
Codified Areas SWER Powerline Replacement Program

AMS – Electricity Distribution Network

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1 Executive Summary

1.1 Identified Need

The 2009 Victorian Bushfires Royal Commission (VBRC) and the Powerline Bushfire Safety Taskforce (PBST) both recommended the replacement of SWER and 22kV powerlines in the highest risk areas with underground or insulated overhead cables within 10 years.

These recommendations were implemented in 2016 through changes to the *Electricity Safety (Bushfire Mitigation) Regulations 2013* which requires that conductors within *Electric Line Construction Areas* (Codified Areas) which have reached the end of life to be put underground or insulated. AusNet Services has approximately 1,730km of SWER and 22kV powerlines within Codified Areas.

In the current regulatory period, the Victorian Government's Powerline Replacement Fund has been responsible for the majority of powerline replacement works that insulated or undergrounded conductors. This Fund expired in June 2019 and the expectation is that distribution businesses will continue the replacement program as part of ongoing asset replacement programs.

AusNet Services has commenced the implementation of Rapid Earth Fault Current Limiter (REFCL) technology to reduce bushfire risk from 22kV powerlines¹. A focus on powerline replacement of SWER lines within Codified Areas is therefore appropriate to ensure bushfire risk is being addressed across all conductor in Codified Areas.

AusNet Services' current condition-based replacement forecast is for 7 km of SWER conductor in Codified Areas to reach end of life over the 2022-26 regulatory period. This represents 1% of the SWER conductor in Codified Areas replaced over a 5-year period. AusNet Services does not believe that this rate of replacement meets the expectations of our customers and stakeholders. It is therefore proposing an additional program to accelerate the replacement of bare SWER conductor installed within the distribution network.

1.2 Proposed Preferred Option

AusNet Services is proposing a program of accelerated replacement of 100 km of the approximate 645km of SWER conductor in Codified Areas. The SWER conductor will be replaced with a combination of insulated conductor and underground cable.

The proposed program will result in the replacement of 100 km of SWER conductor or 15% of the SWER conductor in Codified Areas over the 2022-26 regulatory period.

The cost of insulating or undergrounding 1 km of conductor is [C.I.C], so this option has a capital cost of [C.I.C], or [C.I.C].

The conductor to be replaced has been selected based on the condition of the conductor and the bushfire risk. The areas selected for prioritised replacement are shown in Appendix A.

¹ REFCL technology only operates on the 22kV network and therefore excludes SWER networks

2 Background

2.1 What are Codified Areas?

The *Electricity Safety Act 1998* defines *electric line construction area* to mean land delineated and shown on a prescribed plan. The *Electricity Safety (Bushfire Mitigation) Regulations 2013* provides the details for this prescribed plan.

Within AusNet Services, these *electric line construction areas* are referred to by AusNet Services as *Codified Areas* and are shown in red in Figure 1.

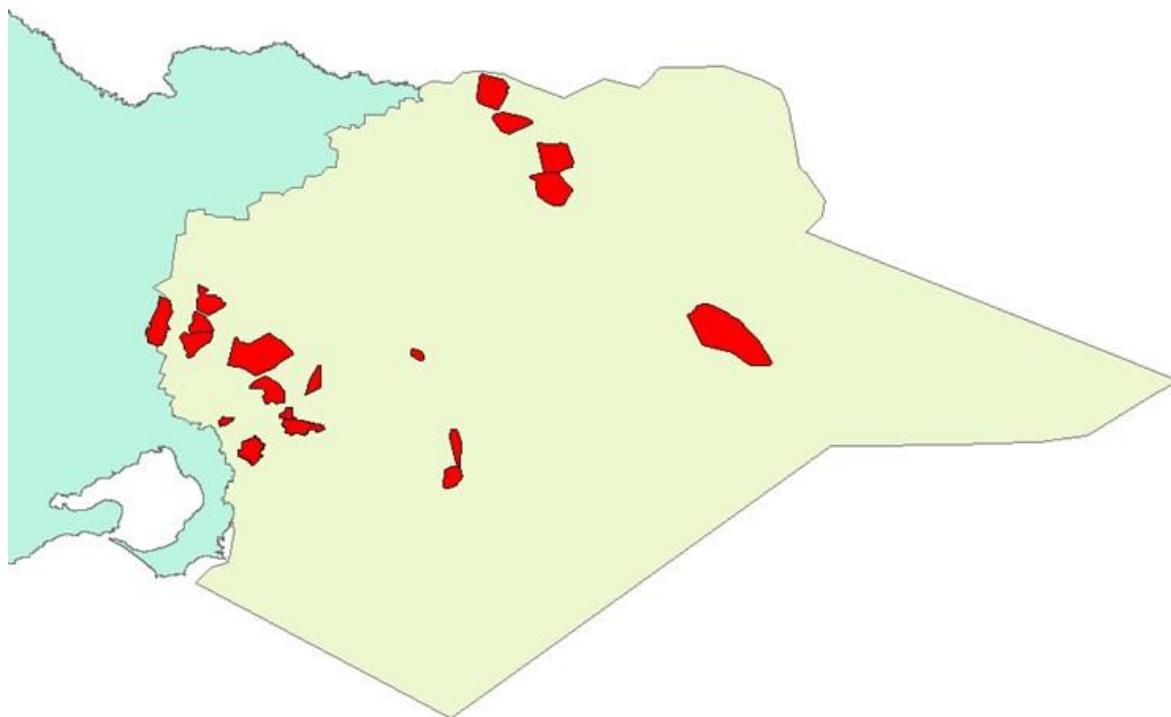


Figure 1: Codified Areas within AusNet Services' distribution network area

Within Codified Areas, the *Electricity Safety Act 1998* requires all new high voltage (HV) lines are either insulated or placed underground. Similarly, when replacing four or more consecutive spans of HV line, these must be insulated or placed underground.

HV lines includes any lines at 22 kV and single wire earth return (SWER) lines (which operate at 12.7 kV) but does not include sub-transmission lines operating at 66 kV. The total route length of 22kV and SWER powerlines within Codified Areas is approximately 1,728km of which approximately 265km is insulated as at 30 April 2018²

² AusNet Services' 2018 Compliance Report, Legislated Bushfire Mitigation Programs

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2.2 Driver for Powerline Replacement in Codified Areas

The requirement to insulate or place underground lines in Codified Areas can be traced to the 2009 Victorian Bushfires Royal Commission's (VBRC) Recommendation 27 which included the following:

- *the progressive replacement of all SWER (single-wire earth return) power lines in Victoria with aerial bundled cable, underground cabling or other technology that delivers greatly reduced bushfire risk. The replacement program should be completed in the areas of highest bushfire risk within 10 years and should continue in areas of lower bushfire risk as the lines reach the end of their engineering lives.*
- *the progressive replacement of all 22-kilovolt distribution feeders with aerial bundled cable, underground cabling or other technology that delivers greatly reduced bushfire risk as the feeders reach the end of their engineering lives. Priority should be given to distribution feeders in the areas of highest bushfire risk.*

The Powerline Bushfire Safety Taskforce (PBST), established to consider how the Victorian Government should implement the recommendations of the VBRC, provided a recommendation on how electricity distributors should implement Recommendation 27.

The PBST recommended that:

Recommendation 1

Electricity distributors implement the 2009 Victorian Bushfires Royal Commission's recommendation 27 by:

(a) installing new generation protection devices to instantaneously detect and turn off power at a fault on high fire risk days:

- *on SWER powerlines in the next five years (new generation SWER ACRs)*
- *on 22kV powerlines in the next 10 years (Rapid Earth Fault Current Limiters)*

(b) targeted replacement of SWER and 22kV powerlines with underground or insulated overhead cable, or conversion of SWER to multi-wire powerlines, in the next 10 years

to the level of between \$500 million and \$3 billion, consistent with the package of measures selected by the Victorian Government. These should be implemented in the highest fire loss consequence areas first.

Any new powerlines that are built in the areas targeted for powerline replacement should also be built with underground or insulated overhead cable.

These recommendations have been implemented through changes introduced in 2016 to the *Electricity Safety (Bushfire Mitigation) Regulations 2013* and through the Victorian Government's Powerline Replacement Fund (PRF).

This has resulted in:

- implementation of new generation SWER automatic circuit reclosers (ACRs);
- a program to install Rapid Earth Fault Current Limiting (REFCL) technology in 22 nominated zone substations;
- targeted undergrounding/insulation of bare HV overhead wires in high risk areas funded by the PRF; and
- the regulation of construction standards applying to conductors in Codified Areas.

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The Regulatory Impact Statement (RIS) prepared for the *Bushfire Mitigation Regulations Amendment* found that there is positive net benefit³ (provided costs are not too high) to putting powerlines underground and insulating conductors that have reached end of life.

The regulations applying to conductors in Codified Areas are described in Section 3.1.

2.3 Replacement of Conductors in Codified Areas

The following activities and timing are considered 'planned' by Energy Safe Victoria:

- Replacement greater than four consecutive spans due to:
 - Risk based – replacement based upon asset condition and criticality
 - Condition based – replacement based upon inspection program
 - Load growth – replacement with increased conductor size to meet load growth
- Relocation greater than four consecutive spans due to:
 - Line relocation – customer or company initiated electric line relocation
- Construction of any new medium voltage electric line that is part of the supply network must be constructed with insulated cable or covered conductor.

Replacement activities exempt from insulated cable or covered conductor construction within Codified Areas include:

- Fault and Emergency works, as these works are not considered 'planned'.

With fault and emergency works, where required planning and design timeframes can be achieved, due to deferral of supply restoration requirements, replacement of medium voltage assets will be undertaken to insulated or covered conductor standards.

2.4 Conductor in Codified Areas

Table 1 shows HV conductor in Codified Areas, both poly-phase and SWER.

Table 1: Conductor construction type in Codified Areas

Construction Type	Length ⁴ (km)
Poly-phase – bare wire	817
Poly-phase – insulated or underground	264
SWER	647
Total	1,728

³ Regulatory Impact Statement – Bushfire Mitigation Regulations Amendment; ACIL ALLEN CONSULTING, 17 November 2015; p 101.

⁴ At 30 April 2018

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The majority of poly-phase lines are supplied by substations that will be fitted with Rapid Earth Fault Current Limiters (REFCL) at the completion of the REFCL program. This means there will be a material reduction in the risk of fire ignition in Codified Areas where supply is via poly-phase lines. SWER sections are isolated from the REFCL network and therefore a REFCL provides no reduction in bushfire risk to SWER network.

There is 3.9 km of bare wire poly-phase conductor in the Murrindindi area that is not supplied from a zone substation that will have a REFCL fitted. The omission of MDI from the regulations prescribing REFCL implementation was deliberate due to the cost of powerline replacement for such a small section of polyphase network with insulated conductor considered a more cost-effective means of risk reduction than installation of REFCL technology. This poly-phase conductor will be replaced with insulated/underground conductor prior to the 2022-26 regulatory period.

2.5 SWER Conductor Condition Based Replacement

Overhead lines are routinely inspected. When the inspection reveals conductor deterioration, an assessment is made whether the deterioration is isolated (possibly the result of previous damage to the conductor) or more widespread (due to age based and/or environmental factors).

Where the deterioration is isolated, a localised repair can be undertaken and where the deterioration is more widespread, a section of powerline is replaced (e.g. ≥ 4 spans).

The approach to forecasting deteriorated conductor requiring replacement is described in *AMS 20-52 Conductor*. Over the 2022-26 period, 1,355 km of conductor is forecast to require replacement of which 15 km is in Codified Areas. Of this 15 km, 7 km is SWER conductor.

Thus, only 7 km of SWER conductor in Codified Areas is forecast to be replaced over the 2022-26 regulatory period. This represents 1% of the SWER conductor in Codified Areas replaced over a 5-year period.

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3 Other Issues

3.1 Regulations

The *Electricity Safety Act 1998* states:

120N Covering or placing underground electric lines

(1) A major electricity company must cover or place underground each new electric line that meets the prescribed specification that it constructs within an electric line construction area.

(2) A major electricity company must cover or place underground each electric line that—

- (a) meets the prescribed specification; and
- (b) it reconstructs or substantially reconstructs within an electric line construction area; and
- (c) is of at least 4 consecutive spans or has conductors on at least 4 consecutive spans.

With respect to replacement and relocation activities the *Electricity Safety (Bushfire Mitigation) Regulations 2013* specify that *wholly or substantially replaced* means:

The planned replacement or relocation of an electric line that involves—

- (a) the relocation of at least 4 consecutive spans of the electric line; or
- (b) the replacement of conductors on at least 4 consecutive spans of the electric line.

The *Electricity Safety (Bushfire Mitigation Duties) Regulations 2017* states:

8 Prescribed specification for covering or placing underground electric lines

For the purposes of sections 120N and 120P of the Act, the prescribed specification for an electric line is that it has a nominal voltage of between 1 kV and 22 kV inclusive.

3.2 Timing of Powerline Replacement

The 2009 VBRC recommendation was to replace SWER powerlines in the areas of highest bushfire risk within 10 years.

The PBST recommendation was for targeted replacement of SWER in the next 10 years.

The Victorian Government's RIS analysis assumed powerlines would be replaced over a 25-year period commencing in 2015 and finishing in 2040, that is, all powerlines would reach end of life within a 25-year period. The current regulations only require the insulating or undergrounding of lines when they reach end of life.

Replacement of SWER conductor based on condition alone will not result in replacement of SWER conductor in a timeframe consistent with the recommendations of the VBRC and PBST or the assumption in the RIS.

AusNet Services' current condition-based replacement forecast is for 7 km of SWER conductor in Codified Areas to reach end of life over the 2022-26 regulatory period.

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3.3 Benefits

The key benefits resulting from insulating or undergrounding lines were outlined and quantified in the RIS.

These are:

- A reduction in bushfire risk
- A reduction in the number of minutes customers are off supply
- A reduction in the number of momentary interruptions experienced by customers

3.3.1 Bushfire risk

A fault on a powerline can release enough energy to start a ground or bushfire. On days of very high bushfire risk, ambient temperatures are high, humidity is low and vegetation has low moisture levels. In these circumstances, there is a possibility that a fire may not be controllable by the Fire Services and could lead to loss of life and property.

The Regulatory Impact Statement for the Bushfire Mitigation Regulations Amendment states:

...putting powerlines underground would reduce the likelihood of bushfires starting by 98 to 99 per cent. Insulating powerlines would reduce the likelihood of bushfires starting by 96 to 98 per cent. Putting powerlines underground or insulating them is therefore a highly effective way to meet the objective of reducing the likelihood that powerlines start bushfires.⁵

The Royal Commission found that:

The SWER and 22kV distribution networks constitute a high risk for bushfire ignition, along with other risks posed by the ageing of parts of the networks and the particular limitations of SWER lines.

3.3.2 Minutes off supply

As insulated aerial conductors are not impacted to the same extent by vegetation, animals and birds as bare aerial conductors, the installation of insulated aerial conductors results in a reduction in the time that customers are off supply.

Further, underground lines experience even fewer interruptions, as they are less susceptible to outage causes such as impact from vehicles, falling trees or lightning. However underground lines experience longer outages as cable faults take longer to find and repair than faults on overhead network.

3.3.3 Momentary interruptions

Momentary interruptions arise when a temporary faults occurs (such as a branch on a line, which subsequently falls to the ground) and the circuit breaker automatically recloses. Customers experience fewer momentary interruptions when conductor is insulated or underground as the conductors are less susceptible to outage causes such as impact from vehicles, falling trees or lightning.

⁵ Regulatory Impact Statement – Bushfire Mitigation Regulations Amendment; ACIL ALLEN CONSULTING, 17 November 2015; p 57.

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4 Identified Need

The 2009 Victorian Bushfires Royal Commission (VBRC) and the Powerline Bushfire Safety Taskforce (PBST) both recommended the replacement of SWER powerlines with underground or insulated overhead cables within 10 years.

These recommendations were implemented through changes to the *Electricity Safety (Bushfire Mitigation) Regulations 2013* which requires that conductors within Codified Areas which have reached the end of life to be put underground or insulated.

The Victorian Government's RIS cost benefit analysis that supported replacement of powerlines within Codified Areas assumed powerlines would be replaced over a 25-year period commencing in 2015 and finishing in 2040. In other words, all powerlines would reach end of life within a 25-year period. Furthermore, regulations induced specifically targeting Codified Areas indicates the Government's intent for distributors to increase bushfire risk mitigation measures in these areas and in a timely manner.

AusNet Services' condition-based replacement forecast only identified 7 km of SWER conductor in Codified Areas to be replaced over the 2022-26 regulatory period. This represents only 1% of the SWER conductor in Codified Areas. Clearly, assumptions made in respect to the engineering life of powerlines for introduction of the new bushfire mitigation legislation, differs significantly from actual engineering life. AusNet Services does not believe that this rate of replacement meets the expectations of our customers, community and stakeholders. It is therefore proposing an additional program to accelerate the replacement of bare SWER conductor installed within Codified Areas.

Media attention around the 10 year anniversary of Black Saturday focussed on what was considered to be minimal replacement (15%) of powerlines in the highest risk areas. Thus, there is considerable customer and stakeholder expectation that distribution businesses will accelerate replacement of bare powerlines in Codified Areas in accordance with the intentions of the bushfire safety legislation.

5 Risk and Options Analysis

5.1 Options Considered

This section outlines the potential options that have been considered to address the risk associated with powerlines in Codified Areas.

The following options have been identified:

1. Condition based replacement (business as usual)
2. Accelerated program of replacement (**Preferred option**)
3. Larger accelerated program of replacement
4. Disconnect SWER lines and supply customers using Remote Area Power Supplies (RAPS)
5. Use alternative technology to replace powerlines
6. Conversion of SWER to multiphase line

5.1.1 Condition based replacement

This option involves replacing conductor when the conductor is inspected and determined to have reached the end of its effective life. This is the business as usual approach to replacement of conductor.

The current forecast is for 7 km of SWER conductor within Codified Areas to be replaced over the period 2022-26. This conductor must be replaced with insulated or underground conductor.

This work will be undertaken as part of business as usual work, regardless of the selection of other options.

5.1.2 Moderate accelerated program of replacement (Preferred option)

This option involves replacing 100 km of SWER. The conductor will be replaced with insulated/underground conductor and will bring forward into the 2022-26 period conductor that would otherwise not be replaced until after 2025.

5.1.3 High accelerated program of replacement

The VBRC and PBST both envisaged replacement of conductor in high bushfire risk areas over a 10-year timeframe. The regulatory expectation subsequently determined in 2016 was that the powerlines be replaced by 2040.

A program could be developed to replace all the SWER conductor in Codified Areas over a ten-year timeframe. This would involve replacing approximately 300 km over the 2022-26 period (60 km per year).

5.1.4 Disconnect SWER lines and supply customers using Remote Area Power Supplies (RAPS)

The primary benefit from insulating or undergrounding SWER conductor in Codified Areas is to reduce the risk of bushfire ignition.

An alternative method of achieving risk reduction is to supply customers using remote area power supplies (RAPS) and to disconnect sections of the SWER network.

This would avoid the cost of insulating or undergrounding sections of network.

As current regulations prevent distribution networks from owning remote area power supplies there are regulatory impediments to this option.

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5.1.5 Use alternative technology to replace powerlines

This option involves replacing the same length of SWER conductor but using different powerline technologies than those proposed. It is assumed that these alternative technologies would be cheaper to install than the current technologies used to insulate or underground powerlines.

5.1.6 Conversion of SWER to multiphase line

SWER network could be converted to multiphase line and would then be protected by the REFCL. However, as the network is located in Codified Areas any multiphase network constructed would also need to be insulated or undergrounded.

5.2 Analysis of Options

5.2.1 Advantages and Disadvantages

The advantages and disadvantages of the options are presented in Table 2.

Table 2: Option Advantages and Disadvantages

Option	Advantages	Disadvantages
1. Condition based replacement	<ul style="list-style-type: none"> • Defers expenditure until future regulatory periods. • May allow time for alternative technologies to become feasible or for regulations to enable RAPS. 	<ul style="list-style-type: none"> • Very little reduction in bushfire risk from SWER networks over the 2022-26 period. • Practically no progress towards the recommendations of the VBRC and PBST as they relate to insulating SWER conductor in high-risk areas.
2. Moderate accelerated program of replacement (Preferred option)	<ul style="list-style-type: none"> • Some reduction in bushfire risk from SWER networks over the 2022-26 period. • Some improvement in network reliability to SWER customers. • Demonstrated progress towards the recommendations of the VBRC and PBST as they relate to insulating SWER conductor in high-risk areas 	<ul style="list-style-type: none"> • Expenditure incurred over the 2022-26 period that would otherwise be deferred until after 2025. • Proposed program only replaces approximately 20% of SWER conductor and therefore most of the SWER conductor bushfire risk remains after 2026.

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Option	Advantages	Disadvantages
3. High accelerated program of replacement	<ul style="list-style-type: none"> • Larger reduction in bushfire risk from SWER networks over the 2022-26 period than Option 2. • Some improvement in network reliability to SWER customers. • Demonstrated progress towards the recommendations of the VBRC and PBST as they relate to insulating SWER conductor in high-risk areas 	<ul style="list-style-type: none"> • More expenditure incurred over the 2022-26 period that would otherwise be deferred until after 2025. • An accelerated program would not replace all SWER conductor and therefore some of the SWER conductor bushfire risk remains after 2025.
4. Disconnect lines and supply customers using RAPS	<ul style="list-style-type: none"> • Eliminates risk of bushfire ignition from powerlines disconnected. • Likely to be cheaper to use RAPS for some customers than to convert existing network to insulated/underground. 	<ul style="list-style-type: none"> • Currently regulations prevent Networks from owning RAPS and no ability for Networks to recover costs of subsidising customer or third-party owned RAPS. • Likely to introduce additional safety/bushfire risk from liquid fuel generation. • RAPS requires more maintenance than SWER network.
5. Alternative powerline technology	<ul style="list-style-type: none"> • Cheaper than current methods of insulating conductor. 	<ul style="list-style-type: none"> • No technology currently available and proven. • Installation of unproven technology introduces risk of early life failure leading to increased lifecycle costs. (New conductor rapidly deteriorates.)
6. Convert to multiphase lines	<ul style="list-style-type: none"> • Multiphase lines can be protected by REFCL. • Makes additional capacity available to customers. 	<ul style="list-style-type: none"> • More expensive than proposed option as new multiphase lines in Codified Areas must be insulated or underground. • Limited benefit from additional capacity as most customers do not require additional capacity.

5.2.2 Options Discussion

The first three options (Condition based, Moderate Accelerated and High Accelerated) and option 6, all result in replacement of bare SWER conductor with insulated or underground conductor.

The difference between the options is the timing of replacement with the condition-based option deferring the bushfire risk reduction benefit and deferring expenditure; the Moderate

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Accelerated and High Accelerated options bring forward some of the bushfire risk reduction benefit and increases expenditure over the regulatory period.

Of the other options described, those which have the potential to reduce bushfire risk at a lower cost than the first three options are:

- Option 4: Disconnecting lines and supply customers using RAPS, and
- Option 5: Alternative powerline technology.

Neither of these options is currently feasible.

The current rules do not allow a Distribution Network Supplier to own generation therefore the only way that a RAPS system could be utilised is for the customer or a third party to own the system.

At an individual customer level, the cost of installing, operating and maintaining a RAPS system would be greater than the cost to the customer of network and retail energy charges.

Currently, there is no avenue for the Distribution Network Supplier to subsidise the customer or a third party RAPS supplier and therefore it is unlikely that any customer would prefer a RAPS service to a network service as the cost of a RAPS service will be higher than remaining connected to the network.

Alternative powerline technologies have been trialled and continue to be trialled.

SWER networks generally feature a light weight and high tensile strength steel conductor that facilitate long spans between poles.

Current insulated cable alternatives are heavier than steel conductor and cannot be strung over long spans. This leads to the need to install additional poles and, where physical or practical constraints prevent the installation of additional poles, undergrounding is required.

Some trials of alternative technology have been undertaken but these trials have not satisfactorily proven the alternatives.

AusNet Services is currently undertaking two further trials of spacer cable technology and [C.I.C] covered conductor. Each of these committed trials will replace over 10 km of bare conductor in Codified Areas during 2020 and will test design, construction and work practices associated with the technology and, over time, will test the durability of the technology.

5.3 Preferred Option

AusNet Services is proposing a program of accelerated replacement of 100 km of SWER conductor in Codified Areas. The SWER conductor will be replaced with a combination of insulated conductor and underground cable.

The proposed program will result in the replacement of 100 km of SWER conductor or 15% of the SWER conductor in Codified Areas over the 2022-26 regulatory period.

The cost of insulating or undergrounding 1 km of conductor is [C.I.C], so this option has a capital cost of [C.I.C], or [C.I.C].

The conductor to be replaced has been selected based on the condition of the conductor and the bushfire risk.

The areas selected for prioritised replacement are shown in Appendix A.

5.4 Relationship to Other Programs

Overhead lines are routinely inspected. When the inspection reveals conductor deterioration, an assessment is made whether the deterioration is isolated (possibly the result of previous

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damage to the conductor) or more widespread (due to age based and/or environmental factors).

Where the deterioration is isolated, a localised repair can be undertaken and where the deterioration is more widespread, a section of conductor is replaced.

The approach to forecasting deteriorated conductor requiring replacement is described in *AMS 20-52 Conductor*.

Over the 2022-26 period, 1,355 km of conductor is forecast to require replacement of which 15 km is in Codified Areas. Of this 15 km, 7 km is SWER conductor.

The 100 km of SWER conductor to be replaced in this program is additional to the 7 km of conductor forecast in the business as usual condition-based replacement program.

In the current regulatory period, the Victorian Government has funded a program of powerline replacement as part of its package of Powerline Bushfire Safety Program. This has resulted in the insulation and undergrounding of lines in Codified Areas.

As shown in

Table 1, over 30% of multiphase conductor in Codified Area is now insulated or underground and much of this is the result of Government funding.

The current Government funding for this type of work has been allocated and the construction works concluded in 2019.

It is possible that the Government could fund additional powerline replacement works. If the Government does fund additional insulating or undergrounding this could result in an overlap with this program.

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Appendix A Areas Selected for Accelerated SWER Conductor Replacement

Area	Construction	Length (km)
Lancefield North	SWER	19.4
Kinglake East	SWER	18.3
Kinglake West	SWER	26.8
Seymour	SWER	3.9
Mitchell-Kilmore	SWER	19.1
Lancefield East	SWER	10.5
Lancefield West	SWER	14
	Total	112