

OPTIONS EVALUATION REPORT (OER)



Protection - Capacitor Condition

OER 000000001387 revision 3.0

Ellipse project no.: P0008047

TRIM file: [TRIM No]

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

Project category: Prescribed - Asset Renewal Strategies

Approvals

Author	Adam Hoare	Senior Secondary Systems Analyst
Endorsed	Hazem Khamis	Secondary Systems Strategist
	Azil Khan	Investment Analysis Manager
Approved	Lance Wee	M/Asset Strategy
Date submitted for approval	14 December 2016	

Change history

Revision	Date	Amendment
0	17 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

1. Need/opportunity

Capacitor protection relays are used throughout the NSW network to protect high voltage capacitor banks at all voltage levels. The assets investigated under this Need are a variety of models of protective relays that have reached the end of their technical life resulting in reduced capabilities to meet reliability performance requirements.

The use of duplicated protection schemes across all capacitor banks 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

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

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 deteriorating condition of the assets or the risk cost associated with the Need. At \$1.50m per annum, the risks are foreseen to increase as the probability of failure of the assets will also likely increase. Key drivers for this risk cost are:

- > Estimated average future probability of asset failure is approximately 10.9%
- > 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.
- > Inability to acquire spares

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 1387A](#), [OFS 1387A](#)]

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 \$10.3k 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 Installations¹.

The expected total capital cost to replace all 135 assets identified under this Need is \$10.75m. This costing is estimated using TransGrid’s “Success” estimating system. For this OER, the quantity of asset replacements has been reduced to 83 and cost has been adjusted to \$6.77m to account for 39 assets that will be replaced under Secondary Systems Renewal Needs. 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 \$0.17m per annum (base case risk cost = \$1.50m). 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 \$4.78m. This costing was estimated using the unit costs provided under OFS 1387A and applying them to those assets that would be replaced. These costs are broken down in Table 1.

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

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

Item	Unit Cost, Including Labour	Quantity	Total Cost
Relay Capacitor	79.6	60	4,780
Total estimated cost			4,780

The residual risk associated with this portion of assets upon completion of the project amounts to \$0.05m per annum (base case risk cost component = \$0.77m). 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 protecting primary assets where the peak load at risk is greater than 150MW and service voltage is less than 330kV.

The expected capital cost to replace this category of assets is \$1.51m. This costing was estimated using the unit costs provided under OFS 1387A and applying them to those assets that would be replaced. These costs are broken down Table 2.

Table 2 – Expected cost for assets protecting primary assets <330kV and >150MW (\$ thousand)

Item	Unit Cost, Including Labour	Quantity	Total Cost
Relay Capacitor	79.6	19	1,510
Total estimated cost			1,510

The residual risk associated with this portion of assets upon completion of the project amounts to \$0.07m per annum (base case risk cost component = \$0.62m). 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 protecting primary assets where the service voltage is greater than or equal to 330kV.

The expected capital cost to replace this category of assets is \$0.318m. This costing was estimated using the unit costs provided under OFS 1387A and applying them to those assets that would be replaced. These costs are broken down in Table 3.

Table 3 – Expected cost for assets protecting primary assets >330kV (\$ thousand)

Item	Unit Cost, Including Labour	Quantity	Total Cost
Relay Capacitor	79.6	4	318,000
Total estimated cost			318,000

The residual risk associated with this portion of assets upon completion of the project amounts to \$0.01m per annum (base case risk cost component = \$0.13m). 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 4.

Table 4 – 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	NA	0.021	1.51	NA	NA	2
A	Replace individual Assets	6.77	0.010	0.17	1.09	(1.94)	1
i)	Replace <150MW Assets	4.78	0.008	0.05	(0.27)	(1.03)	-
ii)	Replace >150MW Assets	1.51	0.002	0.07	1.41	(0.55)	-
iii)	Replace >=330kV Assets	0.318	0.001	0.01	0.31	(0.07)	-

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 all three options with changing discount rates are shown in Table 5.

Table 5 – Discount rate sensitivities (\$ million)

Option	Description	Economic NPV @13%	Economic NPV @6.75%
A	Replace individual Assets	(0.14)	3.20
i)	Replace <150MW Assets	(0.87)	0.79
ii)	Replace >150MW Assets	0.84	2.37
iii)	Replace >=330kV Assets	0.19	0.52

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 6.

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

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

Table 6 – Feasible options (\$ thousand)

Option	Description	CAPEX	Expected Life	Annualised CAPEX
Base	Run-to-fail	N/A	N/A	N/A
A	Replace individual Assets	6,770	15 years	450

Table 7 – Annual risk calculations (\$ thousand)

Option	Annual Residual Risk			Annual Risk Savings		
	Safety Risk	Reliability Risk	Bushfire Risk	Safety Risk	Reliability Risk	Bushfire Risk
Base	10	710	0	N/A	N/A	N/A
A	0	70	0	10	640	10

Table 8 - Reasonably practicable test (\$ thousand)

Option	Network Safety Risk Reduction ²	Annualised CAPEX	Reasonably practicable ³ ?
A	94	450	No

Option A is not reasonably practicable.

4.3 Preferred option

The outcome of the SFAIRP/ALARP evaluation is that Option A is beyond reasonably practicable to provide the greatest network safety risk reduction, and is therefore not required to satisfy the organisation's SFAIRP/ALARP obligations.

The option to address the condition of the identified assets is Option A (ii) – Replacement of Assets >150MW and (iii) - Replacement of Assets >330kV. This option has been selected due to its technical viability and positive economic NPV.

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

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

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. 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 recommended to proceed with the replacement of 23 identified assets with capex estimate of \$1.83m.

Attachment 1 – Assets for replacement

A.1 Assets protecting $\geq 150\text{MW}$

Table 9 – Assets protecting $\geq 150\text{MW}$

EQUIP_NO	EQUIP_CLASS	PLANT_NO	ITEM_NAME_1	EQUIP_LOCATION
000000057359	PT	SYPCA1CR89T2E1	NO2 132KV CAPACITOR NO1 PROTECTION	CA1
000000084922	PT	SYPCA1CR90T2W1	NO3 132KV CAPACITOR NO1 PROTECTION	CA1
000000010190	PT	CMPDPTCR1092V21	NO2 132KV CAPACITOR NO1 PROTECTION	DPT
000000010188	PT	CMPDPTCR1072J21	NO1 132KV CAPACITOR NO1 PROTECTION	DPT
000000020478	PT	NNPNEWCR90T2EE1	NO1 132KV CAPACITOR NO1 PROTECTION	NEW
000000020479	PT	NNPNEWCR90B2EE2	NO1 132KV CAPACITOR NO2 PROTECTION	NEW
000000020484	PT	NNPNEWCR91T2FE1	NO2 132KV CAPACITOR NO1 PROTECTION	NEW
000000075632	PT	NNPNEWCR89T2HZ1	NO4 132KV CAPACITOR NO1 PROTECTION	NEW
000000075633	PT	NNPNEWCR89B2HZ2	NO4 132KV CAPACITOR NO2 PROTECTION	NEW
000000075635	PT	NNPNEWCR88T2GZ1	NO3 132KV CAPACITOR NO1 PROTECTION	NEW
000000075636	PT	NNPNEWCR88B2GZ2	NO3 132KV CAPACITOR NO2 PROTECTION	NEW
000000073019	PT	CMPSE1CR1992FU1	NO1 132KV CAPACITOR NO1 PROTECTION	SE1
000000074539	PT	CMPSE1CR2002JS1	NO2 132KV CAPACITOR NO1 PROTECTION	SE1
000000073020	PT	CMPSE1CR1992FU2	NO1 132KV CAPACITOR NO2 PROTECTION	SE1
000000074540	PT	CMPSE1CR2002JS2	NO2 132KV CAPACITOR NO2 PROTECTION	SE1
000000010007	PT	CMPSYSCR3142K11	NO1 132KV CAPACITOR NO1 PROTECTION	SYS
000000010008	PT	CMPSYSCR3142K12	NO1 132KV CAPACITOR NO2 PROTECTION	SYS
000000073025	PT	CMPVYDCRG112K1	NO1 132KV CAPACITOR NO1 PROTECTION	VYD

EQUIP_NO	EQUIP_CLASS	PLANT_NO	ITEM_NAME_1	EQUIP_LOCATION
000000073023	PT	CMPVYDCRG102K2	NO1 132KV CAPACITOR NO2 PROTECTION	VYD

A.2 Assets protecting $\geq 330\text{kV}$

Table 10 – Assets protecting $\geq 330\text{kV}$

EQUIP_NO	EQUIP_CLASS	PLANT_NO	ITEM_NAME_1	EQUIP_LOCATION
000000089370	PT	CMPKCRCRXXX1L1	NO2 330KV CAPACITOR NO1 PROTECTION	KCR
000000084050	PT	NNPTOMCRD3T1M1	NO1 330KV CAPACITOR NO1 PROTECTION	TOM
000000085043	PT	NNPVP1CR8381BD1	NO1 330KV CAPACITOR NO1 PROTECTION	VP1
000000085047	PT	NNPVP1CR8371AD1	NO2 330KV CAPACITOR NO1 PROTECTION	VP1

Attachment 2 – Commercial evaluation report

Option A NPV calculation

Project_Option Name			Option A - Individual Asset Replacements - All Assets		
1. Financial Evaluation (excludes VCR benefits)					
NPV @ standard discount rate	10.00%	-\$1.94m	NPV / Capital (Ratio)	-0.29	
NPV @ upper bound rate	13.00%	-\$2.39m	Pay Back Period (Yrs)	0.04 Yrs	
NPV @ lower bound rate (WACC)	6.75%	-\$1.07m	IRR%	4.28%	
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%	\$1.09m	NPV / Capital (Ratio)	0.16	
NPV @ upper bound rate	13.00%	-\$0.14m	Pay Back Period (Yrs)	5.13 Yrs	
NPV @ lower bound rate (WACC)	6.75%	\$3.20m	IRR%	12.58%	
Benefits					
Risk cost	As Is	To Be	Benefit	VCR Benefit	\$0.64m
Systems (reliability)	\$0.71m	\$0.07m	\$0.64m	ENS Penalty	\$0.00m
Financial	\$0.78m	\$0.10m	\$0.68m	All other risk benefits	\$0.69m
Operational/compliance	\$0.00m	\$0.00m	\$0.00m	Total Risk benefits	\$1.33m
People (safety)	\$0.01m	\$0.00m	\$0.01m	Benefits in the financial NPV*	\$0.69m
Environment	\$0.00m	\$0.00m	\$0.00m	*excludes VCR benefits	
Reputation	\$0.00m	\$0.00m	\$0.00m	Benefits in the economic NPV**	\$1.33m
Total Risk benefits	\$1.50m	\$0.17m	\$1.33m	**excludes ENS penalty	
Cost savings and other benefits			\$0.00m		
Total Benefits			\$1.33m		
Other Financial Drivers					
Incremental opex cost pa (no depreciation)			-\$0.01m	Write-off cost	\$0.00m
Capital - initial \$m			-\$6.77m	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 - Protecting less than 1%

1. Financial Evaluation (excludes VCR benefits)

NPV @ standard discount rate	10.00%	-\$1.03m	NPV / Capital (Ratio)	-0.21
NPV @ upper bound rate	13.00%	-\$1.43m	Pay Back Period (Yrs)	0.06 Yrs
NPV @ lower bound rate (WACC)	6.75%	-\$0.28m	IRR%	5.89%

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%	-\$0.27m	NPV / Capital (Ratio)	-0.06
NPV @ upper bound rate	13.00%	-\$0.87m	Pay Back Period (Yrs)	6.72 Yrs
NPV @ lower bound rate (WACC)	6.75%	\$0.79m	IRR%	9.00%

Benefits

Risk cost	As Is	To Be	Benefit		
Systems (reliability)	\$0.16m	\$0.00m	\$0.16m	VCR Benefit	\$0.16m
Financial	\$0.61m	\$0.05m	\$0.56m	ENS Penalty	\$0.00m
Operational/compliance	\$0.00m	\$0.00m	\$0.00m	All other risk benefits	\$0.56m
People (safety)	\$0.00m	\$0.00m	\$0.00m	Total Risk benefits	\$0.72m
Environment	\$0.00m	\$0.00m	\$0.00m	Benefits in the financial NPV*	\$0.56m
Reputation	\$0.00m	\$0.00m	\$0.00m	*excludes VCR benefits	
Total Risk benefits	\$0.77m	\$0.05m	\$0.72m	Benefits in the economic NPV**	\$0.72m
Cost savings and other benefits			\$0.00m	**excludes ENS penalty	
Total Benefits			\$0.72m		

Other Financial Drivers

Incremental opex cost pa (no depreciation)	-\$0.01m	Write-off cost	\$0.00m
Capital - initial \$m	-\$4.78m	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(ii) NPV calculation

Project_Option Name

Option A - Individual Asset Replacements - Protecting greater th

1. Financial Evaluation (excludes VCR benefits)

NPV @ standard discount rate	10.00%	-\$0.55m	NPV / Capital (Ratio)	-0.36
NPV @ upper bound rate	13.00%	-\$0.62m	Pay Back Period (Yrs)	0.02 Yrs
NPV @ lower bound rate (WACC)	6.75%	-\$0.41m	IRR%	2.29%

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%	\$1.41m	NPV / Capital (Ratio)	0.94
NPV @ upper bound rate	13.00%	\$0.84m	Pay Back Period (Yrs)	2.78 Yrs
NPV @ lower bound rate (WACC)	6.75%	\$2.37m	IRR%	22.01%

Benefits

Risk cost	As Is	To Be	Benefit	VCR Benefit	\$0.42m
Systems (reliability)	\$0.46m	\$0.04m	\$0.42m	ENS Penalty	\$0.00m
Financial	\$0.15m	\$0.03m	\$0.13m	All other risk benefits	\$0.13m
Operational/compliance	\$0.00m	\$0.00m	\$0.00m	Total Risk benefits	\$0.55m
People (safety)	\$0.00m	\$0.00m	\$0.00m	Benefits in the financial NPV*	\$0.13m
Environment	\$0.00m	\$0.00m	\$0.00m	*excludes VCR benefits	
Reputation	\$0.00m	\$0.00m	\$0.00m	Benefits in the economic NPV**	\$0.55m
Total Risk benefits	\$0.61m	\$0.07m	\$0.55m	**excludes ENS penalty	
Cost savings and other benefits			\$0.00m		
Total Benefits			\$0.55m		

Other Financial Drivers

Incremental opex cost pa (no depreciation)	-\$0.00m	Write-off cost	\$0.00m
Capital - initial \$m	-\$1.51m	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 - Protecting greater th		
1. Financial Evaluation (excludes VCR benefits)					
NPV @ standard discount rate	10.00%	-\$0.07m	NPV / Capital (Ratio)	-0.23	
NPV @ upper bound rate	13.00%	-\$0.10m	Pay Back Period (Yrs)	0.05 Yrs	
NPV @ lower bound rate (WACC)	6.75%	-\$0.03m	IRR%	5.48%	
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%	\$0.31m	NPV / Capital (Ratio)	0.98	
NPV @ upper bound rate	13.00%	\$0.19m	Pay Back Period (Yrs)	2.71 Yrs	
NPV @ lower bound rate (WACC)	6.75%	\$0.52m	IRR%	22.49%	
Benefits					
Risk cost	As Is	To Be	Benefit	VCR Benefit	\$0.08m
Systems (reliability)	\$0.09m	\$0.01m	\$0.08m	ENS Penalty	\$0.00m
Financial	\$0.04m	\$0.00m	\$0.04m	All other risk benefits	\$0.04m
Operational/compliance	\$0.00m	\$0.00m	\$0.00m	Total Risk benefits	\$0.12m
People (safety)	\$0.00m	\$0.00m	\$0.00m		
Environment	\$0.00m	\$0.00m	\$0.00m	Benefits in the financial NPV*	\$0.04m
Reputation	\$0.00m	\$0.00m	\$0.00m	*excludes VCR benefits	
Total Risk benefits	\$0.13m	\$0.01m	\$0.12m		
Cost savings and other benefits			\$0.00m	Benefits in the economic NPV**	\$0.12m
Total Benefits			\$0.12m	**excludes ENS penalty	
Other Financial Drivers					
Incremental opex cost pa (no depreciation)			-\$0.00m	Write-off cost	\$0.00m
Capital - initial \$m			-\$0.32m	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