

## Approvals

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<b>Date submitted for approval</b>	15 December 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 December 2016	Update to format

## 1. Need/opportunity

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Most of the assets raised within this Need will have exceeded their nominal average life by 2023. These relays have started to exhibit end of life characteristics. The fault rates for these relays are increasing and this behaviour is compounded by the fact that the majority of TransGrid staff who are experienced in the repair and maintenance of these relays have now retired. All spares are currently obtained from old equipment for this model and are projected to be exhausted.

The use of duplicated protection schemes across all transmission lines and 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 \$0.47m per annum<sup>1</sup>, 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 8 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 1377A, OFS 1377A]

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 \$1.50k 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>2</sup>.

The expected total capital cost to replace 23 identified assets under this Need is \$2.97m. This costing is estimated using TransGrid’s “Success” estimating system. This cost has been adjusted to \$1.03m for analysis in this OER to account for the reduction of 15 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 \$0.03m per annum (base case risk cost = \$0.47m). The risk reduction is realised through the reduction in the probability of failure for all assets.

The assets under investigation have been divided into two broad categories:

### Assets protecting primary assets ≤220kV and ≤150MW

This configuration covers only replacing the assets protecting primary assets where the peak load at risk is less than or equal to 150MW and service voltage is less or equal to 220kV.

The expected capital cost to replace this category of assets is \$0.40m. This costing was estimated using the unit costs provided under OFS 1377A 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> This risk cost accounts for the 8 remaining RADSB relays. The total risk cost in the IRT output is stated as \$5.43m per annum but it includes negotiated assets in GAD site and other RADHL and RADHA relays across UT11, TP1 and TP2 sites which are being replaced in 2016/17. Excluding these assets, the total risk cost amounts to \$0.47m per annum. Please refer to the IRT output risk cost calculation in MS Excel spreadsheet uploaded to supporting documents.

<sup>2</sup> Refer SSA Strategy - Renewal and Maintenance -Secondary Systems Site Installations

**Table 1 – Expected costs for replacing assets protecting primary assets ≤220kV and ≤150MW (\$ thousand)**

Item	Unit Cost, Including Labour	Quantity	Total Cost
Transformer Protection ≤220kV, ≤150MW	133	3	399
<b>Total estimated cost</b>			<b>399</b>

The residual risk associated with this portion of assets upon completion of the project amounts to \$0.00m per annum (base case risk cost component = \$0.05m). The risk reduction is realised through the reduction in the probability of failure for the affected assets.

#### 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 to replace this category of assets is \$0.67m. This costing was estimated using the unit costs provided under OFS 1377A and applying them to those assets that would be replaced. These costs are broken down in Table 2.

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

Item	Unit Cost, Including Labour	Quantity	Total Cost
Transformer Protection ≥330kV	133	5	665
<b>Total estimated cost</b>			<b>665</b>

The residual risk associated with this portion of upon completion of the project amounts to \$0.03m per annum (base case risk cost component = \$0.41m). 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 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 3.

**Table 3 – 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	N/A	0	0.47	N/A	N/A	2

Option	Description	Total capex	Annual opex	Annual post project risk cost	Economic NPV @10%	Financial NPV @10%	Rank
A	Replace individual Assets	1.03	0	0.03	1.29	(0.37)	1 <sup>3</sup>
i)	Replace Assets ≤220kV, ≤150MW	0.40	0	0	(0.07)	(0.16)	-
ii)	Replace Assets ≥330kV	0.67	0	0.03	1.31	(0.20)	-

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%
A	Replace individual Assets	0.81	2.07
i)	Replace Assets ≤220kV, ≤150MW	(0.11)	0.01
ii)	Replace Assets ≥330kV	0.88	2.01

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

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

<sup>3</sup> This option is ranked 1 only for those categories of assets that provide a positive NPV.

**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	1,032	15 years	70

**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	370	0	N/A	N/A	N/A
A	0	20	0	0	350	0

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

Option	Network Safety Risk Reduction <sup>4</sup>	Annualised CAPEX	Reasonably practicable <sup>5</sup> ?
A	35	70	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 (ii) – 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.

#### Capital and operating expenditure

There is negligible difference in predicted ongoing operational expenditure between the option and Base Case. Implementing Option A will reduce callouts to address defects and this benefit has been captured in the risk assessment.

#### 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.

<sup>4</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>5</sup> Reasonably practicable is defined as whether the annualised CAPEX is less than the Network Safety Risk Reduction

## 5. Recommendation

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It is recommended to proceed with the replacement of all 5 identified assets.

## Attachment 1 – Assets for replacement

### A.1 Protection for <220kV and <150MW Assets

EQUIP_NO	EQUIP_CLASS	PLANT_NO	ITEM_NAME_1	EQUIP_LOCATION
00000071352	PT	COPMPPCRB151A1	NO1 132/66/11KV TRANSFORMER NO1 PROT	MPP
00000071350	PT	COPMPPCRB171B1	NO2 132/66/11KV TRANSFORMER NO1 PROT	MPP
00000057930	PT	COPPKSCRC121B1	NO2 132/66/11KV TRANSFORMER NO1 PROT	PKS

### A.2 Protection for ≥330MW Assets

EQUIP_NO	EQUIP_CLASS	PLANT_NO	ITEM_NAME_1	EQUIP_LOCATION
00000048719	PT	NTPAR1CR66T1C1	NO3 330/132/11KV TRANSFORMER NO1 PROT	AR1
00000053799	PT	NTPLSMCRA071A2	NO1 330/132/11KV TRANSFORMER NO2 PROT	LSM
00000053802	PT	NTPLSMCRA111B2	NO2 330/132/11KV TRANSFORMER NO2 PROT	LSM
00000048725	PT	NTPAR1CR70T1A1	NO6 330/132/11KV TRANSFORMER NO1 PROT	AR1
00000076706	PT	NNPMN1CR1271AF32	NO3 330/132/11KV TRANSFORMER NO2 PROT	MN1

## 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%	-\$0.37m	NPV / Capital (Ratio)	-0.36	
NPV @ upper bound rate	13.00%	-\$0.42m	Pay Back Period (Yrs)	0.03 Yrs	
NPV @ lower bound rate (WACC)	6.75%	-\$0.26m	IRR%	2.53%	
<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%	\$1.29m	NPV / Capital (Ratio)	1.25	
NPV @ upper bound rate	13.00%	\$0.81m	Pay Back Period (Yrs)	2.35 Yrs	
NPV @ lower bound rate (WACC)	6.75%	\$2.07m	IRR%	24.97%	
<b>Benefits</b>					
Risk cost	As Is	To Be	Benefit	VCR Benefit	\$0.35m
Systems (reliability)	\$0.37m	\$0.02m	\$0.35m	ENS Penalty	\$0.00m
Financial	\$0.10m	\$0.01m	\$0.09m	All other risk benefits	\$0.09m
Operational/compliance	\$0.00m	\$0.00m	\$0.00m	Total Risk benefits	\$0.44m
People (safety)	\$0.00m	\$0.00m	\$0.00m	Benefits in the financial NPV*	\$0.09m
Environment	\$0.00m	\$0.00m	\$0.00m	*excludes VCR benefits	
Reputation	\$0.00m	\$0.00m	\$0.00m	Benefits in the economic NPV**	\$0.44m
Total Risk benefits	\$0.47m	\$0.03m	\$0.44m	**excludes ENS penalty	
Cost savings and other benefits			\$0.00m		
Total Benefits			\$0.44m		
<b>Other Financial Drivers</b>					
Incremental opex cost pa (no depreciation)			-\$0.00m	Write-off cost	\$0.00m
Capital - initial \$m			-\$1.03m	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 - <=220kV and <=151

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

NPV @ standard discount rate	10.00%	-\$0.16m	NPV / Capital (Ratio)	-0.40
NPV @ upper bound rate	13.00%	-\$0.18m	Pay Back Period (Yrs)	0.01 Yrs
NPV @ lower bound rate (WACC)	6.75%	-\$0.13m	IRR%	1.49%

### 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%	-\$0.07m	NPV / Capital (Ratio)	-0.17
NPV @ upper bound rate	13.00%	-\$0.11m	Pay Back Period (Yrs)	8.09 Yrs
NPV @ lower bound rate (WACC)	6.75%	\$0.01m	IRR%	6.98%

### Benefits

Risk cost	As Is	To Be	Benefit		
<i>Systems (reliability)</i>	\$0.02m	\$0.00m	\$0.02m	VCR Benefit	\$0.02m
<i>Financial</i>	\$0.03m	\$0.00m	\$0.03m	ENS Penalty	\$0.00m
<i>Operational/compliance</i>	\$0.00m	\$0.00m	\$0.00m	All other risk benefits	\$0.03m
<i>People (safety)</i>	\$0.00m	\$0.00m	\$0.00m	Total Risk benefits	\$0.05m
<i>Environment</i>	\$0.00m	\$0.00m	\$0.00m	Benefits in the financial NPV*	\$0.03m
<i>Reputation</i>	\$0.00m	\$0.00m	\$0.00m	*excludes VCR benefits	
Total Risk benefits	\$0.05m	\$0.00m	\$0.05m	Benefits in the economic NPV**	\$0.05m
Cost savings and other benefits			\$0.00m	**excludes ENS penalty	
Total Benefits			\$0.05m		

### Other Financial Drivers

Incremental opex cost pa (no depreciation)	-\$0.00m	Write-off cost	\$0.00m
Capital - initial \$m	-\$0.40m	Major Asset Life (Yrs)	15.00 Yrs
Residual Value - initial investment	\$0.03m	Re-investment capital	\$0.00m
Capitalisation period	5.00 Yrs	Start of the re-investment period	0.00 Yrs

## Option A(ii) NPV calculation

Project\_Option Name

Option A - Individual Asset Replacements - >=330kV

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

NPV @ standard discount rate	10.00%	-\$0.20m	NPV / Capital (Ratio)	-0.31
NPV @ upper bound rate	13.00%	-\$0.24m	Pay Back Period (Yrs)	0.04 Yrs
NPV @ lower bound rate (WACC)	6.75%	-\$0.12m	IRR%	3.81%

### 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%	\$1.31m	NPV / Capital (Ratio)	1.97
NPV @ upper bound rate	13.00%	\$0.88m	Pay Back Period (Yrs)	1.73 Yrs
NPV @ lower bound rate (WACC)	6.75%	\$2.01m	IRR%	30.85%

### Benefits

Risk cost	As Is	To Be	Benefit		
<i>Systems (reliability)</i>	\$0.34m	\$0.02m	\$0.32m	VCR Benefit	\$0.32m
<i>Financial</i>	\$0.07m	\$0.01m	\$0.07m	ENS Penalty	\$0.00m
<i>Operational/compliance</i>	\$0.00m	\$0.00m	\$0.00m	All other risk benefits	\$0.07m
<i>People (safety)</i>	\$0.00m	\$0.00m	\$0.00m	Total Risk benefits	\$0.39m
<i>Environment</i>	\$0.00m	\$0.00m	\$0.00m	Benefits in the financial NPV*	\$0.07m
<i>Reputation</i>	\$0.00m	\$0.00m	\$0.00m	*excludes VCR benefits	
Total Risk benefits	\$0.41m	\$0.03m	\$0.39m	Benefits in the economic NPV**	\$0.39m
Cost savings and other benefits			\$0.00m	**excludes ENS penalty	
Total Benefits			\$0.39m		

### Other Financial Drivers

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