Program of Works

2017 – 2022

MSS-DDTS 1 and 2 – 330kV lines Tower Upgrade

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1 Summary

PROGRAM	MSS-DDTS 1 & 2 Tower Upgrade Program
SERVICE DATE	On-going throughout period 2017/18 – 2021/22
LOCATION	Northern Victoria, Murray Switching Station to Dederang Terminal Station
VALUE	$ 3.5M

1.1 Program Scope

The program involves the upgrade of 48 transmission towers to the current tower design code, AS/NZS 7000 along the Murray Switching Station (MSS) to Dederang Terminal Station (DDTS) numbers 1 and 2 – 330kV lines, which is 9% of the towers on the MSS-DDTS line. The upgrade program is focussed on the highest risk towers along the line and will commence in FY2018 and finish in FY2019. Tower upgrade includes:

- Perform the structural design of new towers using AS/NZS 7000;
- Perform site inspection to verify site conditions including traffic management requirements, site access for plant machinery and suitability of live line work to minimise outage requirement;
- Procure all required materials including steel members and hardware, if necessary.
- Site reinstatement must be performed if required; and
- Update the transmission asset management system with the necessary 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)
23	3,519	-	-	-	3,542

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.

2 Project Drivers

Assessment of the tower fleet have revealed that 0.37% of the entire tower fleet which belongs to MSS-DDTS 330kV 1 & 2 lines should be reinforced[1] to reduce the risk of a tower collapse event to So Far As Is Practical (SFAIP) levels.
Reducing risk to SFAIP levels is appropriate for transmission towers as the collapse of a tower can result in the structure and conductors falling to the ground which can lead to:

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

Implementation of this program of work will assist AusNet Services to address 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;
  - Prevent civil actions resulting from personal injury / compromised health.

- Regulatory compliance:
  - Compliance with Electricity Safety (Network Assets) Regulations;
  - Occupational Health & Safety Act (provide safe work environment).

- Corporate image maintained as prudent asset managers:
  - Manage risk as low as practicable.

[1] The MSS-DDTS towers are similar to the DDTS-SMTS towers which were reinforced to comply with AS/NZS7000.

3 Overview

There are approximately 13,000 transmission towers in service on the transmission network as at April 2015. These steel lattice towers and structures hold up approximately 6,500 km extra high voltage lines across the state of Victoria. The earliest constructed towers are single circuit towers which transport electricity from one terminal station to another. Later towers were designed to carry two circuits which improved reliability of supply whilst marginally increasing the cost.

There are generally four types of towers in the network, i.e. light suspension, heavy suspension, light strain and heavy strain, with an expected service life of approximately 70 years depending on the environmental conditions of the site.

There have been thirteen failure incidents in the tower fleet resulting in 5 collapses in the past 63 years. The majority of these failures (70%) were due to the inadequate design of the structure, which were imported from other countries and did not have the capacity to carry the wind loading experienced in the Victorian environment.

This lack of tower strength prompted the State Electricity Commission of Victoria (SECV) in 1965 to create and implement its own transmission line design standard, *The Code of Practice for the Design of Transmission Structures and Foundations.* This document became the basis of new structures to be built and existing towers were checked against its requirements.

However, the most recent tower collapse event in November 2014 where 5 light suspension towers and 1 heavy suspension tower along the Bendigo to Kerang 220kV line failed due to a high intensity wind (HIW) event called a microburst proved that, even with the more stringent requirements of the SECV tower code, cascade failure is a risk that needs to be addressed.

In December 2010, Standards Australia and Standards New Zealand approved and published *AS/NZS 7000: Overhead Line Design – Detailed Procedure*. This tower code uses the advances in design methodology and requires the implementation of failure containment measures by using strength coordination of line components and allows the design of stronger structures which assures the minimum number of towers are affected due to strong wind events.

It is the objective of AusNet Services for new structures as well as existing structures on lines subject to up-rating, re-conductoring, and communication projects are designed and/or reviewed against the requirements of this tower code.[2]

In order to assure the reliable performance of the tower fleet, two programs are proposed to be implemented during the 2017/18 to 2021/22 regulatory period. The tower upgrade program is the first item while the second program is the tower corrosion mitigation program, which is classified as an Opex step change.

[2] AS/NZS 7000 requires structures that are deemed to be overloaded due to new loads introduced to the tower are uprated using its requirements.

4 Risk Matrix

Functional failures of transmission line structures can result in structures and live conductors falling to the ground with significant effects or consequences. Major structure failures can lead to three different effects including health and safety, bushfire ignition and network constraint 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 1.

Analysis of the Mean Time Between Failures (MTBF) for transmission line structure guides the likelihood scoring in an objective fashion. A MTBF of 6.4 years indicates that there have been functional failures once every 6.4 years on average which corresponds to an annual probability of approximately fifteen per cent. This probability aligns with a likelihood score of B on the AusNet Services risk matrix. This likelihood is applied to the network constraint risk caused by a transmission line structure functional failure. Not every major failure of a structure 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.

The tower reinforcement program will significantly reduce the likelihood of a major event involving tower failure in the network. This reduction in likelihood will be achieved by upgrading towers which are in high risk areas based on the design wind speeds and their location within the network, i.e. across road crossings, rail crossings and high bushfire risk areas.

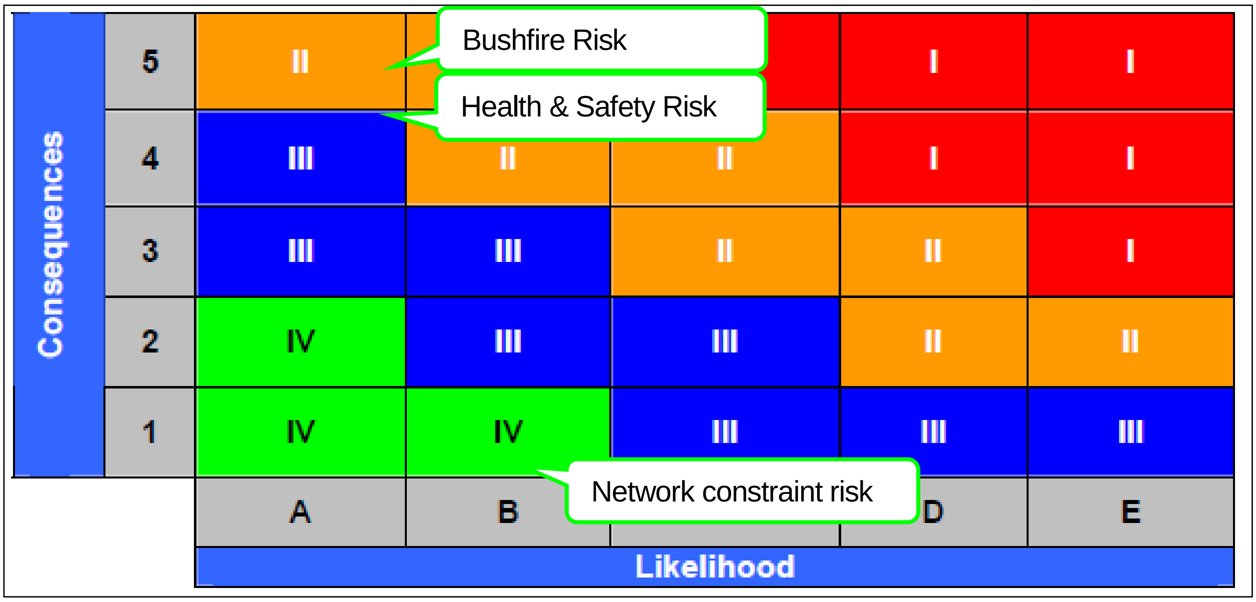

Figure 1– AusNet Services' Risk Matrix[3]

[3] AusNet Services' Risk Management Framework – RM 001 2006.

5 Options

Three options to reduce the risk of tower failure have been evaluated:

Option 1: Do Nothing
Option 2: Risk based tower replacement
Option 3: Risk based tower upgrade.

5.1 Option 1 – Do Nothing

The Do Nothing option involves:

- Continuing inspection and maintenance activities such as bolt and member replacement as needed.
- Reactively replacing towers which collapse.

5.2 Option 2 – Risk Based Tower Replacement

Implementing a risk based replacement program involves:

- Proactively replacing 0.12% of the tower fleet which present risks which justify their replacement under an SFAIP scheme.
- Reducing the risks associated with a tower collapse event at an estimated direct cost of $8.7M.
- Continuing inspection and maintenance activities such as bolt and member replacement as needed.

5.3 Option 3 – Risk based tower upgrade

Implementing a risk based tower upgrade program involves:

- Proactively upgrading 0.37% of the tower population which present risks which justify their upgrade under an SFAIP scheme.
- Reducing risks associated with a tower collapse event at an estimated direct cost of $3.5M.
- Continuing inspection and maintenance activities such as bolt and member replacement as needed.

6 Options Analysis

6.1 Option 1 – Do Nothing

This option fails to address any of the key business drivers listed in the Project Drivers section.
The 'do nothing' approach exposes AusNet Services to significant financial and regulatory risk by failing to demonstrate an appropriate level of due diligence. This option presents potentially significant health and safety and financial liabilities.
This option involves accepting risks associated with towers which, based on its design parameters and history of tower collapse events, demonstrate a high probability of failures due to design wind exceedance. In choosing Option 1 the costs and repercussions associated with a failure event occurring on any of the high risk locations would be significantly higher than the cost of tower replacement.
Option 1 is not a viable option for AusNet Services as it does not demonstrate the requirement to maintain transmission network service performance so as to minimise the risks associated with failure of the assets.

6.2 Option 2 – Risk Based Tower Replacement

This option addresses all of the key business drivers listed in the Project Drivers section.
Design strength and the probability of occurrence of high intensity winds have been used to quantify the risks associated with the tower fleet. Lines which have a history of failures whose design strengths are inadequate (i.e. pre- SECV design code) and are in high consequence areas have been identified with their risks quantified.
By comparing the potential risk reduction achieved by replacing a tower structure with the cost of replacing the tower the viability of the replacement has been evaluated.
Option 2 is a viable option as it reduces the risk but it is not the most economic option as the cost is materially higher than the alternative tower strengthening option.

6.3 Option 3 – Risk Based Tower Upgrade

This option addresses all of the key business drivers listed in the Project Drivers section.
The risk based tower upgrade program reduces potentially significant health and safety, bushfire related and financial liabilities by strengthening tower structures which, following a risk assessment, have been deemed economically justified for upgrading under an SFAIP scheme.
This option gives the same benefits and removes the same risks as Option 2 at a lower cost. By comparing the potential risk reduction achieved by upgrading a tower structure with the cost of replacing the tower the viability of tower upgrading has been evaluated.
Choosing option 3 will ensure that risks associated with a tower collapse are reduced to SFAIP levels, which is crucial considering the potential consequences of a tower collapse event.
The economic evaluation has identified that the optimal program will result in the reinforcement of 0.37% of the tower fleet by 2012 and will remove 6% of the existing risk associated with major failure of transmission tower.

7 Financial Analysis

Each option has been financially analysed using an NPV model[4]. Option 3 which is the risk based upgrade option has a positive Net Present Value and also the lowest capex of the viable options.

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	-	(4,406)	(4,092)	-	(8,498)	-
Risk based tower replacement	(8,387)	(4,303)	(842)	-	(13,532)	605
Risk based tower upgrade	(3,519)	(4,064)	(582)	-	(8,165)	197

Figure 2 – NPV results

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

8 Recommended Action

The risk based tower upgrade program, Option 3, is recommended.

9 Reference Documents

- Electricity Safety (Network Asset) Regulations.
- Occupational Health & Safety Act – provision of safe work environment.
- Asset Management Strategy for the Victorian Electricity Transmission Network (AMS 10-01).
- Asset Management Strategy document entitled “Transmission Line Structures” (AMS 10-77).

[4] Tower Upgrading_Proj Evaluation Template ver4.xls.