# OPTIONS EVALUATION REPORT (OER)

Underground Cable Capital Spares

OER- N2488 revision 0.0

**Ellipse project no(s):**
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**Project reason:** Capability - Asset Replacement for end of life condition
**Project category:** Prescribed - Asset Renewal Strategies

**Approvals**

| | | |
|---|---|---|
| **Author** | Jeffree Cairns | Transmission Lines and Cables Asset Strategist |
| **Endorsed** | Charles Kurniawan | Transmission Lines and Cables Asset Manager |
| | Debashis Dutta | Asset Analytics & Insights Manager |
| **Approved** | Andrew McAlpine | A/Head of Asset Management |
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# Executive summary

TransGrid keeps underground cable joints and terminations to enable repairs of the cable system in the event of cable strike or catastrophic failure. In the event an underground cable is damaged, say from a cable strike or accessory failure, a repair is undertaken by removing the damaged section and installing new cable with new joints at either end. If an incident occurs near a substation, a new termination may be required also. For operational reasons, TransGrid holds spares for these credible situations, with the minimum levels specified in the Underground Cables Spares Plan.

The supplier of TransGrid's SCFF cable accessories have sent notification that manufacturing of oil cable accessory will progressively cease from 2025. With respect to TransGrid's XLPE spares, these have a limited shelf life. Action is required to ensure that TransGrid can repair its cables within an acceptable timeframe.

The following options have been considered to ensure adequate response to cable failures and lifetime management of TransGrid's underground cable assets.

**Table 1 - Evaluated options**

| Option | Description | Direct capital cost ($m) | Network and corporate overheads ($m) | Total capital cost[1] ($m) | Rank |
|---|---|---|---|---|---|
| Option A – Cable 42 full joints and cable drum + XLPE spares | Full drum of Cable 42 equivalent plus 12 full joints to enable repairs until end of design life.<br>XLPE spares at end of shelf life renewed.<br>No spares purchased for Cable 41 (26F). | 3.51 | 0 | 3.51 | 3 |
| Option B – Cable 42 Joint (papers only) and cable drum + XLPE spares | Full drum of Cable 42 equivalent plus 12 joints worth of papers.<br>XLPE spares at end of shelf life renewed.<br>No spares purchased for Cable 41 (26F). | Does not meet need | | | |
| Option C – Joint Paper for Cables 41 and 42, and Drum of Cable 42 | 12 joints worth of papers for Cable 42 and four joints worth of papers for Cable 41 (26F).<br>Service agreement option for XLPE. | Does not meet need | | | |

[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.

| | | | | | |
|---|---|---|---|---|---|
| Option D - Design, Testing and Manufacture SCFF to XLPE Cable Joints | New SCFF to XLPE joints to allow repairs of Cable 42 using the XLPE cable spares for Cable 43/44.<br>XLPE spares at end of shelf life renewed. | 2.75 | 0 | 2.75 | 1 |
| Option E – Cable 42 Full joints and drum only | Spares for Cable 42 (full drum and joints). XLPE spares would require a service agreement. | 3.46 | 0 | 3.46 | 4 |
| Option F – Cable 42 Papers only + Cable drum | Full drum of Cable 42 equivalent plus 12 joints worth of papers.<br>XLPE spares would require a service agreement.<br>No spares purchased for Cable 41 (26F). | Does not meet need | | | |
| Option G – Cable 41 and 42 Papers Only | 12 joints worth of papers for Cable 42 and four joints worth of papers for Cable 41 (26F). No additional Cable drum for Cable 42.<br>XLPE spares would require a service agreement. | Does not meet need | | | |
| Option H – new Full XLPE and SCFF joints | Full joints for Cable 42.<br>Cable 43/44 joints and terminations. | 2.69 | 0 | 2.69 | 2 |

The preferred option is Option D. Whilst Option H has a marginally lower capital cost it has higher ongoing OPEX costs due to the service agreement with the manufacturer to supply XLPE spares on a very short lead time. It is not yet certain that a mutual agreement would be able to be reached. It is therefore recommended that Option D be scoped in detail and progressed to DG2.[2]

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

# 1. Need/opportunity

The quantities specified in the Underground Cables Spares Plan assume that items are able to be reordered. These cable components are distinct depending on their technology:

- **Self Contained Fluid Filled (SCFF) Cables –** This technology is being phased out by Sumitomo, the manufacturer of SCFF Cables 41 and 42. Sumitomo have advised that they will no longer manufacture SCFF cable from 2025 and accessories from 2030, with no further spares available for purchase after these dates.
- **Cross-Linked Polyethylene (XLPE) Cables –** XLPE cable accessories contain rubberised materials which must be installed within a specified timeframe. Accordingly, spare XLPE accessories must be renewed to ensure that their condition remains acceptable for use. TransGrid used XLPE technology from Cables 43/44 onwards.

## 1.1 SCFF Cables

### 1.1.1 Cable 42

Cable 42, commissioned in 2004, is within the first 50% of its design life of 45 years. TransGrid has set its current acceptable holdings of two joints and one drum of cable on the basis that these levels can be replenished. Based on Sumitomo's latest advice, without a current increase to TransGrid's current spares holdings, only one cable repair would be possible after 2025. Additional Cable 42 spares are required to enable its operation to the end of its design life in 2049. The main risk to the asset is expected to come from third party strikes. Thermal runaway failures are mitigated by the Distributed Temperature System.

### 1.1.2 Cable 41

Cable 41 commissioned in 1979 is at the end of technical life as a 330 kV asset. Its condition issues are primarily related to voltage stresses. Following the completion of the Powering Sydney's Future project, Cable 41 will be converted to 132 kV operation as Cable 26F. As per the advice from Network Planning, this circuit is required for 132 kV operation for a minimum of ten years, which is expected to be well within the technical capability of the asset given voltage stresses are less likely to arise from the lower 132 kV operation. The main risk to the asset is expected to come from third party strikes or thermal runaway failures caused by inappropriate service crossings.

Given the condition issues on Cable 41, TransGrid currently holds a greater quantity of spares for Cable 41 to cover for a thermal runaway event. The existing spares levels are expected to be adequate for a period of ten years during its operation as Cable 26F. However, there exists an opportunity to purchase additional SCFF components suitable for Cable 41 to keep the option of using this cable open beyond the current planning timeframe.

### 1.1.3 SCFF Spares Options

In order to repair an SCFF cable, a new length of cable bridging the failed location cable can be installed and the connected to the existing cable with new joints. There are two options for the cable system:

- In between cable can be kept life-for-like as SCFF
- In between cable can be XLPE – the mixed technology method reduces the need to keep SCFF cable, but will require SCFF to XLPE transition joints that contain paper components that will no longer be manufactured.

Details of the options to replace the SCFF capital spares are presented in Section 3. It is noted that the options have been considered on the basis that the remaining spare cable length in store should not be a restriction to any required repair.

The failure to implement any option may result in the inability to repair the SCFF cables after existing spares are depleted. Essentially a cable strike, which may cost $5 million to repair, would require planning to begin for a replacements in the order of hundreds of millions in value. This would take multiple years to deploy. The damaged cable would have to be retired resulting in a significant write-down for the business (Cable 41 $9 million; Cable 42 ~$120 million).

Sydney CBD and surrounding suburbs have a “modified N-2” reliability requirement. Having Cable 42 available is essential in meeting this compliance requirement. If Cable 42 was unavailable for an extended period, which was exacerbated by not having adequate spares, TransGrid may be found in breach of their licence.

## 1.2 XLPE Accessories

### 1.2.1 Cable 43/44 and 45

The long lead cable spare items (joints and terminations) associated with Cable 43/44 were supplied at the time of its construction and commissioning in 2014. Based on the Spares Plan, TransGrid’s current holdings to account for credible failure situations are two remoulded joints and one gas insulated switchgear (GIS) termination. TransGrid had one failure event in 2015, where a contractor bored into the Cable 43. The damaged cable was replaced with new cable from existing joint bay to joint bay. New joints were purchased for this repair. Spare cable was used which was replenished as part of the repair works.

When stored in packaging especially designated for spares storage, these long lead items have a shelf life of 10 years (accessories shipped for construction would typically only have a shelf life of two years). The current spares require replacement as they will reached the end of life in 2025. Details of the specific accessory components specific to Cable 43/44 are shown in Table 2 below.

**Table 2 — Cable 43/44 XLPE Accessory Component Shelf Life and Lead Time**

| Accessory | Spare Component | Shelf Life | Lead Time |
|---|---|---|---|
| Joint | Epoxy insulator (sectionalising barrier)<br><br>Premoulded insulator | 10 years (in special packaging) | Minimum two months (emergency request with air freight) |
| GIS Termination | Epoxy bushing<br><br>Stress relief cone | | |

In the tunnel Cable 45 uses that same style of joints as Cable 43/44. At Sydney Park and Haymarket, the cable uses prefabricated joints to join the Ausgrid 132 kV cable with TransGrid’s cable. Due to the location of these joints failure by external interference would be rare. These prefabricated joints are significantly more expensive that the premoulded joints used elsewhere. Due to the cost, small population and likelihood of failure, continual renewal of these prefabricated joints would be considered disproportionate under ALARP.

### 1.2.2 Cable 39

Cable 39 is a different cable size to Cable 43/44, however TransGrid holds adaptor kits which enable Cable 39 to be repaired with Cable 43/44 joints and cable in the event of a failure. There is no current requirement for these to be replaced.

### 1.2.3 XLPE Spares Options

A solution to the expiring XLPE spare cable accessories is required by 2025. Two options are to be considered:

- Renewal of the existing spares
- TransGrid to enter into a service agreement with the Original Equipment Manufacturer (OEM) to guarantee accessories within a specified lifetime

With the commissioning of Powering Sydney’s Future (Cable 46) these cables now form part of the supply of electricity to the Sydney CBD and surrounding suburbs. These have a “modified N-2” reliability requirement. Taking no action could result in breach of these requirements in the event of cable failure as the failed cable would be unavailable for an extended period of time.

## 2. Related needs/opportunities

> Need N2490 - Cable Monitoring Systems Renewal – Spare holdings have been set with the expectation that these systems are operational.

## 3. Options

The base case for this assessment is a 'do nothing' scenario, where the no spares are purchased and no service agreements are entered into. In addition to the base case, eight other options have been considered due to the different spares requirements for SCFF and XLPE cable technologies, and the various options available to each. The matrix of the requirements under each option is summarised in Table 3 below.

**Table 3 – Matrix of options assessed**

| | XPLE Spares Replacement | Cable 42 SCFF Full Joints + Cable 42 Drum | SCFF Papers (Cable 42 only) + Cable 42 Drum | SCFF Papers (Cable 41 and 42) | New XLPE – SCFF joints |
|---|---|---|---|---|---|
| Option A | Yes | Yes | No | No | No |
| Option B | Yes | No | Yes | No | No |
| Option C | Yes | No | No | Yes | No |
| Option D | Yes | No | No | No | Yes |
| Option E | No | Yes | No | No | No |
| Option F | No | No | Yes | No | No |
| Option G | No | No | No | Yes | No |
| Option H | No | No | No | No | Yes |

### 3.1 Base case

The base case will result in no spares being procured. For XLPE cables the existing spares will reach the end of their shelf life in 2024/2025. Any failures will result in delays of six months to restore the circuit due to the lead time of the joints or terminations.

For the SCFF cables, there is only the stores capacity to account for one failure. Whilst these spares do not have a shelf life, with the manufacturer withdrawing support starting 2025, should a cable strike occur any subsequent events may not be able to be restored. Cable 42 is only half way through its design life. The base case would not address the need as there would be a significant risk that Transgrid will be unable to meet the requirements of the Spares Policy and the Underground Cables Spares Plan.

## 3.2 Options evaluated

**Option A** — Cable 42 full joints and cable drum + XLPE spares [NOSA N2488, OFS 2488A]

This option will acquire 12 full joints and a cable drum for of the design for cable 42. The spares held for Cable 43/44/45 and 39 will be refreshed.

Cable 41 will not have any additional spares purchased. There are already sufficient holdings for either three cable strikes or a thermal runaway failure. Cable 41 is almost fully depreciated. It will be shortly be operating at 132 kV so will have a lower criticality.

It is estimated that this option would cost $3.51 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 2027/2028.

**Option B** — Cable 42 Joint (papers only) and cable drum + XLPE spares [NOSA N2488, OFS 2488B]

This option would purchase the insulating paper components of 12 Cable 42 joints. Minimal full joints will be retained in store. When the full joints are consumed, remaining components will be purchased and added to these papers to from full joints. A full drum of Cable 42 would also be purchased. As only partial joints would be purchased this option would not completely meet the need of providing spares capacity on cable 42 for the rest of its design life.

As per Option A, no additional spares will be purchased for Cable 41 but the XLPE spares for Cable 43/44/45 will be renewed.

Purchasing papers will not qualify for capital spares. Capitalisation will only be possible as full joints are consumed and .the remainder of the joint components are purchased to form complete joints. In this situation the cost of the papers will remain on the CAPEX works in progress for many years. Only the cable drum will be able to be capitalised.

As this option does no completely meet the need and does not fully qualify to be capital works, this option will not be considered further.

**Option C** — Joint Paper for Cables 41 and 42, and Drum of Cable 42 [NOSA N2488, OFS 2488C]

This option would purchase the insulating paper components of 12 Cable 42 joints and four (4) cable 41 joints. Minimal full joints will be retained in store. When the full joints are consumed, remaining components will be purchased and added to these papers to from full joints. A drum of Cable 42 would also be purchased. As only partial joints would be purchased this option would not completely meet the need of providing spares capacity on cable 42 for the rest of its design life.

Purchasing papers will not qualify for capital spares. Capitalisation will only be possible as full joints are consumed and .the remainder of the joint components are purchased to form complete joints. In this situation the cost of the papers will remain on the CAPEX works in progress for many years. Only the cable drum will be able to be capitalised.

As this option does no completely meet the need and does not fully qualify to be capital works, this option will not be considered further.

**Option D** — Design, Testing and Manufacture SCFF to XLPE Cable Joints [NOSA N2488, OFS 2488D]

This option will introduce a new type of cable joint which will allow joining of Cable 42 with the XLPE cable kept for Cable 43/44. The spare accessories held for Cable 43/44/45 and 39 will also be refreshed.

This option removes the risk that the spare cable would get depleted.

As this is a new joint, type testing will be required. These new joints would contain both insulating papers, which will no longer be available during 2023-28 regulatory period and the rubberised stress cone component of the XLPE joints, which suffer from the limited shelf life issue. Twelve (12) joints will be purchased.

As this option involves purchasing complete components, full capitalisation of the materials will be possible.

It is estimated that this option would cost $2.75 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 2027/2028.

**Option E** — Cable 42 Full joints and drum only [NOSA N2488, OFS 2488E]

This Option is essentially Option A but without purchase of any XLPE spares. To cover for failures on the XLPE network, a service agreement will be required with the OEM providing spares accessories within a defined timeframe. The annual OPEX cost for this is currently unknown. For the purpose of this OER it will be assumed to be $10,000 per annum.

As this option involves purchasing complete components, full capitalisation of the materials will be possible.

To cover for failures on the XLPE network, a service agreement will be required with the OEM providing spares accessories within a defined timeframe. The annual OPEX cost for this is currently unknown. For the purpose of this OER it will be assumed to be $10,000 per annum. There is a risk that TransGrid will be unable to reach an agreement with acceptable terms, making this option completely unable to meet the need.

It is estimated that this option would cost $3.46 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 2027/2028.

**Option F** — Cable 42 Papers only + Cable drum [NOSA N2488, OFS 2488F]

Option F is Option B but without the XLPE spares.

A whole cable drum and insulating papers for 12 Cable 42 joints will be purchased. In the event that full joints are utilised from store then the remainder of the parts will be purchased to make augment with these papers to form full joints. As only partial joints would be purchased this option would not completely meet the need of providing spares capacity on cable 42 for the rest of its design life.

To cover for failures on the XLPE network, a service agreement will be required with the OEM providing spares accessories within a defined timeframe. The annual OPEX cost for this is currently unknown. For the purpose of this OER it will be assumed to be $10,000 per annum. There is a risk that TransGrid will be unable to reach an agreement with acceptable terms, making this option completely unable to meet the need.

Purchasing papers will not qualify for capital spares. Capitalisation will only be possible as full joints are consumed and .the remainder of the joint components are purchased to form complete joints. In this situation the cost of the papers will remain on the CAPEX works in progress for many years. Only the cable drum will be able to be capitalised.

As this option does no completely meet the need and does not fully qualify to be capital works, this option will not be considered further.

**Option G** — Cable 41 and 42 Papers Only [NOSA N2488, OFS 2488G]

This option would purchase insulating papers for joints on Cable 42 (12 sets) and Cable 41 (4 sets). When fill joints in the store are consumed, the remaining parts of the joints to go with the papers will be purchased to form full joints.

To cover for failures on the XLPE network, a service agreement will be required with the OEM providing spares accessories within a defined timeframe. The annual OPEX cost for this is currently unknown. For the purpose of this OER it will be assumed to be $10,000 per annum. There is a risk that TransGrid will be unable to reach an agreement with acceptable terms, making this option completely unable to meet the need.

With the commissioning of PSF (Cable 46) Cable 41 will be converted to 132 kV operation. The need for this link will continue for the foreseeable future. The issues with the cable joints which were partly a driver for PSF were voltage related. When operating at 132 kV those issues would be more or less eliminated. Whilst Cable 41 will soon reach end of economic life, when operating at 132 kV the remaining useful life would be expected to be at least 20 years, given current condition. Ensuring that spares are available will enable full utilisation of this remaining useful life.

Purchasing papers will not qualify for capital spares. Capitalisation will only be possible as full joints are consumed and .the remainder of the joint components are purchased to form complete joints. In this situation the cost of the papers will remain on the CAPEX works in progress for many years. Only the cable drum will be able to be capitalised.

As this option does no completely meet the need and does not fully qualify to be capital works, this option will not be considered further.

**Option H** — New full XLPE to SCFF transition joints, No XLPE Spares [NOSA N2488, OFS 2488H]

This option will purchase 12 new SCFF to XLPE transition joints. This joints allow repairs or diversions on cable 42 to be implemented by using these new joints with the XLPE spare cable for Cable 43/44.

This option allows significant cable deviations or modifications to the cable route to occur as the new cable section would be installed using cable that is still being produced and utilised existing cable spares.

The ongoing spares management is higher with this option. The silicon/EPR rubber stress cones on the XLPE side have limited shelf life.

As these joints would be a new design, type testing is required. The design and texting costs are a significant portion of the capital cost for this option.

To cover for failures on the XLPE network, a service agreement will be required with the OEM providing spares accessories within a defined timeframe. The annual OPEX cost for this is currently unknown. For the purpose of this OER it will be assumed to be $10,000 per annum. There is a risk that TransGrid will be unable to reach an agreement with acceptable terms, making this option completely unable to meet the need.

Full joints will enable immediate capitalisation.

It is estimated that this option would cost $2.69 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 2027/2028.

## 3.3 Options considered and not progressed

The options considered have been exhaustive. There are no further options that have been considered and not progressed.

# 4. Evaluation

The Underground Cable Assets Spares Plan provides guidelines in establishing appropriate minimum spares requirements for TransGrid to provide meets the required reliability standards. A summary of credible options is shown below in Table 4

**Table 4 - Commercial evaluation (PV, $ million)**

| Option | Capital Cost PV | OPEX Cost PV | Ranking |
|---|---|---|---|
| Option A | 3.51 | 0 | 3 |
| Option B | Not evaluated. Does not fully meet need. | | |
| Option C | Not evaluated. Does not fully meet need. | | |
| Option D | 2.75 | 0 | 1 |
| Option E | 3.46 | 0.1 | 4 |
| Option F | Not evaluated. Does not fully meet need. | | |
| Option G | Not evaluated. Does not fully meet need. | | |
| Option H | 2.69 | 0.1 | 2 |

## 4.1 ALARP evaluation

ALARP evaluation is not applicable for this need as the need relates the restoration of assets after failure or deteriorated condition and which does not have a quantified safety risk cost.

## 4.2 Preferred option

Option D was the preferred option as it future proofs Cable 42 by allowing it to be repaired with modern XLPE cable. Repairs and deviations are not limited by stock of spare cable or joints.

Option H, whilst having a slightly lower overall capital cost achieves the need by having a service agreement with the manufacturer. This comes at a higher operational cost to Transgrid. It is not yet certain that Transgrid could come to a mutual agreement. Purchasing of XLPE spares removed the risk that a service agreement will be unable to be executed, or an executed plan fails to deliver spares in the required timeframe.

**Capital and Operating Expenditure**

The required capital expenditure is $2.75 million.

**Regulatory Investment Test**

A regulatory investment test for transmission (RIT-T) is not required as the estimated capital cost for all options are below the threshold of $6 million.

## 5. Optimal Timing

The optimal timing for this need is when the shelf life for the existing XLPE spares is reached. This also aligns with beginning of the ramp down for the manufacturing of SCFF cable and accessories. This year is 2024/2025, commencing in the 2024-2028 Regulatory Period.

## 6. Recommendation

The preferred option is Option D. It is therefore recommended that this option be scoped in detail, so that it can be progressed to DG2. Total project cost is $2.75 million.

**Approval Record**

| WF Ref: | Process Name | Actioned By | Action | Comments | Date |
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| 204993 | Document Review | Kurniawan Charles | Reviewed | Comments in Document | 03-11-2021 |
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