Program of Works

2017 – 2022

Transmission Line Conductor and Groundwire Replacement

Document number	N/A
Issue number	1
Status	Approved
Approver	K. Miller
Date of approval	12/10/2015

ISSUE/AMENDMENT STATUS

Issue Number	Date	Description	Author	Approved by
0.1	04/06/15	Initial draft	P. Kilevics	
1.0	12/10/15	2nd draft	P. Kilevics	K. Miller

Disclaimer

Contact

This document is the responsibility of Asset Engineering – Asset Management Division, AusNet Services. Please contact the indicated owner of the document with any inquiries.

Edoardo Viel
Manager Electricity Networks
AusNet Services
Level 31, 2 Southbank Boulevard
Melbourne Victoria 3006
Ph: (03) 9695 6000

Table of Contents

1 Summary

PROGRAM	Transmission Line Conductor and Groundwire Replacement Program 2017 – 2022
SERVICE DATE	On-going throughout period 2017 – 2022
LOCATION	Different areas of Victorian electricity transmission network
VALUE	$ 19.0M

This works program document should be read in conjunction with AMS 10-79 Transmission Line Conductors and AMS 10-56 Communications Systems documents. AMS 10-79 details the background and the analysis performed in order to determine optimal replacement strategies of groundwires. AMS 10-56 describes the current communications system and the strategy to utilise Optical Fibre Ground Wire (OPGW) as a communications bearer.

2 Scope

The scope of the program is to replace conductors and groundwires that have been identified as being in poor condition and close to end of life due to corrosion. No major conductor issues have been identified, so the program is targeted at replacing steel groundwires. In some instances upgrade to an OPGW rather than like for like replacement is economic to cater for future communications requirements.

226km of groundwires in the following lines have been identified as being close to end of life based on visual assessment of corrosion:

8km	KTS-BLTS 36-48 (2 x 4 km)**
4km	KTS-GTS 1, 3 157-166
16km	TTS-KTS 2
22km	TTS-KTS 1
15km	ROTS-MTS 341-389
15km	ROTS-RTS 1 341-389
15km	ROTS-RTS 4 341-389**
5km	CBTS-FTS 58-72
26km	DDTS-SMTS2 515-550 (2x13km)
19km	HWPS-ROTS 279-339
19km	YPS-ROTS 7&8 279-339
8km	SVTS-HTS 2
53km	YPS-ROTS 5, 6 (120-264 and 317-ROTS)**
3km	NPSD-BLTS 11-20

***- Economic to upgrade to OPGW*

The estimated cost of like-for- like replacement is $16.3M and a further $2.7M to install OPGW on those lines identified as requiring future communications routes.

2.1 Program Expenditure Forecast

2017/18 ($k)	2018/19 ($k)	2019/20 ($k)	2020/21 ($k)	2021/22 ($k)	Total ($k)
3,802	3,802	3,802	3,802	3,802	19,010

Table 1 – Program timing and forecast expenditure

Forecast costs shown in Table 1 are $2014/15 P50 direct costs. These costs exclude overheads, finance charges and cost escalation. Unit costs are described in Appendix 4D: Unit Rates.

3 Project Drivers

The replacement program will significantly reduce the likelihood of a major failure which would cause conductors or groundwires to fall to ground.

Consequences of such a failure include:

- Health and Safety incidents;
- Bushfire ignition;
- Financial penalties;
- Significant repair costs;
- Increased risk of loss of supply to many customers;
- Damage to third party assets.

Implementation of this program of work will assist AusNet Services in addressing the following business drivers:

- Safety of employees, contractors and the general public:
  - Minimise OH&S risk to employees and contractors;
  - Minimise risk to public due to asset failure.
- Financial risk:
  - Reduce capital and operating costs through prevention of asset failures;
  - Reduce financial penalties associated with poor asset availability;
  - Reduce civil actions resulting from personal injury/compromised health.
- Regulatory compliance:
  - Electricity Safety Act;
  - Electricity Safety (Management) Regulations;
  - Occupational Health & Safety Act.
- Corporate image maintained as prudent asset managers:
  - Manage risk so far as is practicable.

4 Overview

4.1 Conductors

The AusNet Services transmission system contains approximately 40,500km of conductors in 17,800 spans, including spans within Terminal Stations.

The phase conductors are mostly ACSR and a small amount of AAAC (<400km) operating at voltages from 66kV to 500kV. Bundling is a mixture of quad, twin and single conductors per phase.

Most of the conductor is from the original line construction. Other than works for diversion of small sections of lines for various reasons, the only significant condition related conductor replacements have been:

- HYTS and APD T591-APD (2012).
- RWTS-TTS- 5km in Thomastown area (1998).

No specific conductor replacement has been identified for this period. SAIP (Smart Aerial Imaging and Processing) is to be introduced as part of preventative maintenance strategies for the early identification of issues and defects. It is expected that some conductors in the more corrosive environments will meet end of life in the next 10 to 15 years.

4.2 Groundwires

There are approximately 20,400 spans of groundwires on transmission lines and terminal stations in the network. They are strung above conductors and plant on lines and stations to reduce outages and possible damage associated with lightning strikes. A secondary purpose is to provide a return path for fault currents and reducing step and touch potentials at a structure in the event of a fault. More recent groundwires include optical fibres to provide a high speed communications network between stations.

Groundwires installed on all lines and stations prior to the introduction of the 500kV system in 1968 were all galvanized steel wires. The first use of ACSR groundwires was on 500kV lines and stations in 1968. The type initially used was Brahma and was later superseded by Grape or Cricket in about 1978. A mix of steel and ACSR groundwires continued to be used in lines up to 330kV, mainly due to the structural capacity limitation of existing tower designs to support the extra loadings imposed by the larger diameter and heavier ACSR groundwires. OPGW was first used around 1987.

ACSR is now the preferred option for new groundwires as its higher conductivity provides a better fault current return path and reduces step and touch potentials at tower sites.

Steel groundwires are approximately 44% of the population and are also the oldest groundwires.

Most of the groundwire is from the original line construction. Other than works for diversion of small sections of lines for various reasons and OPGW retrofits, the only condition related groundwire replacements have been:

- HWTS-SMTS No 1 from T1 to T048 (2015);
- YPS-ROTS 5/6 from T7 to T120 (1997);
- YPS switchyard (2000);
- HYTS-APD T592-T627 (2011);
- KTS-WMTS (current project);
- KTS-GTS 2 (current project).

5 Risk Matrix

Conductor and ground wire functional failures can result in conductors falling to the ground or onto phase conductors below and so can have significant impacts or consequences. Major conductor and ground wire failures can lead to three different consequence types including health and safety, bushfire ignition and network performance. These consequences can be quantified using the 1 – 5 scoring system shown on the vertical axis of AusNet Services' risk matrix which is displayed in Figure 14.

Analysis of the MTBF for conductor and ground wire guides the likelihood scoring in an objective fashion. A MTBF of 9.29 years indicates that there have been functional failures once every 9.29 years on average which corresponds to an annual probability of 10 per cent. This probability aligns with a likelihood score of B on the AusNet Services risk matrix. This likelihood is applied to the network performance risk caused by a conductor or ground wire functional failure. Not every major failure of a conductor or ground wire presents health and safety risk or bushfire ignition risk to the public; the event will have to occur under exceptional circumstances. The probability is very low and aligns with a likelihood score of A on the AusNet Services risk matrix.

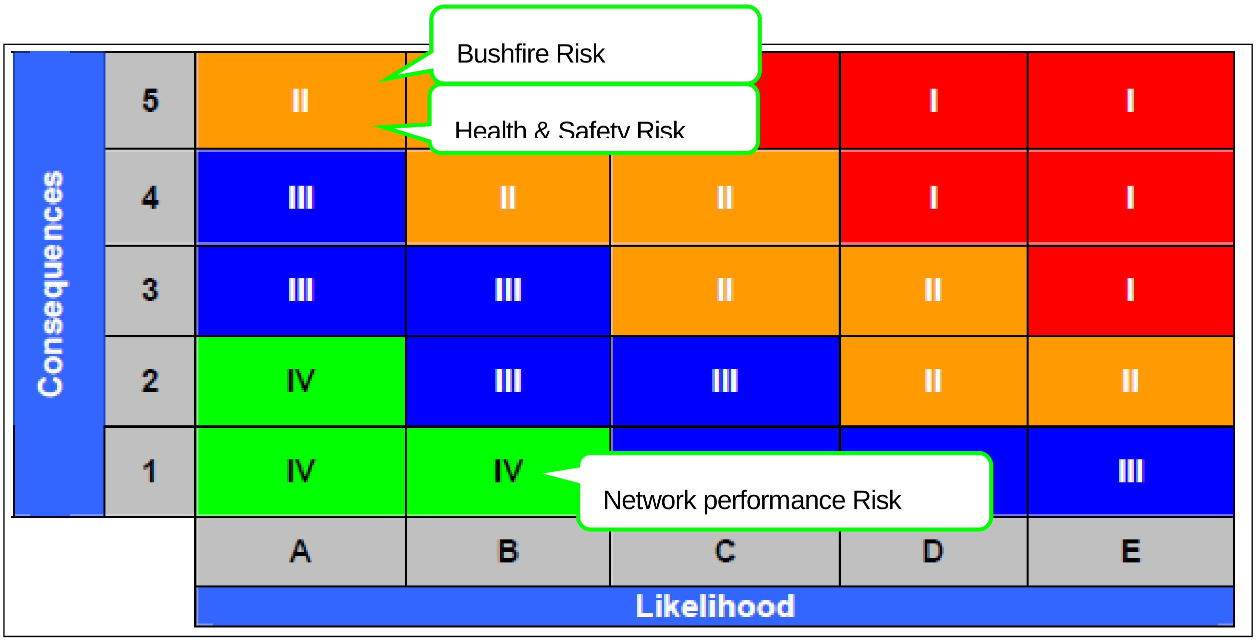

Figure 1 – AusNet Services' Risk Matrix

Recent risk assessments performed with the use of current condition and asset age data reveals the need to continue the planned replacement of conductors and groundwires in order to maintain acceptable levels of risk into the future. Economic evaluations performed in conjunction with risk assessments have identified items for which replacement is economic in accordance with the requirements of the Electricity Safety Act and the Occupational health and Safety Act.

6 Options

Four options have been evaluated to prevent the failure of groundwires:

Option 1: Do Nothing

Option 2: Replace groundwires

Option 3: Defer the work by five years

Option 4: Replace groundwires including some OPGW

6.1 Option 1 – Do Nothing

This option involves inspecting and maintaining groundwires but only undertaking repairs after the conductor has failed. No replacement of sections of groundwire would occur; only repairs where the groundwire has failure.

This option implies the acceptance of failures before action is taken, together with associated safety hazards and outages. Opex costs would increase as a result of undertaking unplanned repairs and additional Opex would be incurred for emergency repairs if failures occur at peak times. Further, as no deteriorated groundwire is replaced, an exponential increase in failures and resulting costs will occur.

This option does not align to our Mission Zero values, is inconsistent with AusNet Services' Electricity Safety Management Scheme and asset management strategy, and does not meet the obligations that arise from the National Electricity Rules. It is therefore not recommended.

6.2 Option 2 – Replace Groundwires

This option involves the replacement of 226km of groundwires in deteriorated condition. Replacements are targeted at lines where inspections have identified a significant proportion of spans in poor condition. Replacement of continuous sections of groundwire will be carried out as it is more effective to replace continuous sections of line rather than individual spans, due to the lowers costs of mobilising, less outages and more efficient work techniques. Replacing continuous sections also avoids the introduction of unnecessary joints which introduce additional possible future failure points.

This option materially reduces the risk of groundwire failure by replacing deteriorated assets before they fail.

6.3 Option 3 – Defer Work for 5 years

This option defers the replacement of groundwires in deteriorated condition by 5 years and continues repairing damage on failure. This defers the Capex required to replace deteriorated groundwire for 5 years.

Deferral to future years is not recommended as there is a significant risk that the failure rate will increase and there will be increased safety hazards. There will also be higher costs associated with unplanned outages and pressure on resources if program acceleration is required to rectify problems. Deferral also increases the risk of failures during replacement works as badly corroded groundwires tend to break more easily when disturbed which presents a safety hazard to construction crews.

Although deferral has a lower PV Capital Cost than carrying out replacement work, it has a lower NPV when cost impact of failures is taken into account. This option does not align to our Mission Zero values, is inconsistent with the Electricity Safety Management Scheme and is not recommended.

6.4 Option 4 – Upgrade to OPGW where Required

This option involves the replacement of groundwires in deteriorated condition as in Option 2. Replacements are targeted at lines where inspections have identified a significant proportion of spans in poor condition. Replacement of continuous sections of groundwire will be carried out as it is more effective to replace continuous sections of line rather than individual spans, due to the lowers costs of mobilising, less outages and more efficient work techniques. Replacing continuous sections also avoids the introduction of unnecessary joints which introduce additional possible future failure points.

Groundwire will be replaced on a like for like basis except where the line has been identified as a future communication route. Where the line has been identified as a future communications route to satisfy operational requirements, the groundwire will be replaced with OPGW where it is economic to do so.

The resulting program involves replacing 154km of on a like for like basis and 72km of groundwire with OPGW.

This option materially reduces the risk of groundwire failure by replacing deteriorated assets before they fail and has the additional benefit of providing a communications bearer which will be used to replace obsolete communications bearers or provide required additional communications capacity.

Option 4 is the recommended option as it meets safety and reliability obligations and has the most positive NPV.

7 Financial

NPV analysis of the options is shown in **Error! Reference source not found.**. Options 2 and 4 are both NPV positive with Option 4 slightly more positive. Option 4 involves more capex than Option 2 however Option 4 is the preferred option as it achieves both Conductor and Communications strategies.

Economic Analysis of Investment Options ($'000s)	PV Capital Cost	PV Opex Costs	PV Community Costs & Benefits	Total PV Cost	NPV including Reg Return (post tax)
Do Nothing	-	(13,346)	(16,154)	**(29,501)**	#N/A
Replace 226km Groundwires	(15,103)	-	-	**(15,103)**	732
Defer for 5 years	(10,393)	(3,234)	(3,914)	**(17,541)**	(1,529)
Replace 154km Groundwires and 72km OPGW	**(17,614)**	**916**	**10,317**	**(6,381)**	**854**
	-	-	-	**-**	-

All figures are in $000's unless otherwise stated.
(nominal and discounted)

Table 2 – NPV analysis

8 Recommendation

Replacement of 226km of nominated groundwire spans is recommended, including OPGW upgrades for future communications requirements on defined lines.