Program of Works

2017 – 2022

Transmission Line Insulator Replacement (Public Version)

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1 Summary

PROGRAM	Transmission Line Insulator Capital Replacement Program 2017/18 – 2021/22
SERVICE DATE	On-going throughout period 2017 – 2022
LOCATION	Different areas of Victorian electricity transmission network
VALUE	$ 5.23M

This program aims to maintain the condition of the total insulator strings fleet by replacing various insulators based on their assessed condition.

This works program document should be read in conjunction with AMS 10-75 Transmission Line Insulators document. The works program details the background and the analyses performed in order to determine optimal insulator replacement strategies. More detail relating to these strategies is provided in the AMS 10-75 document including condition assessment and risk assessment methodologies.

1.1 Project Scope

Activities associated with the replacement of deteriorated transmission line insulators are as follows:

- Perform site inspection to verify site conditions including traffic management requirements, site access for plant machinery and suitability of live line or de-energised replacement works.
- Procure all required materials including polymeric composite insulators, disc insulators, fittings and hardware.
- Replace insulators including bridging strings, fittings and hardware. Replace vibration dampers which are corroded or install where missing.
- Replace fixing plates which have been identified as being in poor condition.
- Live line replacements will take place on intermediate structures except when the circuit is flanked by other circuits. This will be the case on some multi circuit easements.
- De energised replacements will take place on strain structures using a crane to support the phase conductors.
- Site reinstatement must be performed if required.
- Update all relevant transmission asset management systems with new insulator data following completion of site works.

1.2 Program Expenditure Forecast

2017/18 ($k)	2018/19 ($k)	2019/20 ($k)	2020/21 ($k)	2021/22 ($k)	Total ($k)
1,134	1,070	1,070	1,070	887	5,231

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.

2 Project Drivers

The transmission line insulator replacement program will significantly reduce the likelihood of a major insulator failure which could cause live conductors to fall to the ground over a rail line, road way or within vegetation in a high fire ignition risk area. Consequences of such a failure include:

- Health and Safety incidents;
- Bushfire ignition;
- Financial penalties; and
- Significant repair costs.

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 including risk of live conductors falling to ground and risk of ground fire ignition.
- 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.

3 Overview

There are approximately 89,000 transmission line insulator strings in service on the transmission network as at November 2014. Porcelain, glass or a mixture of both have historically been the preferred insulator type in Victoria since the 1950s. Advances in polymer manufacturing have triggered an increase in use of polymeric composite types over the last 15 years. Each different type of insulator displays different performance characteristics in terms of corrosion resistance, tensile strength and electrical insulation properties.

AusNet Services' transmission line network is exposed to varying levels of corrosivity depending on environmental factors. 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. In order to manage the effects of corrosion, condition assessments of insulators take place every three years as part of tower climbing inspections.

The insulator replacement program started in 2006 and is set to continue beyond 2022. There have been no incidents of major insulator failure since 2009; two years after the existing program began.
Under the Occupational Health and Safety Act, AusNet Services is required to, so far as is reasonably practicable, maintain for employees a working environment that is safe and without risks to health.

The Electricity Safety Act requires AusNet Services to, operate its electricity transmission network to minimise, so far as is practicable, hazards to the safety of any person.

These Acts require AusNet Services to have regard to the likelihood and harm and what is known or should be known about safety hazards. AusNet Services must also consider ways to eliminate or mitigate hazards and the availability and suitability of ways to eliminate or mitigate safety hazards. AusNet Services is further obliged to have regard to the cost of removing or mitigating the safety hazard or risk.

The insulator replacement projects from previous periods were: X669, X870 and X939. Project XC76 which started in FY2015/16 spans the current and forecast regulatory periods. It aims to replace C-I-C insulator strings and components with composite insulators by 2020.

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

4 Risk Matrix

Major insulator failures can lead to three different types of consequence 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 (consequence) of AusNet Services' risk matrix which is displayed in Figure 1.

Analysis of the Mean Time Before Failure (MTBF) for insulators in AMS 10-75 Transmission Line Insulators guides the likelihood scoring in an objective fashion. A MTBF of 4.79 years indicates that there have been insulator functional failures once every 4.79 years on average which corresponds to an annual probability of 20 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 an insulator functional failure. Not every major insulator failure 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.

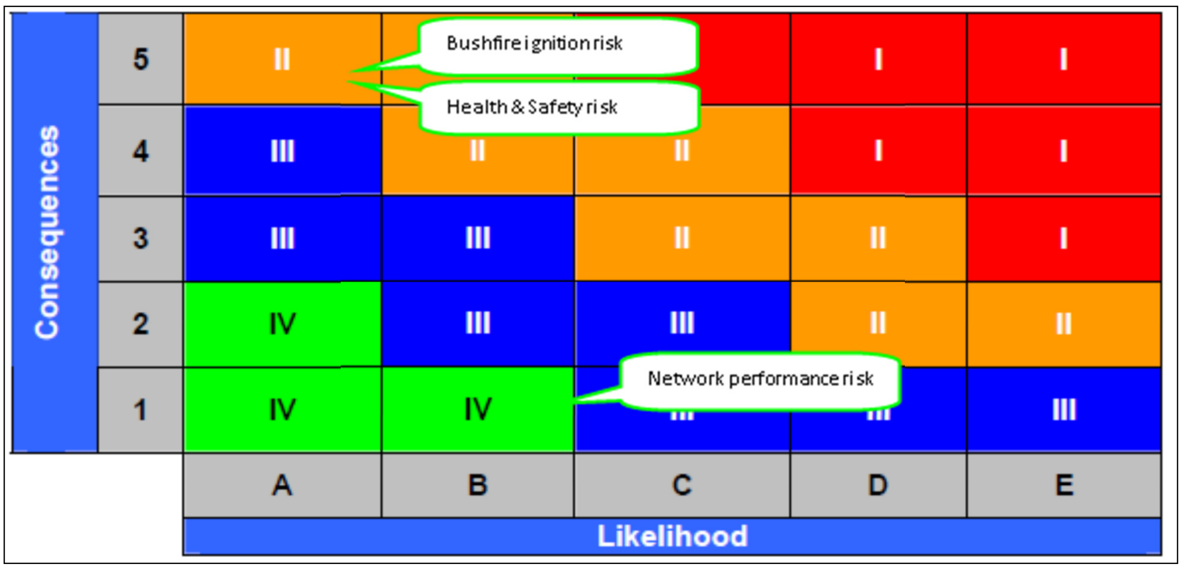

Figure 1 – AusNet Services' Risk Matrix

5 Options

Option 1: Do Nothing

Option 2: Replace insulators based on a cost optimised risk assessment

Option 3: Defer the work by five years

Option 4: Selective replacements of insulators based on risk only

5.1 Option 1 – Do Nothing

The Do Nothing option involves:

- Continuing inspection and maintenance activities for transmission line insulators.
- Reactively replacing insulators which during line patrols and inspections are identified as defective / damaged.
- Progressive decrease in the mean time between failures (MTBF) of insulator strings.
- Increased Opex costs for washing and testing of old insulator strings.
- Gradually building higher risk on environmental, corporate reputation, safety and regulatory compliance.

5.2 Option 2 – Replace insulators based on a cost optimised risk assessment

Implementing a condition based replacement program involves:

- Planned replacement of C-I-C of the insulator population.
- Selection of insulators to be replaced is based on a mixed risk assessment and financial efficiency criteria.
- Reducing the risks associated with insulator failure at an estimated direct cost of $5.23M.
- Continuing inspection and maintenance activities for transmission line insulators.
- Reactively replacing insulators which during line patrols and inspections are identified as defective / damaged.
- Stable MTBF for insulator strings.

5.3 Option 3 – Defer the work by five years

Deferring the works by five years involves:

- Continuing inspection and maintenance activities for transmission line insulators.
- Reactively replacing insulators which during line patrols and inspections are identified as defective / damaged.
- Progressive decline in the mean time between failures (MTBF) of insulator strings.
- Increased Opex costs for washing and testing of old insulator strings.
- Gradually building higher risk on environmental, corporate reputation, safety and regulatory compliance.

5.4 Option 4 – Selective replacements of insulators based on risk only

Replacing insulators on selective locations across the network targeting those with the highest risk involves:

- Planned replacement of C-I-C of the insulator population.
- Reducing the risks associated with insulator failure at an estimated direct cost of $6.77M.
- Continuing the inspection and maintenance activities for transmission line insulators.
- Reactively replacing insulators which during line patrols and inspections are identified as defective / damaged.
- Stable MTBF for insulator strings.

6 Options Analysis

Table 2 below outlines the risks which will be addressed through implementation of each option.

	Risks addressed			
	Condition based	Age based	Insulator Type based	Cost Optimisation
Option 1	X	X	X	N/A
Option 2	✓	✓	✓	✓
Option 3	X	✓	X	N/A
Option 4	✓	✓	X	X

Table 2 – Option analysis

6.1 Option 1 – Do Nothing

This option fails to address any of the key business drivers listed in the Project Drivers section and presents potentially significant health and safety, network performance and financial liabilities.
This option is inconsistent with AusNet Services' obligation under the Electricity Safety Act to operate its electricity network to minimise hazards to the safety of people as far as is practicable, and under the Occupational Health and Safety Act to maintain a safe and without risks to health working environment as far as is reasonably practicable.

Improved levels of insulator performance observed since 2008 are unlikely to continue if this option is implemented.

6.2 Option 2 – Replace insulators based on a cost optimised risk assessment - preferred

This option addresses all of the key business drivers listed in the Project Drivers section.
A mixed risk assessment and financial efficiency criteria replacement program reduces existing health and safety, network performance and financial liabilities risks.

The risk evaluation criteria considers: insulators with a condition score of 3, 4 and 5, insulators aged 55 years or more and insulator types which had a high number of failures.

Condition, age and type data have been used to quantify the risks associated with the insulator fleet. Insulators which are aged or exhibit poor condition can generate comparatively high amounts of risk. Furthermore the insulators identified for replacement on adjacent locations are bundled in a replacement range. Thus savings on mobilisation and work preparation are achieved. This reduces the replacement cost substantially.

This option is consistent with the Electricity Safety Act requirement to minimise hazards to the safety of people as far as is practicable, and the Occupational Health and Safety Act requirement to maintain a working safe environment without risks to health as far as is reasonably practicable.
Choosing option 2 ensures that risks associated with insulator corrosion and non-visual age based degradation are addressed in the most economic manner and further that risks associated with insulators are reduced “so far as is practicable” (SFAIP).

Implementation of an optimised risk based replacement program will maintain the levels of performance and reliability associated with the insulator fleet.

6.3 Option 3 – Defer the work by five years

This option fails to address some of the key business drivers listed in the Project Drivers section.
Implementing this strategy will lead to increased risk of failure and hence a progressive decline in the mean time between failures (MTBF) of insulator strings.

The risk on environmental, corporate reputation, safety and regulatory compliance will escalate together with the cost required to mitigate the risk and higher unit rates due to adhoc replacement.
Concurrently the opex cost for washing and testing old insulators will rise.

6.4 Option 4 – Selective replacements of insulators based on risk only

This option addresses all of the key business drivers listed in the Project Drivers section but presents a net inferior value for money compared to Option 2 as 9% more capex is required than Option 2.
A risk based replacement program reduces potentially significant health and safety, network performance and financial liabilities by replacing high failure risk insulators.

This option is also consistent with the Electricity Safety Act requirement to minimise hazards to the safety of any people as far as is practicable, and the Occupational Health and Safety Act requirement to maintain a safe working environment without risks to health as far as is reasonably practicable.
Condition and age data have been used to quantify the risks associated with the insulator fleet. Insulators which are aged or exhibit poor condition can generate comparatively high amounts of risk. This option was found more expensive compared to option 2 when comparing the potential risk reduction achieved by replacing an insulator with the cost of that replacement.

Implementation of a risk based replacement program will maintain the improving levels of performance and reliability associated with the insulator fleet at a higher cost compared to option 2.

7 Financial Analysis

The results of NPV analysis1 is shown in Table 3. Option 2, the cost optimised risk assessment replacement, has a similar NPV to Option 4, replace on risk only. Option 2 has been selected as it involves less capex.

Economic Analysis of Options ($'000s)	PV Capital Cost	PV Opex Costs	PV Community Benefits	PV Proceeds From Sales	Total PV Cost	NPV including Reg Return
Do Nothing	-	(2,366)	(5,776)	-	(8,142)	(24,293)
Replace insulators based on a cost optimised risk assessment	(4,880)	(18)	-	-	(4,898)	34
Defer the work by five years	(3,358)	(400)	(535)	-	(4,293)	(1,614)
Selective replacements of insulators based on risk only	(6,752)	(18)	-	-	(6,769)	211

Table 3 – NPV analysis

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

8 Recommended Action

The cost optimised risk assessed replacement program, Option 2, is recommended. Implementation of this option will cost $5.23M over a five year period between 2017/18 and 2021/22.

There is an approved project (XC76) to replace C-I-C insulator strings on various transmission lines over five financial years from 2015/16 to 2019/20. Project XC76 is part of this program and a new project will be created to continue the insulator replacement program in 2020/21 and 2021/22 financial years.

9 Reference Documents

- Electricity Safety Act.
- Electricity Safety (Management) Regulations.
- Occupational Health & Safety Act.
- AMS 10-01 Asset Management Strategy for the Victorian Electricity Transmission Network.
- AMS 10-75 Transmission Line Insulators.

[1] Insulator replacement program 2015-2020 NPV.xls