OPTIONS EVALUATION REPORT (OER)

Cable Monitoring Systems Renewal

OER- N2490 revision 0.0

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

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

Approvals

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Date submitted for approval	8 November 2021	

Change history

Revision	Date	Amendment
0	08/11/2021	First Issue

Executive summary

In its operation of the underground cable network, TransGrid uses various monitoring systems to check that cable system parameters such as temperature and oil pressure are within their operating limits. The components that these monitoring systems comprise of have shorter nominal lives than the high voltage cable and joints. These systems will reach end of life over the 2023/24 – 2022/28 regulatory period.

These systems reduce the risk on the cable asset. A Distributed Temperature System can prevent a thermal runaway event, a catastrophic situation.

Cable oil pressure monitoring is a critical function for a Self-Contained Fluid Filled (SCFF) cable. The pressure monitoring systems must be kept operational to prevent cable damage from oil starvation and reduce environmental impact by promptly responding to leaks.

A Distributed Acoustic System can detect activities in the vicinity the cable, allowing TransGrid to intervene and prevent a cable strike. Even in instances where a cable incursion did not result in strike, the resultant investigations, backfill correction and investigations are resource intensive. Addressing the incursions as they occur can avoid this.

There is a need to remediate these issues to:

> Provide an economic benefit to consumers through reductions in financial, safety and environmental risks. The direct impact of cable strike or backfill interference can result in a cable failure event with potential safety hazard consequences to the general public and/or cable oil leak which can result in environmental contamination, as evaluated in the associated modelling.

Table 1 - Evaluated options

Option	Description	Direct capital cost ($m)	Network and corporate overheads ($m)	Total capital cost[1] ($m)	Weighted NPV (PV, $m)	Rank
Option A	CMS/DTS System replacements Cable 41 Pressure Monitoring Cable 41 Temperature Monitoring (decommission) Distributed Acoustic Sensing (DAS)	3.29	0.64	3.93	0.12	1
Option B	CMS/DTS System replacements Cable 41 Pressure Monitoring Cable 41 Temperature Monitoring (renew) Distributed Acoustic Sensing (DAS)	3.33	0.64	3.97	0.10	2

[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.

The preferred option is Option A. It is therefore recommended that Option A be scoped in detail and progressed to DG2.[2]

1. Need/opportunity

In its operation of the underground cable network, TransGrid uses various monitoring systems to check that cable system parameters such as temperature and oil pressure are within their operating limits. The components that these monitoring systems comprise of have shorter nominal lives than the high voltage cable and joints.

TransGrid has the following monitoring systems for their cables.

Cable 41
The pressure and temperature monitoring systems on Cable 41 (to be re-named 26F following its switch to 132 kV operation upon completion of Powering Sydney's Future) have issues that require addressing as they reach end of life.

Pressure Monitoring
TransGrid's commissioned its current pressure monitoring system on Cable 41 in 2017. The differential pressure monitoring system, an internally developed Intelligent Electronic Device (IED) that communicates securely over 4G to a TransGrid server, enables TransGrid to remotely monitor oil pressures. Without this system, pressure gauges will require manual checking, relying on the absolute pressure alarms transmitted through the pilot cable.

The twisted pair pilot cable is used for the DC pressure alarms and powering the online current pressure monitoring system. This pilot cable has reached the end of its useful life, with a number of cores failing. Powering the online system by this pilot cable has resulted in several components of the system have failed under switching transients, Spot Temperature Monitoring

The spot temperature monitoring system on Cable 41 utilises a 3G modem to communicate securely back to the TransGrid server. This system will become dysfunctional when Telstra decommissions their 3G network in 2024.

The options for the current system is to either decommission or replaced by a new system by 2024. It is noted that the current system is limited in effectiveness as the monitored locations are may not necessarily be the hottest spots on the cable.

Cable 42 and 45
The Cable 42 Cable Monitoring System (CMS), which was renewed in 2016, monitors both oil pressure and cable temperature. The host machine at Haymarket also monitors Cable 45. The system relies on servers which have a technical life of five to eight years. By 2026, the system will be 10 years old, with many components having reached or exceeded the end of their technical lives. This includes the Distributed Temperature System (DTS), which has optical fibre termination equipment that has a technical life of 10 years. Further, at this point, manufacturer support and spares components will no longer be available.

Cable 43/44
Cable 43/44 has a DTS that was commissioned in 2015, with units at Holroyd and Rookwood Road Substations. This system has the same technical lives that apply to the Cable 42 system, and by 2025, it will have reached end of life with manufacturer support and spares components no longer be available. Whilst failure of this DTS unit will not necessarily result in immediate adverse cable operation, sustained periods where the cable is in a high thermal environment would go undetected and could potentially cause irreversibly damage the cable.

[2] DG stands for 'decision gate' that forms a part of TransGrids investment decision process.

Cable 39
Cable 39 has a DTS that was commissioned in December 2018. It currently resides at Sydney West Substation but is will likely be moved to the proposed Western Sydney Aerotropolis Substation when it is completed. Similar to Cables 42 and 43/44 noted above, the technical lives of the components in the cabinets are between 5 to 10 years.

It is noted that the development occurring around the new aerotropolis increases the possibility of cable hotspots occurring due to changes of surface levels and/or installation of new services. Again, whilst failure of this DTS unit will not necessarily result in immediate adverse cable operation, sustained periods where the cable is in a high thermal environment would go undetected and could potentially cause irreversibly damage the cable.

The abovementioned system requires replacement by November 2028.

Distributed Acoustic Sensing (DAS) System
Following completion of the Power Sydney's Future project, TransGrid will deploy a Distributed Acoustic Sensing (DAS) System on Cables 43/44, 46 and 39 to detect activity (e.g. excavation and construction) in the vicinity of the cables which might result in a public safety incident as well as damage the cable. The relevant DAS interrogator unit is located at Holroyd Substation, and is held under an Indefeasible Right of Use (IRU)[3] which will expire in 2026. Beyond this time, the DAS interrogator unit would be operating beyond its technical life, and ongoing service is not guaranteed after expiry.

Without a DAS in place, alternate measures would be required to appropriately mange the risk of cable strike by a third party. A new IRU is required to be in place by 2026.

There is a need to remediate these issues to:

> Provide an economic benefit to consumers through reductions in financial, safety and environmental risks. The direct impact of cable strike or backfill interference can result in a cable failure event with potential safety hazard consequences to the general public and/or cable oil leak which can result in environmental contamination, as evaluated in the associated modelling.

If the condition issues on the line are not addressed in sufficient time, then the asset will operate with increasing risk of failure as it continues to deteriorate. The level of reactive corrective maintenance needed to keep the line operating within required standards may also increase, particularly when asset failures ultimately occur.

Consequently, the proposed project has an economic benefits need, and addressed this need will provide avoided cost savings from reduced environmental and safety risk, and maintenance costs that would otherwise occur without replacements.

2. Related needs/opportunities

Not applicable.

3. Options

The base case for this assessment is a 'do nothing' scenario, where the assets are left in service until they fail and require replacement. In addition to the base case, two remediation options have been considered.

[3] IRU's are commonly used in telecommunications agreements for the supply of cable system capacity services. IRU's have specific tax treatment under section 995.1 of the Income Tax Assessment Act 1997 (Cth) and are treated as capital expenditure for suppliers and customers.

Option A involves replacing all cable monitoring systems when they reach end of life, with the exception of the Cable 41 (26F) temperature monitoring, which would be retired. Option B is the same as Option A except the Cable 41 temperature monitoring would be renewed instead of decommissioned.

3.1 Base case

The base case option would run the existing systems to failure. While there have not been any significant defects to date, it should be noted that this equipment has a bathtub failure curve. Similar to microprocessor based relays the condition of these systems cannot be readily inspected. After the nominal life of these items are exceeded the probability of failure increases dramatically. When the Cable 42 equipment was last planned to be replaced, replacement was deferred a couple of years for budgetary reasons. A DTS unit failed and reported max temperature, tripping the cable.

The base case would result in an unplanned approach for replacement. The replacement items are long lead time and the cable would be unmonitored until the system could be replaced. A factor of 20% could be applied for completion of unplanned works.

The base case option is incompatible with the quantities of cable joints held as per the Spares Plan, which is based on the DTS being operational. There are inadequate spares to cover a thermal runaway event on cables monitored with a DTS. The DTS detects if the cable system is getting too hot and deenergises the cable before too much damage is done.

In the cable of the Cable 41 oil pressure monitoring, the existing system relies on the pilot cable for power supply. The pilot cable is at end of life. Compounding the issue is that the “traditional” DC pressure alarms are sent over this pilot cable too. The base case would force continued dependency on the pilot cable.

Without Distributed Acoustic Sensing (DAS), increased cable route patrols would be required as the asset would no longer be monitored for rogue activities. The existing DAS system has allowed reduced route patrol frequency. If the system is not available the frequencies would need to increase.

3.2 Options evaluated

Option A — Renew Systems, Decommission C41 Temperature Monitoring [NOSA N2490, OFS N2490A]

This option will involve the renewal of the following:

- CMS/DTS System replacements
  - Cable 42, 43/44 and 39
- Cable 41 Pressure Monitoring
- Cable 41 Temperature Monitoring (decommission)
- Distributed Acoustic Sensing (DAS)

It is estimated that this option would cost $3.93 million ± 25% ($2020-21).

This option is expected to be completed progressively in stages within the 2024 – 2028 regulatory period, and is expected to be completed in 2025/2026.

Option B — Renew Systems, Renew C41 Temperature Monitoring [NOSA N2490, OFS N2490B]

This option contains the scope of Option A but instead of decommissioning the Cable 41 temperature monitoring it will be renewed.

It is estimated that this option would cost $3.97 million ± 25% ($2020-21).

This option is expected to be completed progressively in stages within the 2024 – 2028 regulatory period, and is expected to be completed in 2025/2026.

3.3 Options considered and not progressed

Option	Reason for not progressing
Non-network solutions	No non-network solutions have been considered, as these systems support existing cable circuits.

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 2 - Scenario parameters

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 benefits	100%	75%	125%
Scenario weighting	**50%**	**25%**	**25%**

Parameters used in this commercial evaluation:

Table 3 – Key Parameters

Parameter	Parameter Description	Value used for this evaluation
Discount year	Year that dollar values are discounted to	2020/2021
Base year	The year that dollar value outputs are expressed in real terms	2020/2021dollars
Period of analysis	Number of years included in economic analysis with remaining capital value included as terminal value at the end of the analysis period.	10 years
ALARP disproportionality (repex only)	Multiplier of the environmental and safety related risk cost included in NPV analysis to demonstrate implementation of obligation to reduce 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 2. Details appear in Appendix A.

Table 4 - Commercial evaluation (PV, $ million)

Option	Capital Cost PV	Central scenario NPV	Lower bound scenario NPV	Higher bound scenario NPV	Weighted NPV	Ranking
Option A	3.31	-0.07	-1.88	2.49	0.12	1
Option B	3.34	-0.09	-1.91	2.49	0.10	2

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.

In its Network Risk Assessment Methodology, under the ALARP test with the application of a gross disproportionate factor, the weighted benefits are expected to exceed the cost. 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 + 3 or 6 x Safety Risk Reduction + 0.1 x Reliability Risk Reduction.

Results of the ALARP evaluation are set out in Table 5.

Table 5 - Reasonably practicable test ($ million)

Option	Network Safety Risk Reduction	Annualised Capex	Reasonably Practicable?[4]
A	**0.07**	**0.50**	**No**
B	**0.07**	**0.51**	**No**

The result of the ALARP evaluation is that neither option meets the ALARP threshold.

4.4 Preferred option

The preferred Option is Option A. The existing Cable 41 temperature monitoring system is providing only a small benefit, as it only monitors a limited number of "point" locations.

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

Capital and Operating Expenditure

The capital cost of the preferred option is $3.93 million.

Having active DAS on these major cables allows a reduced patrol frequency, saving approx. $400k per annum.

Decommissioning the Cable 41 temperature monitoring would eliminate the corrective maintenance costs on this system, appox. $2k per annum.

Regulatory Investment Test

As the capital cost of both options are less than $6 million a RIT-T is not required.

5. Optimal Timing

In consideration of the delivery requirements and the NPV analysis for the need, its optimal timing is 2024/2025.

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: 2025/2026
- Commissioning year annual benefit: $0.52 million
- Annualised cost: 0.5 million

Based on the optimal timing, the project is expected to be completed in the 2024-2028 Regulatory Period.

6. Recommendation

The preferred option is Option A as it has the highest weighted NPV result of all the technically and commercially feasible options considered as part of this need. It is therefore recommended that this option be scoped in detail, so that it can be progressed from DG1 to DG2. Total project cost is $3.93 million including an amount of $0.5 million to progress the project from DG1 to DG2.

Appendix A – Option Summaries

Option A – Renew Systems, Decommission C41 Temperature Monitoring

Project Description	Cable Monitoring Systems		
Option Description	Option A - Renew Systems, Decommission C41 Temperature Monitoring		
Project Summary			
Option Rank	*1*	Investment Assessment Period	*10*
Asset Life	*10*	NPV Year	2021
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, $m)	-0.07	Annualised CAPEX @ Central Benefit Scenario ($m)	Annualised Capex - Standard (Business Case) 0.50
NPV @ Lower Bound Scenario (PV, $m)	-1.88	Network Safety Risk Reduction ($m)	Network Safety Risk Reduction 0.07
NPV @ Higher Bound Scenario (PV, $m)	2.49	ALARP	ALARP Compliant? No
NPV Weighted (PV, $m)	0.12	Optimal Timing	Optimal timing (Business Case) 2026
Cost (Central Scenario)			
Total Capex ($m)	3.93	Cost Capex (PV,$m)	3.31
Terminal Value ($m)	0.00	Terminal Value (PV,$m)	0.00
Risk (Central Scenario)	**Pre**	**Post**	**Benefit**
Reliability (PV,$m)	Reliability Risk (Pre) 0.00	Reliability Risk (Post) 0.00	Pre – Post 0.00
Financial (PV,$m)	Financial Risk (Pre) 0.58	Financial Risk (Post) 0.27	Pre – Post 0.31
Operational/Compliance (PV,$m)	Operational Risk (Pre) 0.00	Operational Risk (Post) 0.00	Pre – Post 0.00
Safety (PV,$m)	Safety Risk (Pre) 0.17	Safety Risk (Post) 0.09	Pre – Post 0.08
Environmental (PV,$m)	Environmental Risk (Pre) 0.73	Environmental Risk (Post) 0.36	Pre – Post 0.37
Reputational ($m)	Reputational Risk (Pre) 0.00	Reputational Risk (Post) 0.00	Pre – Post 0.00
Total Risk (PV,$m)	Total Risk (Pre) 1.47	Total Risk (Post) 0.72	Pre – Post 0.75
OPEX Benefit (PV,$m)			OPEX Benefit 2.48
Other benefit (PV,$m)			Incremental Net Benefit 0.00
Total Benefit (PV,$m)			Business Case Total Benefit 3.24

Option B - Renew Systems, Renew C41 Temperature Monitoring

Project Description	**Cable Monitoring Systems**		
Option Description	Option B - Renew Systems, Renew C41 Temperature Monitoring		
Project Summary			
Option Rank	*2*	Investment Assessment Period	*10*
Asset Life	*10*	NPV Year	2020/2021
Economic Evaluation			
NPV @ Central Benefit Scenario (PV, $m)	-0.09	Annualised CAPEX @ Central Benefit Scenario ($m)	Annualised Capex - Standard (Business Case) 0.51
NPV @ Lower Bound Scenario (PV, $m)	-1.91	Network Safety Risk Reduction ($m)	Network Safety Risk Reduction 0.07
NPV @ Higher Bound Scenario (PV, $m)	2.49	ALARP	ALARP Compliant? No
NPV Weighted (PV, $m)	0.10	Optimal Timing	Optimal timing (Business Case) 2026
Cost (Central Scenario)			
Total Capex ($m)	3.97	Cost Capex (PV,$m)	3.34
Terminal Value ($m)	0.00	Terminal Value (PV,$m)	0.00
Risk (Central Scenario)	**Pre**	**Post**	**Benefit**
Reliability (PV,$m)	Reliability Risk (Pre) 0.00	Reliability Risk (Post) 0.00	Pre – Post 0.00
Financial (PV,$m)	Financial Risk (Pre) 0.58	Financial Risk (Post) 0.27	Pre – Post 0.31
Operational/Compliance (PV,$m)	Operational Risk (Pre) 0.00	Operational Risk (Post) 0.00	Pre – Post 0.00
Safety (PV,$m)	Safety Risk (Pre) 0.17	Safety Risk (Post) 0.09	Pre – Post 0.08
Environmental (PV,$m)	Environmental Risk (Pre) 0.73	Environmental Risk (Post) 0.36	Pre – Post 0.37
Reputational ($m)	Reputational Risk (Pre) 0.00	Reputational Risk (Post) 0.00	Pre – Post 0.00
Total Risk (PV,$m)	Total Risk (Pre) 1.47	Total Risk (Post) 0.72	Pre – Post 0.75
OPEX Benefit (PV,$m)			OPEX Benefit 2.50
Other benefit (PV,$m)			Incremental Net Benefit 0.00
Total Benefit (PV,$m)			Business Case Total Benefit 3.25

Approval Record

WF Ref:	Process Name	Actioned By	Action	Comments	Date
205527	Document Review	Kurniawan Charles	Reviewed		07-11-2021
205700	Document Review	Dutta Debashis	Reviewed		08-11-2021
205729	Document Approval	McAlpine Andrew	Approve		08-11-2021