OPTIONS EVALUATION REPORT (OER)

FY24-28 Prot - Reactor Renewal

OER- n2244 revision 0.0

Ellipse project no(s):
TRIM file: [TRIM No]

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

Approvals

Author	Anh Diep	Asset Engineer
Endorsed	Adam Hoare	Digital Infrastructure Asset Manager
	Debashis Dutta	Asset Analytics and Insights Manager
Approved	Lance Wee	Head of Asset Management
Date submitted for approval	19 October 2021	

Change history

Revision	Date	Amendment
0	19/10/2021	Initial Revision

Executive summary

Reactor protection relays are used throughout the NSW network to isolate reactor faults in order to reduce their impacts on system security, system reliability and network infrastructure. The relays under investigation are installed at 33kV, 132kV, 220kV and 330kV voltage levels. Representing a subset of TransGrid's transmission line protection relay asset base, there are currently 18 installed units under consideration for this Need. The units have installation dates from 1984.

A number of Reactor Protection Schemes are reaching end of life by 2027/28. Manufacturer support for the majority of models is limited or withdrawn, meaning that repair and replacement facilities are expected to be unavailable by 2027/28.

There is a need to address degrading asset health and increasing risks associated with the identified assets. Addressing this need will ensure TransGrid will continue to meet its regulatory obligations set out in the NER.

The assessment of options considered to address this need appears in Table 1, which includes reactor protection schemes evaluated as NPV positive, and reaching end of life by 2027/28.

Table 1 - Evaluated options

Option	Description	Direct capital cost ($m)	Overheads ($m)	Total capital cost[1] ($m)	Weighted NPV (PV, $m)	Rank
Option A – N2244A	Renewal of Individual Assets	0.87	0.36	1.23	3.49	1

It is recommended that Option A – Renewal of Individual Assets, be scoped in detail. Option A is the only technically and commercially feasible solution to enable TransGrid to continue meeting its regulatory obligations.

Option A involves individual replacements of 14 identified assets across 6 sites within the regulatory period. The option is based on a like-for-like approach whereby the asset is replaced by its modern equivalent.

[1] Total capital cost is the sum of the direct capital cost and network and corporate overheads. Total capital cost is used in this OER for all analysis.

1. Need/opportunity

Reactor protection relays are used throughout the NSW network to isolate reactor faults in order to reduce their impacts on system security, system reliability and network infrastructure. The relays under investigation are installed at 33kV, 132kV, 220kV and 330kV voltage levels. Representing a subset of TransGrid's reactor protection relay asset base, there are currently 18 installed units under consideration for this Need of which have install dates from 1984.

A number of Reactor Protection Schemes are reaching end of life by 2027/28. Manufacturer support for many models is limited or withdrawn, meaning that repair and replacement facilities are expected to be unavailable by 2027/28.

Network Performance Requirements, set out in Schedule 5.1 of the NER, place an obligation on TNSPs to provide redundant protection schemes to ensure the transmission system is adequately protected. Schedule 5.1.9(c) of the NER requires a TNSP to provide sufficient primary and back-up protection systems, including any communications facilities and breaker fail protection systems, to ensure that a fault of any type anywhere on its transmission system is automatically disconnected.

Additionally, TNSPs are required to disconnect the unprotected primary systems where a secondary systems fault lasts for more than eight hours (for planned maintenance) or 24 hours (for unplanned outages). TNSPs must also ensure that all protection systems for lines at a voltage 66 kV or above are well-maintained in order to always be available excluding short periods (less than eight hours) for protection system maintenance. In the event of an unplanned outage, AEMO's Power System Security Guidelines require that the primary network assets must be taken out of service within 24 hours.

Though the replacement of failed secondary systems components is a possible interim measure, the approach is not sustainable as spare components may not be available due to supplier constraints and technological obsolescence in the future. Once manufacturer support ceases and subsequently, spares are depleted, defect repairs can no longer be a viable approach to maintain compliance with performance obligations.

In accordance with TransGrid's Renewal and Maintenance Strategy for Automation Systems[2], a pre-emptive approach to asset renewals is required to address several factors increasing the risk of identified assets including:

- Withdrawal of manufacturer support for repair and procurement.
- Depletion of spares
- Increasing probability of failure (for secondary system devices the majority of failure modes lead to the complete loss asset function resulting in replacement).

2. Related needs/opportunities

The following related needs could improve efficiency of delivery where timing is coordinated in alignment with risk profiles:

- N2242 – FY24-28 Prot - Line Renewal
- N2246 – FY24-28 Prot - Busbar Renewal
- N2245 – FY24-28 Prot - Capacitor Renewal
- N2243 – FY24-28 Prot - Transformer Renewal
- N2212 – FY24-28 Prot - UFLS Renewal

Appendix C lists related Needs that include works covered under this project and have had their associated assets removed.

[2] Refer to Renewal and Maintenance Strategy – Automation Systems

3. Options

3.1 Base case

The Base Case for this Need is to continue with TransGrid's business as usual operations and maintenance (O&M) for the identified assets. This approach does not address the deteriorating condition of the assets under evaluation or the risk cost associated with maintaining aging assets. The risk will likely increase due to:

- The probability of failure increasing as assets move further along their failure curves[3].
- TransGrid's inability to recover from asset failure in the future due to reducing levels of manufacturer support, and depletion of spares availability that would otherwise limit the overall consequence of asset failure.

Key drivers for this risk cost are:

- The assets identified will have reached their end of life or have limited spares and no manufacturer support. This increases the likelihood of a hazardous event occurring and decreases TransGrid's ability to mitigate or repair failures.
- Assets have increasing numbers of faults as they progress along their failure curves, degrading components or are prone to mechanical wear, increasing the likelihood of a hazardous event occurring.

Increasing maintenance on secondary systems equipment cannot reduce the probability of failure or reduce risk costs. This is because maintenance of secondary assets is focused on device inspection and functional performance checks only, the conduct of maintenance at an electronic component level is neither feasible nor practicable.

3.2 Options evaluated

Option A — Renewal of Individual Assets [NOSA N2244, OFS N2244A]

This option involves individual replacements of 14 identified assets (listed in Appendix B) across 6 sites within the regulatory period. The option is based on a like-for-like approach whereby the asset is replaced by its modern equivalent. Additional system modifications or additional functionalities would not be deployed under this option.

This option would deliver risk mitigation and reduced corrective maintenance benefits to consumers and the networks by only targeting the probability of failure of identified assets. This option will not deliver any additional operational benefits such as improved capabilities for remote interrogation and predictive activities.

This option will phase asset renewals across the regulatory control period. Deployments are prioritised based on investment benefit with consideration also given to efficient delivery strategies. Targeted assets will be in service for approximately 15 years, with some assets remaining at each site to incur investment in future years.

3.3 Options considered and not progressed

Table 2 - Option considered but not progressed

Option	Reason for not progressing
Secondary Systems Renewal	This option would have required the complete renewal of all secondary systems assets at each site. The condition of remaining assets at identified sites did not warrant additional expenditure. Therefore, this option is not commercially feasible.

[3] Refer to Network Asset Health Framework

Option	Reason for not progressing
Refurbishment of Individual Assets	This option is not technically feasible due to the specialised skillsets required and the inability to resolve the lack of support from manufacturers.
Asset Retirement	This can only be achieved through retirement of the associated primary assets, which is not technically or commercially feasible.
Non-network solutions	It is not technically feasible for non-network solutions to provide the functionality of secondary systems assets for protection, control, communications and metering

4. Evaluation

4.1 Commercial evaluation methodology

The economic assessment undertaken for this project includes three scenarios that reflect a central set assumptions based on current information that is most likely to eventuate (central scenario), a set of assumptions that give rise to a lower bound for net benefits (lower bound scenario), and a set of assumptions that give rise to an upper bound on benefits (higher bound scenario).

Assumptions for each scenario are set out in the table below.

Table 3 - Scenarios

Parameter	Central scenario	Lower bound scenario	Higher bound scenario
Discount rate	4.8%	7.37%	2.23%
Capital cost	100%	125%	75%
Operating expenditure benefit	100%	75%	125%
Risk costs benefit	100%	75%	125%
Other benefit	100%	75%	125%
Scenario weighting	**50%**	**25%**	**25%**

Parameters used in this commercial evaluation:

Table 4 - Parameters used in commercial evaluation

Parameter	Parameter Description	Value used for this evaluation
Discount year	Year that dollar values are discounted to	2020/21
Base year	The year that dollar value outputs are expressed in real terms	2020/21 dollars
Period of analysis	Number of years included in economic analysis with remaining capital value included as terminal value at the end of	15 years

Parameter	Parameter Description	Value used for this evaluation
	the analysis period.	
Safety disproportionality	Multiplier of the safety risk cost included in NPV analysis to demonstrate implementation of obligation to reduce safety to ALARP.	Refer to section 4.3 for details.

The capex figures in this OER do not include any real cost escalation.

4.2 Commercial evaluation results

The commercial evaluation of the technically feasible options is set out in Table 5. Details appear in Appendix A.

Table 5 - Commercial evaluation (PV, $ million)

Option	Capital Cost PV	Central scenario NPV	Lower bound scenario NPV	Higher bound scenario NPV	Weighted NPV	Ranking
Option A	0.98	3.19	1.23	6.35	3.49	1

Note: The evaluation above is a consolidation of reactor protection schemes that were individually evaluated as NPV positive, and reaching end of life by 2027/28. The individual protection schemes are listed in Appendix B.

4.3 ALARP evaluation

TransGrid manages and mitigates bushfire and safety risk to ensure they are below risk tolerance levels or 'As Low As Reasonably Practicable' ('ALARP'), in accordance with the regulation obligations and TransGrid's business risk appetite. Under the Electricity Supply (Safety and Network Management) Regulation 2014 Section 5 'A network operator must take all reasonable steps to ensure that the design, construction, commissioning, operation and decommissioning of its network (or any part of its network) is safe.' TransGrid maintains an Electricity Network Safety Management System (ENSMS) to meet this obligation[4].

In its Network Risk Assessment Methodology, under the ALARP test with the application of a gross disproportionate factor[5], the weighted benefits are expected to exceed the cost. Where TransGrid's analysis concludes that the costs are less than the weighted benefits from mitigating bushfire and safety risks, the proposed investment will enable TransGrid to continue to manage and operate this part of the network to a safety and risk mitigation level of ALARP.

Evaluation of the above options has been completed in accordance with As Low As Reasonably Practicable (ALARP) obligations. The Network Safety Risk Reduction is calculated as 6 x Bushfire Risk Reduction + 6 x Safety Risk Reduction + 3 x other Environmental Risk Reduction + 0.1 x Reliability Risk Reduction.

Results of the ALARP evaluation are set out in Table 6.

Table 6 - Reasonably practicable test ($ million)

Option	Network Safety Risk Reduction	Annualised Capex	Reasonably Practicable?[6]

[4] TransGrid's ENSMS follows the International Organization for Standardization's ISO31000 risk management framework which requires following hierarchy of hazard mitigation approach

[5] In accordance with the framework for applying the ALARP principle, a disproportionality factor of 6 has been applied to risk cost figures. The values of the disproportionality factors were determined through a review of practises and legal interpretations across multiple industries, with particular reference to the works of the UK Health and Safety Executive. The methodology used to determine the disproportionality factors in this document is in line with the principles and examples presented in the AER Replacement Planning Guidelines and is consistent with TransGrid's Revised Revenue Proposal 2023/24- 2027/28.

[6] Reasonably practicable is defined as whether the annualised CAPEX is less than the Network Safety Risk Reduction.

A	0.01	0.12	No

The result of the ALARP evaluation is that the overall proposed program does not meet ALARP.

4.4 Preferred option

The preferred option to meet the identified need by 2027/28 is Option A. Option A is the only technically and commercially feasible solution to enable TransGrid to continue meeting its regulatory obligations set out in Schedule 5.1 of the NER.

Capital and Operating Expenditure

There is negligible difference in predicted ongoing planned routine operational expenditure between the option and the Base Case.

Resultant corrective maintenance under the base case strategy is anticipated to result in higher expenditure over the upcoming regulatory period. Delivery of proposed works under Option A will reduce the risk of increasing direct defect response costs.

It has been modelled that under corrective maintenance, those components with no manufacturer support and limited spares could incur significant costs associated with design and preparation, and likely augmentation of linking systems required to move to a different design solution. Such costs would not be present in cases where a like-for-like replacement is feasible.

These operating expenditure benefits have been captured in the economic evaluation.

Regulatory Investment Test

The program and estimate allows for the appropriate Regulatory approvals as required.

5. Optimal Timing

The test for optimal timing of the preferred option has been undertaken. The approach taken is to identify the optimal commissioning year for the preferred option where net benefits (including avoided costs and safety disproportionality tests) of the preferred option exceeds the annualised costs of the option. The commencement year is determined based on the required project disbursement to the meet the commissioning year based on the OFS.

The results of optimal timing analysis is:

- Optimal commissioning year: 2027/28
- Commissioning year annual benefit: $0.22 million
- Annualised cost: $0.12 million

Based on the optimal timing, the project is expected to commence in the 2023/24-2027/28 Regulatory Period.

6. Recommendation

It is recommended that Option A – Renewal of Individual Assets, be scoped in detail.

The total project cost is $1.23 million including an amount of $0.35 million to progress the project from DG1 to DG2.

Appendix A – Option Summaries

Project Description	FY24-28 Reactor Protection Renewal		
Option Description	Option A - Replace individual assets		
Project Summary			
Option Rank	*1*	Investment Assessment Period	*15*
Asset Life	*15*	NPV Year	2020/21
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, $m)	3.19	Annualised CAPEX @ Central Benefit Scenario ($m)	Annualised Capex - Standard (Business Case) 0.12
NPV @ Lower Bound Scenario (PV, $m)	1.23	Network Safety Risk Reduction ($m)	Network Safety Risk Reduction 0.01
NPV @ Higher Bound Scenario (PV, $m)	6.35	ALARP	ALARP Compliant? No
NPV Weighted (PV, $m)	3.49	Optimal Timing	Optimal timing (Business Case) 2025/26
Cost (Central Scenario)			
Total Capex ($m)	1.23	Cost Capex (PV,$m)	0.98
Terminal Value ($m)	0.00	Terminal Value (PV,$m)	0.00
Risk (Central Scenario)	**Pre**	**Post**	**Benefit**
Reliability (PV,$m)	Reliability Risk (Pre) 0.95	Reliability Risk (Post) 0.50	Pre – Post 0.45
Financial (PV,$m)	Financial Risk (Pre) 5.53	Financial Risk (Post) 3.09	Pre – Post 2.44
Operational/Compliance (PV,$m)	Operational Risk (Pre) 0.00	Operational Risk (Post) 0.00	Pre – Post 0.00
Safety (PV,$m)	Safety Risk (Pre) 0.01	Safety Risk (Post) 0.01	Pre – Post 0.00
Environmental (PV,$m)	Environmental Risk (Pre) 0.03	Environmental Risk (Post) 0.01	Pre – Post 0.02
Reputational ($m)	Reputational Risk (Pre) 0.00	Reputational Risk (Post) 0.00	Pre – Post 0.00
Total Risk (PV,$m)	Total Risk (Pre) 6.52	Total Risk (Post) 3.61	Pre – Post 2.91
OPEX Benefit (PV,$m)			OPEX Benefit 0.00
Other benefit (PV,$m)			Incremental Net Benefit 1.25
Total Benefit (PV,$m)			Business Case Total Benefit 4.16

Appendix B – Asset Renewal Program

The table below identifies each of the 14 reactor protection relay replacements recommended to progress under this OER.

Asset ID	Model	Obsolete	Location	Plant Number	Voltage (kV)	Cost ($)	Weighted NPV($)	ALARP	Optimal Timing
101540	DUOBIAS	Y	BAY	NNDBAY6B	33	$88,000	$198,486	NO	2023/24
101544	DUOBIAS	Y	BAY	NNDBAY6A	33	$88,000	$198,486	NO	2023/24
101435	DUOBIAS	Y	BBY	SYDBBY6B2	33	$88,000	$180,713	NO	2023/24
101438	DUOBIAS	Y	BBY	SYDBBY6A2	33	$88,000	$180,713	NO	2023/24
101434	T60	N	BBY	SYDBBY6B2	33	$88,000	$100,720	NO	2023/24
101437	T60	N	BBY	SYDBBY6A2	33	$88,000	$100,720	NO	2023/24
153348	FAC	Y	BFS	CMDBFS2L1	132	$88,000	$24,359	NO	2023/24
92006	DUOBIAS	Y	MTP	CODMTP6B	33	$88,000	$196,308	NO	2023/24
92010	DUOBIAS	Y	MTP	CODMTP6A	33	$88,000	$196,308	NO	2023/24
84341	2V47	Y	SYS	CMDSYS1V	330	$88,000	$293,127	NO	2023/24
84342	2V47	Y	SYS	CMDSYS1W2	330	$88,000	$293,591	NO	2023/24
84337	2V47	Y	SYS	CMDSYS1X	330	$88,000	$282,144	NO	2023/24
1052305	RET521	Y	SYW	CMDSYW1S	330	$88,000	$464,002	NO	2023/24
1052306	SPAD346C	Y	SYW	CMDSYW1S	330	$88,000	$419,940	NO	2023/24

Appendix C Related Needs with Assets Removed

The following Needs contain assets that would otherwise be covered under this proposed program of work. These assets have been captured and justified within the relevant Option Evaluation Report for each Need below.

Need ID	Need Description
N2434	FY24-28 LSM Secondary Systems Renewal
N2411	FY24-28 WL1 Secondary Systems Renewal
N2408	FY24-28 AR1 Secondary Systems Renewal
N2214	FY24-28 ER0 Secondary Systems Renewal
N2212	FY24-28 SE1 Secondary Systems Renewal
N2211	FY24-28 YSN Secondary Systems Renewal