Conductor & Ground Wire Replacement

Regulatory Investment Test for Transmission

Project Specification Consultation Report

Published 29 April 2022

ISSUE/AMENDMENT STATUS

Issue	Date	Description	Author	Approved
1	29/04/2022	First Issue	Auras Bugheanu	Dasun DeSilva

Purpose

AusNet Services has prepared this document to provide information about potential limitations in the Victoria transmission network and options that could address these limitations.

Disclaimer

This document belongs to AusNet Services and may or may not contain all available information on the subject matter this document purports to address.

The information contained in this document is subject to review and AusNet Services may amend this document at any time. Amendments will be indicated in the Amendment Table, but AusNet Services does not undertake to keep this document up to date.

To the maximum extent permitted by law, AusNet Services makes no representation or warranty (express or implied) as to the accuracy, reliability, or completeness of the information contained in this document, or its suitability for any intended purpose. AusNet Services (which, for the purposes of this disclaimer, includes all of its related bodies corporate, its officers, employees, contractors, agents and consultants, and those of its related bodies corporate) shall have no liability for any loss or damage (be it direct or indirect, including liability by reason of negligence or negligent misstatement) for any statements, opinions, information or matter (expressed or implied) arising out of, contained in, or derived from, or for any omissions from, the information in this document.

Contact

This document is the responsibility of AusNet Services.

Please contact the indicated owner of the document with any inquiries.

Auras Bugheanu
AusNet Services
Level 31, 2 Southbank Boulevard
Southbank, Victoria 3006
Ph: (03) 9695 6000

TABLE OF CONTENTS

1 Introduction

1.1 Overview

AusNet Services owns and operates the electricity transmission network in Victoria, which transports electricity from coal, gas and renewable generators across Victoria and interstate, to terminal stations that supply large customers and distribution networks.

The Regulatory Investment Test for transmission (RIT-T) is an economic cost-benefit test used to assess and rank potential investments capable of meeting the identified need. The purpose of the RIT-T is to identify the credible option that maximises the present value of net economic benefit to all those who produce, consume and transport electricity in the National Electricity Market (the preferred option).

The publication of this Project Specification Consultation Report (PSCR) represents the first step in the RIT-T process. This PSCR is focused on our replacement project for phase conductors and ground wire assets.[1] The primary function of phase conductors is to safely and efficiently transmit electrical energy between terminal stations. Ground wire assets have two primary functions:

- Shielding phase conductors from lightning strikes; and
- Reducing voltage rise at structures by providing multiple paths for fault currents.

Where optical fibre ground wire (OPGW) is used, it also has the additional functionality of providing communication links between terminal stations.

In accordance with clause 5.16 of the National Electricity Rules (NER) and section 4.2 of the AER's RIT-T Application Guidelines[2], this PSCR sets out:

- the identified need that AusNet Services is seeking to address, together with the assumptions used in identifying this need;
- a description of the credible network options that may address the identified need, including our reasons why there are no credible non-network options;
- the technical characteristics of each credible option;
- the classes of market benefits that AusNet Services considers are unlikely to be material, together with our reasoning;
- the estimated construction timetable and commissioning date; and
- the total indicative capital and maintenance costs for each option.

1.2 Consultation

In accordance with clause 4.2 of the AER's Application Guidelines, we are seeking submissions on the matters set out in this PSCR. Notification of our request for submissions will be provided to Registered Participants, AEMO, non-network providers, interested parties and persons on our demand side engagement register as required by the NER. We will also publish this report and closing date for submissions on our website.

[1] In accordance with clause 5.16.4(b)(4) of the NER, it should be noted that this project is not described in AEMO's 2020 Integrated System Plan (ISP), being the latest published ISP.

[2] Australian Energy Regulator, Application Guidelines, Regulatory Investment Test for transmission, August 2020.

Submission should be sent to rittconsultations@ausnetservices.com.au by 22 July 2022 and telephone enquiries can be directed to Auras Bugheanu on (03) 9695 6000.

Submissions will be published on AusNet Services' website. If you do not wish to have your submission published, please clearly stipulate this at the time of lodging your submission.

2 Background

Our transmission system contains approximately 6,500 km of phase conductors, consisting of over 17,300 circuit spans. There are three different types of phase conductors in use on our transmission network, being aluminium conductor steel reinforced (ACSR), all aluminium conductor (AAC) and all aluminium alloy conductor (AAAC). All phase conductors are manufactured and tested in accordance with the relevant standards.[3]

Transmission line ground wire (GW) are bare conductors supported at the top of transmission towers. As already noted, a primary purpose of GW is to shield the transmission line and intercept lightning strikes before they reach the phase conductors, reducing the likelihood of lightning induced damage (e.g. current and voltage surges). The GW is securely earthed at each tower, to allow an electrical path for the lightning to earth and prevent interference with the phase conductors.

GW made of steel is used as lightning protection/shield for phase conductors. OPGW is a composite wire that incorporates optical fibres in its core and is used both as lightning protection/shield for phase conductors as well as a communications data transfer route used for SCADA.

To assess the condition of these assets, an improved visual inspection technique, known as Smart Aerial Image Processing (SAIP), was introduced in 2015 and was established as a routine inspection activity in 2020. The SAIP system includes capture of continuous high-resolution conductor images from a helicopter and the use of automatic image recognition technology to locate and prioritise repair and replacement of conductors.

This technology enables the efficient capture of conductor images spanning long distances of transmission lines. Images captured are analysed using machine learning software which aims to automate the identification of signs of corrosion including the presence of white powder, conductor bulging or broken strands. This technology will continue to allow us to ensure that future conductor replacements are even more closely aligned to condition, rather than age-based.

Our asset condition data indicates that only a small percentage, approximately 0.25% of the total phase conductor spans and 2.35% of GW spans are categorised as condition C4 or C5, which are the poorest condition categories. While this is a small percentage of the asset population, functional failure of a phase conductor or GW asset has potential negative outcomes for our customers, our staff and contractors in terms of health and safety risk; bushfire ignition risk; and market impacts.

In order to manage these risks effectively, AusNet Services adopts a proactive approach to asset replacement of phase conductor and GW assets, taking into account the risk and consequences of asset failure. This PSCR explains our proposed project in relation to the proactive replacement of these assets. Our plans are consistent with our asset management strategy (AMS) for these assets.[4]

[3] AS/NZS 3607.1989 Conductors – Bare Overhead – Aluminium and aluminium alloy – Steel reinforced; and AS/NZS 1531.1991 Conductors – Bare Overhead – Aluminium and aluminium alloy.

[4] AusNet Services, AMS 10-79 Transmission Line Conductors and Ground Wires, July 2020.

3 Identified need

3.1 Description of the identified need

Our fleet of transmission line conductors and ground wires are ageing. Approximately 55 per cent of the population has been in service for more than 50 years, this figure will increase to 60 per cent by 2025. While phase conductor and GW assets are generally in good condition, some assets are showing signs of corrosion-based deterioration. The two factors which have the greatest impact on levels of corrosivity include salt deposition experienced in coastal regions and air pollution caused by emissions from heavy industry.

As phase conductor and GW assets deteriorate, the risk of a functional failure increases. The majority of phase conductor and GW functional failures result in loss of mechanical function followed by loss of electrical/communication function i.e. phase conductor or GW falling to ground or onto phase conductors below.

Phase conductor and GW functional failures can lead to three types of adverse consequences for our customers, staff and contractors:

- Health and safety;
- Bushfire ignition; and
- Market impact.

The identified need in relation to phase conductor and GW assets, therefore, is driven by the need to actively manage the risks and consequences of asset failure.

In addition to the need for remedial action to mitigate these risks and consequences, AusNet Services must also ensure that it complies with its regulatory obligations, which include the Electricity Safety Act 1998. This Act requires AusNet Services to minimise hazards and risks to the safety of any person as far as reasonably practicable. In relation to phase conductor and GW assets, compliance with this Act (and other regulations) contribute to the identified need.

3.2 Assumptions

In assessing the identified need, AusNet Services must consider the risk of asset failure and the likelihood of potential adverse consequences eventuating. The assumptions underpinning each of the three consequences of conductor and GW functional failure are discussed briefly below.

3.2.1 Health and safety risks

Phase conductor and GW functional failures can present health and safety risks to members of the public, AusNet Services' employees and contractors accessing the transmission line easements. The Health and Safety asset criticality is quantified at span level by a combination of two characteristics:

- Easement type; and
- Line crossings.

Transmission line easements traverse lands with various use types. Easements are classified into three easement types:

- Urban;
- Rural developed; and
- Rural not-developed.

The Electricity Safety Act 1998 requires AusNet Services to design, construct, operate, maintain, and decommission its network to minimise hazards and risks to the safety of any person as far as reasonably practicable or until the costs become disproportionate to the benefits from managing those risks. By implementing this principle for assessing safety risks from asset failures, AusNet Services uses:

- a value of statistical life to estimate the benefits of reducing the risk of death[5];
- a value of lost time injury[6]; and
- a disproportionality factor[7].

AusNet Services' approach to assessing the risk and consequence of asset failure, including the use of a disproportionality factor, is consistent with the guidance provided by the AER.[8]

3.2.2 Bushfire ignition

Faults on transmission line assets can result in discharges of energy which are capable of igniting ground fires. Some transmission lines are situated in easements through high density fuel loads in grasslands and forests. In extreme weather conditions ground fires started close to such fuel loads can quickly develop into widespread bushfires.

Bushfire loss consequence modelling performed by Dr. Kevin Tolhurst of Melbourne University has enabled the establishment of quantitative bushfire consequence values for transmission line assets. AusNet Services has regard to this analysis in assessing the potential consequences from bushfire ignition.

Historically, there have been no incidents of bushfire ignition from transmission line conductor or GW assets on the Victorian transmission network. The following factors have contributed to the absence of bushfire ignition:

- Low incidence of conductor to ground faults on transmission lines, which reduces the risk of fire start;
- Transmission lines protection systems are very quick to interrupt the current flow into a fault; and
- Transmission lines easements are wide and well managed, which reduces the risk of ignition and fire spread.

While there have been no historical instances of transmission line conductor or GW failures leading to bushfire ignition, a proactive asset inspection and replacement program is essential in continuing to minimise bushfire risk in accordance with our regulatory obligations and community expectations.

---

[5] Department of the Prime Minister and Cabinet, Australian Government, "Best Practice Regulation Guidance Note: Value of statistical life," available at https://www.pmc.gov.au/resource-centre/regulation/best-practice-regulation-guidance-note-value-statistical-life.

[6] Safe Work Australia, "The Cost of Work-related Injury and Illness for Australian Employers, Workers and the Community: 2012-13," available at https://www.safeworkaustralia.gov.au/system/files/documents/1702/cost-of-work-related-injury-and-disease-2012-13.docx.pdf.

[7] Health and Safety Executive's submission to the1987 Sizewell B Inquiry suggesting that a factor of up to 3 (i.e. costs three times larger than benefits) would apply for risks to workers; for low risks to members of the public a factor of 2, for high risks a factor of 10. The Sizewell B Inquiry was public inquiry conducted between January 1983 and March 1985 into a proposal to construct a nuclear power station in the UK.

[8] Australian Energy Regulator, "Industry practice application note for asset replacement planning," available at https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/industry-practice-application-note-for-asset-replacement-planning.

3.2.3 Market impact

The electricity transmission lines forming the National Electricity Market have high levels of redundancy under average loading conditions. However, at peak loading periods; transmission line failures can constrain generator connections causing a re-scheduling of generators and load shedding may be required to provide network security for a subsequent unrelated failure.

Market modelling is required to estimate the expected adverse impact on dispatch costs as a result of a phase conductor failure. In relation to unserved energy, the supply risk costs is the probability of an event occurring multiplied by the cost of the expected unserved energy that would result from that event, where the expected unserved energy is costed in accordance with the AER’s estimated Value of Customer Reliability (VCR).

4 Credible options considered

This section describes the credible options that have been considered to address the identified need, including:

- the technical characteristics of each option;
- the estimated construction timetable and commissioning date; and
- the total indicative capital and operating and maintenance costs.

The purpose of the RIT-T is to identify the credible option for addressing an identified need that maximises the net market benefit. An important aspect of this task is to consider non-network and network options on an equal footing, so that the optimal solution can be identified.

As the identified need in this case arises from the condition of phase conductors and GW assets that are integral to the safe and reliable supply of electricity through the transmission network, there are no credible non-network options that could address this identified need. Specifically, the nature of the risks is asset-related and cannot be mitigated by a non-network option given the significant costs of retiring the assets.

The credible options are therefore:

- **Option 1**: Replace poor condition phase conductors and GW on a like-for-like basis; and
- **Option 2**: As per Option 1, plus replace selected steel GW with OPGW to upgrade the telecommunication network.

Our cost-benefit assessment, which is not presented in this PSCR, will assess the costs of each credible option compared to the costs of a base case 'Business as Usual' (BAU) option, where phase conductor and GW assets are replaced on failure. It should be noted, however, that the BAU option is not regarded as a credible option as it would expose our customers, staff and contractors to unacceptable risks. The BAU option, however, provides a reference point for assessing the net benefits provided by Options 1 and 2.

Neither credible option is expected to have an inter-regional impact. Each credible option is discussed in further detail below.

4.1 Option 1: Replace poor condition phase conductors and GW on a like-for-like basis

Based on a comprehensive risk assessment which considers conductor health score as a proxy for probability of failure, and consequence of failure (collateral damage, safety, market impact and bushfire ignition) 326 km of GW and 35 km of phase conductor have been identified for replacement in the Transmission Conductors and Ground Wires Asset Management Strategy (AMS 10-79). This option would involve the replacement of these identified assets on a like-for-like basis.

In relation to operating expenditure, we do not expect this option to have a material impact on our future costs i.e. routine maintenance expenditure would be substantially unchanged.

This Option would be undertaken in two phases to ensure that the highest risk assets are addressed as soon as practicable, while allowing for refinements in the scope for Phase Two.

Phase One would involve the replacement of 233 km of GW route length at a capital cost of $20.9 million.[9] Phase Two of the project has not yet been fully costed.

4.2 Option 2: As per Option 1, plus replace selected steel GW with OPGW to upgrade the telecommunication network

Under this option, in addition to the work described in Option 1, selected existing steel GW would be replaced by OPGW where a communication link upgrade is required. The current radio network does not have sufficient bandwidth to handle SCADA. By taking the opportunity to replace steel GW with OPGW, this option will improve the reliability of the data communications network and provide improved bandwidth for SCADA.

As noted in relation to Option 1, in order to optimise the project we are planning to deliver it in two phases. By staging the project delivery, lessons can be learnt from Phase One and incorporated in Phase Two. In addition, the scope of work for Phase Two can be finalised in parallel with the delivery of Phase One. The costs of delivering Phase One of Option 2 is greater than the equivalent scope for Option 1, as it provides the additional benefit of an upgraded telecommunications network. We are able to achieve this by reassigning an allocation under the telecommunication TRR approved budget to drive investment efficiency.

Our assessment is that the incremental costs of replacing steel GW with OPGW at selected locations will be offset by the benefits of a more reliable communications network with improved bandwidth. In the absence of the targeted replacement of steel GW with OPGW, it would be necessary to upgrade the radio network. Our assessment is that installing OPGW is more cost efficient and offers net superior reliability and band width compared to upgrading the radio network.

While Phase Two of Option 2 has not yet been fully costed, Phase One comprises a sufficiently large percentage of the total project to demonstrate that Option 2 is preferred to Option 1.

4.3 Preferred option scope, costs and timeframes

Phase One of Option 2 (the preferred option) is expected to replace 233km of GW route length. Phase Two of the project will replace the remaining 93km of GW route length and 35 km of phase conductor that have been identified for replacement. As explained in section 4.2, the replacement project will include like-for-like replacement, plus the targeted replacement of existing steel GW with OPGW where a communication link upgrade is required.

The asset risk assessments were performed at a span level, as each span has different wear out characteristics and criticality. In practice, however it is not possible to replace individual spans and the replacement needs to be from a strain tower to the next strain which forms a strain section. Therefore, in developing the scope of works for this project, the high-risk GW spans are grouped by stringing section and then by circuit.

Phase One of Option 2 will replace GWs on stringing sections with highest length of high-risk GW spans and on circuits which have the highest length of high risk stringing sections. The remainder of high-risk GWs and phase conductors will be replaced in Phase Two, which will be scoped while Phase One of the project is being delivered.

Of the nine transmission line circuits included in the scope of works for Phase One, four circuits have been identified as high priority for an upgrade of the telecommunication network. These transmission line circuits qualify for replacing existing GW with OPGW on the basis of two main criteria:

[9] Excludes overheads, capitalised finance charges, and the value of written down assets.

- the circuit is located in an area in the transmission network where one of the communication routes is radio and one optical fibre; or
- the radio route in the identified area is obsolete and/or in poor condition and needs replacement.

Some transmission towers have two GW peaks, and some have one GW peak. On circuits where we replace existing GW with OPGW we reserve the same GW peak (i.e. RHS) for OPGW from one terminal station to the other. The other GW (i.e. LHS) may require replacement due to poor condition and hence on the same circuit we replace both like-for-like and existing with OPGW. For Phase One, the scope of the circuits identified for like-for-like or GW replacement are summarised in the table below.

Table 1: Proposed scope of work – Option 2, Phase One

Item No.	In Scope	Replace existing GW
IS-1	220kV KTS-BLTS 1	Like-for-like
IS-2	220kV RWTS-TTS	Like-for-like
IS-3	220kV SMTS-TTS 2	Like-for-like and existing with OPGW
IS-4	220kV TSTS-TTS	Like-for-like and existing with OPGW
IS-5	220kV YPS-ROTS 5	Like-for-like and existing with OPGW
IS-6	220kV YPS-ROTS 7	Like-for-like
IS-7	220kV HWPS-ROTS 1	Like-for-like and existing with OPGW
IS-8	220kV ROTS-SVTS 1	Like-for-like
IS-9	220kV SMTS-TTS1	Like-for-like

Source: AusNet Services, TD-0009878 – Transmission Line Groundwire Replacement: Phase 1 Business Case

The scope of work for the replacement of the GW for Option 2 includes the following steps:

- Perform structural assessment of GW peak/ crossarm strength for all tower types where existing GW is replaced with OPGW;
- Strengthen GW peak/crossarm as required;
- Replace existing GW with new GW, like-for-like replacement and GW with OPGW where identified in the detailed scope of works list;
- Install underground optical fibre (OPUG) from terminal tower to the optical distribution frame cabinet (ODF) inside the control room on the circuits where OPGW is installed; and
- Perform destructive conductor test for selected steel GW.

The capital expenditure for Option2, Phase One is summarised in the table below.

Table 2: Capital expenditure forecasts for Option 2, Phase One, $'000, $2021

	FY22	FY23	FY24	**FY25**	Total
Design	112.2	228.9	-	-	**341.1**
Internal Labour	22.6	263.2	310.8	297.8	**894.4**
Material		2,165.4	-	-	**2,165.4**
Plant & Equipment		372.3	569.7	484.2	**1,426.2**
Contracts		4,305.4	6,587.3	5,599.2	**16,491.9**
Risk	27.7	321.7	379.9	364.0	**1,093.3**
Management Reserve				690.6	**690.6**
Total capex	**162.5**	**7,656.9**	**7,847.7**	**7,435.9**	**23,103.0**

Source: AusNet Services, TD-0009878 – Transmission Line Groundwire Replacement: Phase 1 Business Case

Note: Excludes overheads, capitalised finance charges, written down value of assets retired/sold.

As already noted, Phase Two of Option 2 has not been fully scoped or costed at this stage. The scope will be finalised during the delivery of Phase One to ensure that the overall project is optimised.

5 Economic assessment of the credible options

5.1 Market benefits and assessment approach

Clause 5.16.4(b)(6)(iii) of the NER requires the RIT-T proponent to consider whether each credible option provides the classes of market benefits described in clause 5.15A.2(b)(4). To address this requirement, the table below discusses our approach to each of the market benefits listed in that clause for both credible options.

Table 3: Analysis of Market Benefits

Class of Market Benefit	Analysis
(i) changes in fuel consumption arising through different patterns of generation dispatch;	The credible options may affect the costs of dispatch by avoiding network constraints as a result of an asset failure. Any changes in fuel consumption will be determined through market modelling.
(ii) changes in voluntary load curtailment;	The credible options are not expected to lead to changes in voluntary load curtailment.
(iii) changes in involuntary load shedding with the market benefit to be considered using a reasonable forecast of the value of electricity to consumers;	The credible options are expected to have a positive impact on involuntary load shedding, by reducing (but not eliminating) the risk of asset failure. The cost benefit analysis will therefore consider the impact of each option on load shedding. AusNet Services applies probabilistic planning techniques to assess the expected cost of unserved energy for each option.
(iv) changes in costs for parties, other than the RIT-T proponent, due to differences in: *(A) the timing of new plant;* *(B) capital costs; and* *(C) the operating and maintenance costs;*	It is possible that there may be changes in costs for other parties, which will be identified through the market modelling. These changes may arise from reductions in network constraints that could arise from the reduced risk of asset failure.
(v) differences in the timing of expenditure;	As noted above, differences in the timing of expenditure may arise from changes in network constraints impacting dispatch costs.
(vi) changes in network losses;	The credible options are not expected to result in material changes to electrical energy losses.
(vii) changes in ancillary services costs	The credible options are not expected to have a material impact on ancillary service costs.
(viii) competition benefits	The credible options are not expected to provide any competition benefits.
(ix) any additional option value (where this value has not already been included in the other classes of market benefits) gained or foregone from implementing the credible option with respect to the likely future investment needs of the National Electricity Market;	There will be no impact on the option value in respect of the likely future investment needs of the NEM.
(x) any other class of market benefit determined to be relevant by the AER.	There are no other classes of market benefit that are relevant to the credible options.

As explained in the above table, a key market benefit from the credible options is lower dispatch costs that would arise from the reduced risk of phase conductor and GW functional failures. These market benefits, which include reductions in fuel costs and possible changes in the timing of expenditure, will be assessed through market modelling. The market modelling will assess the cost savings that would be expected from lower risks of asset failure.

In addition to the market benefits associated with lower dispatch costs, the credible options may also result in reductions in involuntary load shedding. The cost savings from reductions in involuntary load shedding are calculated as follows:

- **Energy at risk**: This is the amount of energy, weighted by the demand conditions considered (10% POE and 50% POE), that would not be supplied as a result of an asset failure.
- **Expected unserved energy**: This is the energy at risk weighted by the probability of an asset failure. This statistic provides an indication of the amount of energy, on average, that will not be supplied in a year considering the low probability of an asset failure.

The cost saving from a credible option is the reduction in expected unserved energy multiplied by the VCR, which is expressed as $/MWh. The VCR that we will employ in our cost-benefit analysis is the AER's latest estimate, taking account of the mix of customers and the duration of the outage being modelled.

In addition to market benefits described above, the costs associated with health and safety risks and bushfire risk (as discussed in sections 3.2.1 and 3.2.2) must also be factored into the cost-benefit assessment.

5.2 Preferred option

Our cost benefit assessment of the options will be presented in the next stage of the RIT-T process. Subject to considering written submissions, however, we are able to confirm that our preferred option (Option 2) is to:

- Replace 326km of GW and 35km of phase conductor which have been identified for replacement in the Transmission Conductors and Ground Wires Asset Management Strategy; and
- Upgrade the telecommunication network by replacing existing GW with OPGW where:
    - the circuit is located in an area in the transmission network where one of the communication routes is radio and one optical fibre; or
    - the radio route in the identified area is obsolete and/or in poor condition and needs replacement.

This option addresses the identified need and provides an efficient, targeted upgrade to our telecommunications network. This option removes the need to undertake capital expenditure to upgrade the existing radio communications network, which would be a higher cost option.

As already noted, further detailed information regarding the cost-benefit analysis will be presented in the next stage of the RIT-T, which will take into account any submissions on this PSCR.

6 Next steps

AusNet Services intends to publish a Project Assessment Conclusion Report in relation to this project in July 2022**.**