OPTIONS EVALUATION REPORT (OER)

Protection - Alstom Pxxx Condition

OER 000000001376 revision 2.0

Ellipse project no.: P0008018
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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Date submitted for approval	14 December 2016	

Change history

Revision	Date	Amendment
0	23 June 2016	Initial issue
1	31 October 2016	Update to 2016/17 dollars and SFAIRP/ALARP data
2	14 December 2016	Update to format

1. Need/opportunity

The assets raised within this Need have reached or exceeded their estimated technical life by 2023. Manufacturer support for the majority of models has ceased meaning no repair or replacement facilities exist and spares currently held by TransGrid for these models are projected to be exhausted. Additionally there are higher costs associated with managing and maintaining spares and the continuing maintenance capability required for obsolete models.

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

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 increasing failure rates or the risk cost associated with the Need. At $3.5m 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:

- Probability of asset failure is approximately 3.8% for P12x, 4.9% for P442, and 5.0% for P54x
- 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 at 95 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 1376A, OFS 1376A]

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 $6k 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[1].

The expected total capital cost to replace all 95 asset identified under this Need is $9.17m. This costing is estimated using TransGrid's "Success" estimating system. For this OER, the quantity of asset replacements has been reduced to 45 and cost has been adjusted to $4.23m to account for 47 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 $0.48m per annum (base case risk cost = $3.5m). 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 $2.53m. This costing was estimated using the unit costs provided under OFS 1376A and applying them to those assets that would be replaced. These costs are broken down in Table 1.

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

Item	Unit Cost, Including Labour	Quantity	Total Cost
Overcurrent <= 132kV	94	11	1,030

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

Item	Unit Cost, Including Labour	Quantity	Total Cost
Distance <= 132kV	94	15	1,410
Line Differential <= 132kV	94	1	90
Total estimated cost			**2,530**

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 = $0.45m). 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 where the peak load is greater than 150MW and service voltage is less than 330kV.

The expected capital cost to replace this category of assets is $1.69m. This costing was estimated using the unit costs provided under OFS 1376A 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 and >150MW ($ thousand)

Item	Unit Cost, Including Labour	Quantity	Total Cost
Distance <= 132kV	94	13	1,220
Line Differential <= 132kV	94	5	470
Total estimated cost			**1,690**

The residual risk associated with this portion of assets upon completion of the project amounts to $0.40m per annum (base case risk cost component = $3.04m). 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	0.01	3.49	N/A	N/A	2
A	Replace individual Assets	4.23	0.01	0.48	11.02	(1.78)	1

Option	Description	Total capex	Annual opex	Annual post project risk cost	Economic NPV @10%	Financial NPV @10%	Rank
i)	Replace <150MW Assets	2.54	0	0.07	(0.15)	(1.09)	-
ii)	Replace >150MW Assets	1.69	0	0.40	11.17	(0.59)	-

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	7.59	16.62
i)	Replace <150MW Assets	(0.47)	0.41
ii)	Replace >150MW Assets	8.06	16.20

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 **Error! Not a valid bookmark self-reference.**.

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)
- Conductor drop/structure failure - 6 times the bushfire risk , 6 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 5 – Feasible options ($ thousand)

Option	Description	CAPEX	Expected Life	Annualised CAPEX
Base	Run-to-fail	N/A	N/A	N/A

Option	Description	CAPEX	Expected Life	Annualised CAPEX
A	Replace individual Assets	4,230	15 years	280

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	10	3,130	60	N/A	N/A	N/A
A	0	420	0	10	2,710	60

Table 7 – Reasonably practicable test ($ thousand)

Option	Network Safety Risk Reduction[2]	Annualised CAPEX	Reasonably practicable[3]?
A	661	280	Yes

Option A is reasonably practicable.

4.3 Preferred option

The outcome of the SFAIRP/ALARP evaluation is that Option A for all assets is the preferred option as it is reasonably practicable and provides the greatest network safety risk reduction, and is therefore required to satisfy the organisation's SFAIRP/ALARP obligations.

The option to address the condition of the identified assets, Option A – Replacement of individual Assets, is the preferred option.

This option has been selected due to its technical viability and reduction in reliability risk and positive economic 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 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.

5. Recommendation

It is recommended to proceed with the replacement of all 45 identified assets in the categories identified above.

[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

Attachment 1 – Assets for replacement

A.1 Assets Protecting <150MW

EQUIP_NO	EQUIP_CLASS	PLANT_NO	ITEM_NAME_1	EQUIP_LOCATION
000000020788	PT	NNPVP1CR4002F11	957 OURIMBAH TEE 132KV FEEDER NO1 PROT	VP1
000000048776	PT	NTPCOFCRA2B4V2	703 NANA GLEN 66KV FEEDER NO2 PROTECTION	COF
000000048788	PT	NTPCOFCRB5B4J2	711 NORTH COFFS 66KV FDR NO2 PROTECTION	COF
000000048678	PT	NTPAR1CR1572L2	96C/1 COFFS HARBOUR T 132KV FDR NO2 PROT	AR1
000000048687	PT	NTPAR1CR1502T2	966 KOOLKHAN 132KV FEEDER NO2 PROTECTION	AR1
000000048690	PT	NTPAR1CR1482U2	96T GLEN INNES 132 - 132KV FDR NO2 PROT	AR1
000000048693	PT	NTPAR1CR1462V2	96N INVERELL 132 - 132KV FEEDER NO2 PROT	AR1
000000049581	PT	NTPNB2CRA262D2	968 TAMWORTH 330 - 132KV FEEDER NO2 PROT	NB2
000000049587	PT	NTPNB2CRA302J2	9UH BOGGABRI EAST 132KV FEEDER NO2 PROT	NB2
000000062446	PT	SWPFNYCRD072G2	84A JERILDERIE 66KV FEEDER NO2 PROT	FNY
000000062443	PT	SWPFNYCRD052F2	84B FINLEY 66 - 66KV FDR NO2 PROTECTION	FNY
000000062823	PT	SWPYA2CRB206J2	7L4 LEETON 33KV FEEDER NO2 PROTECTION	YA2
000000062826	PT	SWPYA2CRB186M2	7L5 MURRAMI 33KV FEEDER NO2 PROTECTION	YA2
000000076953	PT	NTPNAMCRC8B2F2	9W6 MACKSVILLE 132KV FDR NO2 PROTECTION	NAM
000000076960	PT	NTPNAMCRD9B4J2	752 FIELD TERM. 66KV FDR NO2 PROTECTION	NAM
000000076965	PT	NTPNAMCRD104H2	751 NAMBUCCA HDS 66KV FDR NO2 PROTECTION	NAM
000000076966	PT	NTPNAMCRD114F2	750 NAMBUCCA HEADS 66KV FDR NO2 PROT	NAM
000000087220	PT	NTPGNSCR03E2F2	96T ARMIDALE 330 - 132KV FEEDER NO2 PROT	GNS
000000087235	PT	NTPGNSCR2AB4D2	886 GLEN INNES 66 - 66KV FEEDER NO2 PROT	GNS

EQUIP_NO	EQUIP_CLASS	PLANT_NO	ITEM_NAME_1	EQUIP_LOCATION
000000087087	PT	NNPPMQCRE9B6M2	FREQUENCY INJECTION 33KV NO2 PROTECTION	PMQ
000000087215	PT	NTPGNSCR03A2D2	96R TENTERFIELD 132KV FDR NO2 PROTN	GNS
000000087238	PT	NTPGNSCR2DB4G2	887 GLEN INNES 66 - 66KV FEEDER NO2 PROT	GNS
000000087778	PT	NTPNB2CRB144G2	878 BOGGABRI 66KV FEEDER NO2 PROTECTION	NB2
000000091853	PT	NTPNB2CRB124F2	882 WEE WAA 66KV FEEDER NO2 PROTECTION	NB2
000000091713	PT	NTPKS2CRB226Y2	NO6 ESS. E. FREQ. INJ 33KV FDR NO2 PROT	KS2
000000091993	PT	SWPFNYCRD102J2	84C FINLEY 66 - 66KV FDR NO2 PROTECTION	FNY
000000091997	PT	SWPFNYCRC5B1F2	9R4 132KV FEEDER NO2 PROTECTION	FNY

A.2 Assets Protecting >=150MW

EQUIP_NO	EQUIP_CLASS	PLANT_NO	ITEM_NAME_1	EQUIP_LOCATION
000000009970	PT	CMPSYSCR2052J1	284 MENAI 132KV FEEDER NO1 PROTECTION	SYS
000000009985	PT	CMPSYSCR2072K21	912 PORT HACKING 132KV NO1 PROTECTION	SYS
000000010157	PT	CMPDPTCR2302X2	98F MT TERRY 132KV FEEDER NO2 PROTECTION	DPT
000000010159	PT	CMPDPTCR3212W1	984 TALLAWARRA 132KV FDR NO1 PROTECTION	DPT
000000010165	PT	CMPDPTCR3022S1	987 TALLAWARRA 132KV FDR NO1 PROT	DPT
000000010168	PT	CMPDPTCR3232R1	983 TALLAWARRA 132KV FDR NO1 PROTECTION	DPT
000000010171	PT	CMPDPTCR3272M1	982 SPRINGHILL 132KV FDR NO1 PROTECTION	DPT
000000010174	PT	CMPDPTCR2242L1	98Y SPRINGHILL 132KV FDR NO1 PROTECTION	DPT
000000010178	PT	CMPDPTCR3262K2	981 BELLAMBI CREEK 132KV FEEDER NO2 PROT	DPT
000000010183	PT	CMPDPTCR2192J12	980 BELLAMBI CREEK 132KV FEEDER NO2 PROT	DPT
000000010186	PT	CMPDPTCR3302F2	98W MT TERRY 132KV FDR NO2 PROTECTION	DPT

EQUIP_NO	EQUIP_CLASS	PLANT_NO	ITEM_NAME_1	EQUIP_LOCATION
000000020482	PT	NNPNEWCR62B2F2	96U KURRI ZS 132KV FEEDER NO2 PROTECTION	NEW
000000020488	PT	NNPNEWCR64B2G2	96W CAPRAL 132KV FEEDER NO2 PROTECTION	NEW
000000020494	PT	NNPNEWCR68B2L2	95A AWABA 132KV FEEDER NO2 PROTECTION	NEW
000000020527	PT	NNPNEWCR78B2T2	EX 95N WARATAH WEST 132KV FDR NO2 PROT	NEW
000000020533	PT	NNPNEWCR80B2V2	96B CAPRAL 132KV FEEDER NO2 PROTECTION	NEW
000000020536	PT	NNPNEWCR82B2X2	96A KURRI 132KV FEEDER NO2 PROTECTION	NEW
000000089386	PT	CMPVYDCRJ042E2	938 ROUSE HILL 132KV FDR NO2 PROTECTION	VYD

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%	-$1.78m	*NPV / Capital (Ratio)*	*-0.42*
NPV @ upper bound rate	13.00%	-$1.91m	*Pay Back Period (Yrs)*	*0.01 Yrs*
NPV @ lower bound rate (WACC)	6.75%	-$1.47m	*IRR%*	*0.69%*

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%	$11.02m	*NPV / Capital (Ratio)*	*2.61*
NPV @ upper bound rate	13.00%	$7.59m	*Pay Back Period (Yrs)*	*1.40 Yrs*
NPV @ lower bound rate (WACC)	6.75%	$16.62m	*IRR%*	*35.24%*

Benefits

Risk cost	As Is	To Be	Benefit
Systems (reliability)	*$3.13m*	*$0.42m*	*$2.71m*
Financial	*$0.30m*	*$0.06m*	*$0.24m*
Operational/compliance	*$0.00m*	*$0.00m*	*$0.00m*
People (safety)	*$0.01m*	*$0.00m*	*$0.01m*
Environment	*$0.06m*	*$0.00m*	*$0.06m*
Reputation	*$0.00m*	*$0.00m*	*$0.00m*
Total Risk benefits	$3.50m	$0.48m	$3.02m
Cost savings and other benefits			$0.00m
Total Benefits			$3.02m

VCR Benefit	*$2.71m*
ENS Penalty	*$0.00m*
All other risk benefits	*$0.31m*
Total Risk benefits	$3.02m
Benefits in the financial NPV*	$0.31m
**excludes VCR benefits*	
Benefits in the economic NPV**	$3.02m
***excludes ENS penalty*	

Other Financial Drivers

Incremental opex cost pa (no depreciation)	-$0.01m	Write-off cost	$0.00m
Capital - initial $m	-$4.23m	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 - Only assets <=150MV

1. Financial Evaluation (excludes VCR benefits)

NPV @ standard discount rate	10.00%	-$1.09m	*NPV / Capital (Ratio)*	*-0.43*
NPV @ upper bound rate	13.00%	-$1.17m	*Pay Back Period (Yrs)*	*0.00 Yrs*
NPV @ lower bound rate (WACC)	6.75%	-$0.92m	*IRR%*	*0.35%*

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%	-$0.15m	*NPV / Capital (Ratio)*	*-0.06*
NPV @ upper bound rate	13.00%	-$0.47m	*Pay Back Period (Yrs)*	*6.74 Yrs*
NPV @ lower bound rate (WACC)	6.75%	$0.41m	*IRR%*	*8.96%*

Benefits

Risk cost	As Is	To Be	Benefit		
Systems (reliability)	*$0.24m*	*$0.04m*	*$0.20m*	*VCR Benefit*	*$0.20m*
Financial	*$0.18m*	*$0.03m*	*$0.15m*	*ENS Penalty*	*$0.00m*
Operational/compliance	*$0.00m*	*$0.00m*	*$0.00m*	*All other risk benefits*	*$0.18m*
People (safety)	*$0.00m*	*$0.00m*	*$0.00m*	Total Risk benefits	$0.38m
Environment	*$0.03m*	*$0.00m*	*$0.03m*	Benefits in the financial NPV*	$0.18m
Reputation	*$0.00m*	*$0.00m*	*$0.00m*	**excludes VCR benefits*	
Total Risk benefits	$0.45m	$0.07m	$0.38m		
Cost savings and other benefits			$0.00m	Benefits in the economic NPV**	$0.38m
Total Benefits			$0.38m	***excludes ENS penalty*	

Other Financial Drivers

Incremental opex cost pa (no depreciation)	-$0.00m	Write-off cost	$0.00m
Capital - initial $m	-$2.54m	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 - Only assets <=150MV

1. Financial Evaluation (excludes VCR benefits)

NPV @ standard discount rate	10.00%	-$0.59m	*NPV / Capital (Ratio)*	*-0.35*
NPV @ upper bound rate	13.00%	-$0.68m	*Pay Back Period (Yrs)*	*0.03 Yrs*
NPV @ lower bound rate (WACC)	6.75%	-$0.42m	*IRR%*	*2.64%*

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%	$11.17m	*NPV / Capital (Ratio)*	*6.61*
NPV @ upper bound rate	13.00%	$8.06m	*Pay Back Period (Yrs)*	*Not measurable*
NPV @ lower bound rate (WACC)	6.75%	$16.20m	*IRR%*	*54.45%*

Benefits

Risk cost	As Is	To Be	Benefit		
Systems (reliability)	*$2.88m*	*$0.39m*	*$2.49m*	*VCR Benefit*	*$2.49m*
Financial	*$0.13m*	*$0.01m*	*$0.12m*	*ENS Penalty*	*$0.00m*
Operational/compliance	*$0.00m*	*$0.00m*	*$0.00m*	*All other risk benefits*	*$0.15m*
People (safety)	*$0.00m*	*$0.00m*	*$0.00m*	Total Risk benefits	$2.64m
Environment	*$0.03m*	*$0.00m*	*$0.03m*	Benefits in the financial NPV*	$0.15m
Reputation	*$0.00m*	*$0.00m*	*$0.00m*	**excludes VCR benefits*	
Total Risk benefits	$3.04m	$0.40m	$2.64m		
Cost savings and other benefits			$0.00m	Benefits in the economic NPV**	$2.64m
Total Benefits			$2.64m	***excludes ENS penalty*	

Other Financial Drivers

Incremental opex cost pa (no depreciation)	-$0.00m	Write-off cost	$0.00m
Capital - initial $m	-$1.69m	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