Transmission Line Insulator Replacement Program

Regulatory Investment Test for Transmission

Project Specification Consultation Report

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Purpose

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

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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 the 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 an '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 in accordance with clause 5.16 of the National Electricity Rules (NER) and section 4.1 of the Australian Energy Regulator's (AER's) RIT-T Application Guidelines[1]. In accordance with those requirements, this document 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 discusses the classes of market benefits that are relevant to this project;
- the estimated construction timetable and commissioning date; and
- the total indicative capital and operating and maintenance costs for each option.

1.2 Consultation

In accordance with section 4.1 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.

Submissions should be sent to rittconsultations@ausnetservices.com.au by 10 August 2022 and telephone enquiries can be directed to Francis Lirios 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.

1 Australian Energy Regulator, Application Guidelines, Regulatory Investment Test for transmission, August 2020.

2 Background

Overhead bare conductors are insulated by the surrounding air, with the insulator strings preventing the conduction of electrical current to the steel structure that supports the transmission wire. Insulators are required at points where they are supported by poles or transmission towers. They are also required where the wire enters buildings or electrical assets such as transformers or circuit breakers.

Approximately 89,000 insulator strings are in service on the transmission network. Most insulator strings comprise several linked discs made from either porcelain or glass with steel pins to form a continuous string. Over time the condition of these assets deteriorates due to the environmental conditions that cause corrosion, and mechanical loading.

There are a growing number of polymeric insulators in operation, which consist of composite polymer material that has a fibreglass core with a sheath made from silicone rubber or ethylene propylene diene monomer (EPDM). AusNet Services has undertaken a large program of targeted insulator replacements, which began in 2006. This program responded to increasing trends in disc insulator functional failures in the period between 2000 and 2007. Since then, approximately 25,000 porcelain insulator strings comprising 29% of the total insulator fleet have been replaced with polymeric insulators.

Since 2017, there have been two failures involving polymeric insulators on the No. 2 500kV line from Heywood Terminal Station to Alcoa, Portland Smelter. Both polymeric strings were from the same manufacturer (Sediver), all of which have been removed from service. Some of the replaced samples are currently kept in storage for photo documentation and further testing.

Insulators are currently assessed by visual inspection during condition assessment, and line and easement inspections done either from the ground or a helicopter. Thermal cameras, which are primarily used to inspect phase conductors and joints can be used on an ad hoc basis to assess polymeric insulators to identify any 'hot spots' caused in internal arcing.

AusNet Services has developed risk-based models to assist with the application of formal risk assessments as required by the Electrical Safety (Management) Regulations 2019. Approximately 2,289 insulator strings (2.6% of the insulator fleet) are forecast for replacement before 2027 due to combinations of deteriorated condition, and high failure consequence locations.

Implementation of this selective replacement strategy, addressing both failure frequency and consequences is necessary to maintain public safety and assist in meeting the safety objectives set out in AusNet Services' MissionZero strategy.

This PSCR relates to the next two phases of our insulator replacement program following a condition review completed in 2020. The first phase requires capital expenditure of $7.48 million in nominal terms to replace 773 insulators. The second phase, which is also covered by this PSCR, will be subject to a separate scoping exercise informed by the lessons learnt in the first phase.

3 Identified need

3.1 Description of the identified need

The condition of transmission line insulators is assessed during regular tower inspections. Insulators are assigned a condition grade from a scale between C1 (best) to C5 (worst) against two different grading parameters, fitting wear and pin corrosion. The worst condition from both parameters is then used as the overall condition grade for each insulator string.

A total of 2,289 insulator strings or 2.6% of the total insulator fleet currently belongs to C4 condition which exhibits light rust, or <10% wear. While 291 insulator strings, or 0.3% of the total transmission insulator fleet currently exhibits levels of fitting wear or pin corrosion in line with condition grade C5.

In 2006, an insulator replacement program was introduced after several insulator failures resulted in conductor drop events. AusNet Services concluded that the risk of failure was beyond its risk appetite and so a program to replace insulators which have the highest risk of failure in the fleet was initiated.

Successive replacement programs have continued to target the worst condition insulators in the fleet with the highest consequence of failure. The identified need, therefore, is to continue to address the risk of insulator failure through a risk-based replacement program.

It is noted that AusNet Services must 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 the replacement of insulators that are in poor condition, compliance with this Act (and other regulations) contributes 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. In addition to estimating these risks and consequences eventuating, AusNet Services has adopted the following further assumptions to quantify the potential costs of insulator failure.

3.2.1 Health and safety risk costs

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[2];
- a value of lost time injury[3]; and
- a disproportionality factor[4].

[2] 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.

[3] 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.

[4] 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.

AusNet Services also notes our approach, including the use of a disproportionality factor, is consistent with the guidance provided by the AER[5].

3.2.2 Financial risk costs

In the event of an insulator failure, costs will be incurred in replacing the failed assets (and any consequential damage to other assets). The risk of this financial impact may vary for different credible options and, therefore, should be factored into the cost-benefit assessment.

3.2.3 Bushfire risk costs

Faults on transmission lines can result in explosive failures of insulators which are capable of igniting ground fires due to the expulsion of molten material. 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 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.

In 2007, a small grass fire was ignited following electrical failure of a porcelain insulator on the ROTS-SVTS No.2 line. A combination of pollution and morning fog on the insulator discs caused a flashover. The flashover caused a small amount of molten metal to fall to the ground resulting in a small grass fire. Moisture on the grass caused the fire to extinguish quickly.

The first incident involving a polymeric insulator occurred in 2017 when a Sediver insulator along the HYTS-APD No. 2 500 kV line failed. A defect in the crimping process of the end-seals onto the fibre glass rod caused moisture ingress into the rod causing internal arcing until it failed which resulted in the phase conductor dropping across an arterial road. The conductor contacted a steel fence which caused a small grass fire. The fire was extinguished by the property owner.

In light of these historical events and the known risks, AusNet Services regards a proactive asset inspection and replacement program as essential in continuing to minimise bushfire risk in accordance with our regulatory obligations and community expectations.

3.2.4 Market impact

The electricity transmission lines in the NEM provide 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 an insulator failure causing a dropped phase conductor. In relation to unserved energy, the supply risk cost 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). A further potential impact is the need for AEMO to re-dispatch energy from a different generator (usually a gas generator) due to a line fault that either impacts the line directly or indirectly.

[5] 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.

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 insulators, there are no credible non-network options that could address this identified need. In effect, 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

1. Planned replacement of C5 and C4 insulators; and
2. Planned replacement of C5 insulators only.

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

4.1 Option 1: Planned replacement of C5 and C4 insulators

This option reduces the risks associated with a potential failure of a deteriorated/corroded insulator resulting in a conductor drop event. The planned replacement of insulators is the most efficient and cost-effective method compared to replace upon failure. Planned replacement allows for the most efficient mobilisation of resources to carry out the replacement, under planned outages to assure the safety of line workers.

The scope of work for this option would include:

- Replace existing disc insulators with composite silicone rubber insulators, excepting the bridging string insulators for strain towers which shall be replaced with disc insulator.
- Include the replacement of all hardware, fittings, and if necessary, add vibration dampers.
- The data of the new insulators, i.e. manufacturer, type and quantity per tower-circuit shall be updated in SAP.
- Desktop assessment of the insulator fleet to identify the cohort that will be tested for the insulators' performance and remaining service life.
- Testing of the target porcelain disc insulators will be performed to ascertain the strings’ remaining life. Samples will be collected from target tower circuits and sent off to a specific test facility for testing.

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.

Phase One of Option 1 would replace 773 insulators from 107 tower circuits, which have the highest risk of failure. In addition to replacing the insulators, approximately 3,000 vibration dampers would be installed on the phase conductors to assure strand breakage is avoided as a result of aeolian vibration. The capital expenditure for this option is $7.48 million. Phase Two of Option 1 has not yet been fully scoped or costed.

4.2 Option 2: Planned replacement of C5 insulators only

This option is similar in scope to Option 1, but would only replace insulators that are in the worst condition, being C5. As such, the replacement of C4 condition insulators is deferred.

The estimated cost of this option would be approximately $5.8 million compared to $7.48 million in nominal terms for Option 1. As noted in relation to Option 1, we do not expect this option to have a material impact on our future operating expenditure. The construction timeframes for this option would be similar to Option 1. As noted in relation to Option 1, this option would also have a second phase.

4.3 Preferred option, costs and timeframes

Phase One of Option 1 (the preferred option) is expected to replace 773 insulators that are nearing the end of their service life and have a significant probability of failure. AusNet Services considers that delaying the replacement of these insulators would present an unacceptable risk for our customers and the broader community.

The probability weighted consequence of failure has been estimated to be approximately $114 million in present value terms over the next 30 years (30 years is the expected service life of a new transmission insulator). The probability weighted consequence of failure in the next 5 years (time till the next regulatory reset period in 2027) is estimated to be $15.78 million. These consequence values far exceed the estimated capital expenditure of $7.48 million (nominal) required for a planned replacement of the transmission line insulators.

The circuits identified for insulator replacement, ie those presenting the highest risk (Condition Score 4 or 5 and Asset Criticality 5), are provided in the Appendix TD-0009879 Scope of Works. The summary of the voltages and numbers are shown in the table below.

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

Voltage	Strain Insulators, including Bridging strings	Suspension Insulators	Total
220kV	344	72	416
330kV	12		12
500kV	90	108	198
66kV	27	120	147
Grand Total	**473**	**300**	**773**

The replacement of the insulators will significantly reduce the risk to the public of experiencing an outage or a health and safety incident due to an insulator failure that could result to a conductor drop. The replacement of insulators will restore them to Condition Score 1 and reduce the probability of a failure occurring.

Phase One of Option 1 will replace insulators with the highest risk of failure. Further insulator replacements will be undertaken during Phase Two, which will be scoped while Phase One of the project is being delivered. The capital expenditure for Phase One of Option 1 is summarised in the table below.

Table 2: Capital expenditure forecasts for Option 1, Phase One, $'000, $2021

	2022	2023	2024	2025	Total
Design	135,000	-	-	-	**135,000**
Internal Labour	226,223	276,896	282,434	72,021	**857,575**
Material	774,466	-	-	-	**774,466**
Plant & Equipment	-	547,182	608,865	-	**1,156,047**
Contracts	-	1,692,449	1,883,235	-	**3,575,685**
Risk	62,746	76,801	78,337	19,976	**237,860**
Management Reserve	304,398	-	-	-	**304,398**
Total capex	**1,502,833**	**2,593,329**	**2,852,871**	**91,997**	**7,041,030**

Source: AusNet Services, TD-0009879 Transmission Line Insulator Business Case

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

As already noted, Phase Two of Option 1 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 delivered prudently and efficiently.

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 will not result in changes to electrical energy losses.
(vii) changes in ancillary services costs	The credible options will not have any impact on ancillary services costs.
(viii) competition benefits	The credible options will not 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 insulator 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, financial risk and bushfire risk (as discussed in sections 3.2.1, 3.2.2 and 3.2.3) must also be factored in the cost-benefit assessment. In effect, each credible option (including the BAU option) will have different costs associated with safety, financial and bushfire risks that will play a role in determining the preferred option.

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 is to replace C5 and C4 insulators (Option 1) as this option delivers the highest net market benefit.

This preferred option reduces the risks of potential failure of a deteriorated/corroded insulator resulting in a conductor drop event. The planned replacement of insulators is the most efficient and cost-effective method compared to replace upon failure. Planned replacement allows for the most efficient mobilisation of resources to carry out the replacement, under planned outages to assure the safety of line workers.

6 Next steps

AusNet Services intends to publish a Project Assessment Draft Report in relation to this project in September 2022.