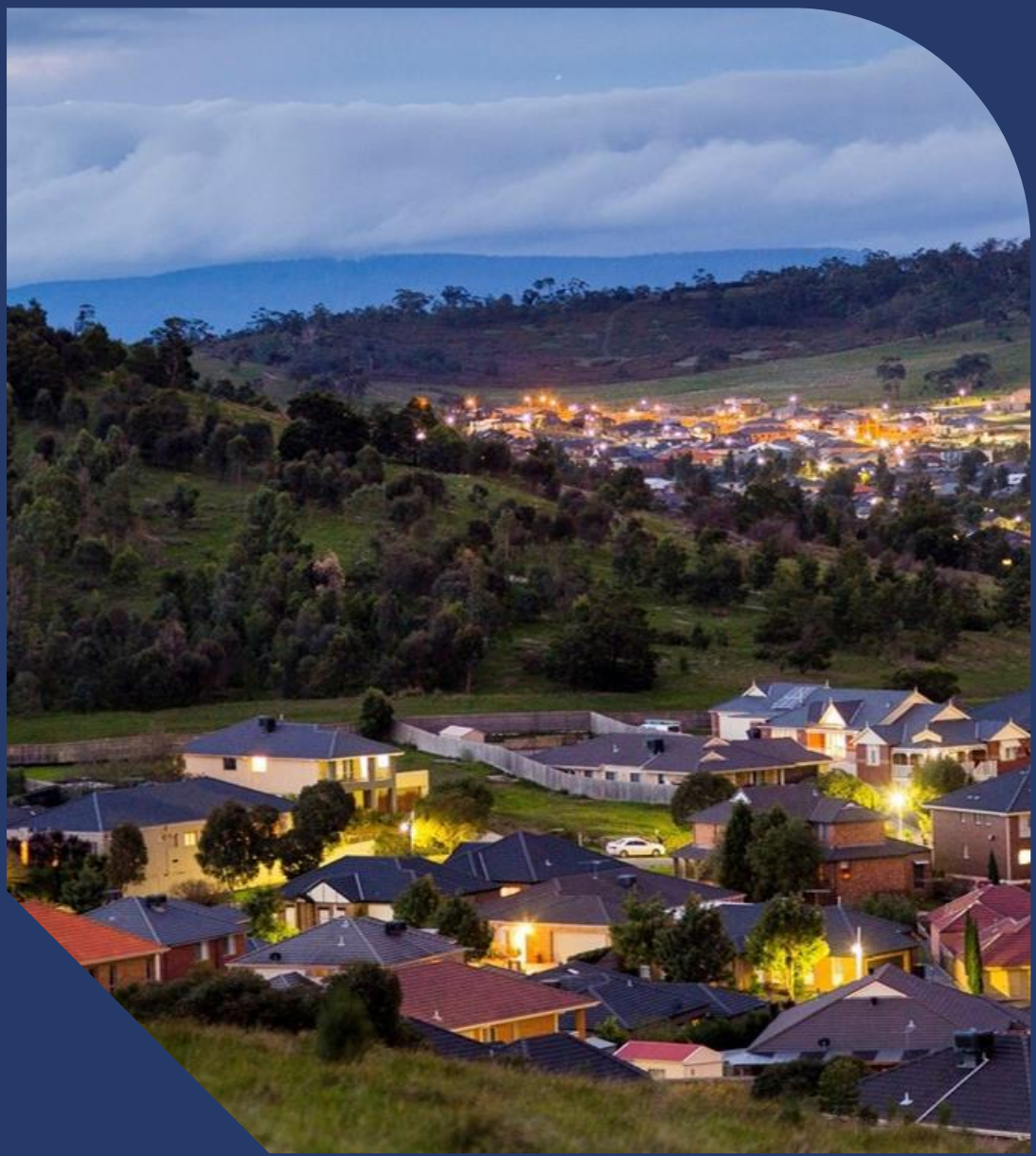
AusNet

Proactive Insulation of SWER Conductor (Codified areas)

AMS – Electricity Distribution Network

Friday, 31 January 2025



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1. Executive summary

AusNet holds an electricity distribution licence issued in 1994. This licence authorises the distribution of electricity to more than 750,000 customers in northern and eastern Victoria via 45,000km of powerlines and underground cables.

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.

The Victorian Government's Powerline Replacement Fund has been responsible for most of the 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 implemented Rapid Earth Fault Current Limiter (REFCL) technology to reduce bushfire risk from 22kV powerlines[1]. A focus on powerline replacement of SWER lines within Codified Areas is therefore appropriate to ensure bushfire risk is being addressed across all conductors in Codified Areas.

AusNet Services' current condition-based replacement forecast is for 20 km of SWER conductor in Codified Areas to reach end of life over the 2021-26 regulatory period. This represents 3% 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 of proactive replacement of bare SWER conductor installed within the distribution network.

1.1. Preferred Option

AusNet is proposing a program of proactive replacement of the approximate 645km of SWER bare conductor for covered (or sometimes referred to as insulated) in Codified Areas over four regulatory reset periods. Stage one is underway with construction and commenced in the 2021-2026 regulatory period. Where possible, bare SWER conductors will be replaced with covered conductors as it is the most cost efficient and technically appropriate option. There is some allowance to replace sections of SWER conductors with underground cable should it be required to mitigate issues arising from route length, terrain or environmental restrictions.

The cost of covering (or insulating) 1 km of conductor is an estimated ~[C.I.C].

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

Each line section to be evaluated for viability of SAPS as a part of detailed design as a cost-effective alternative.

[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.

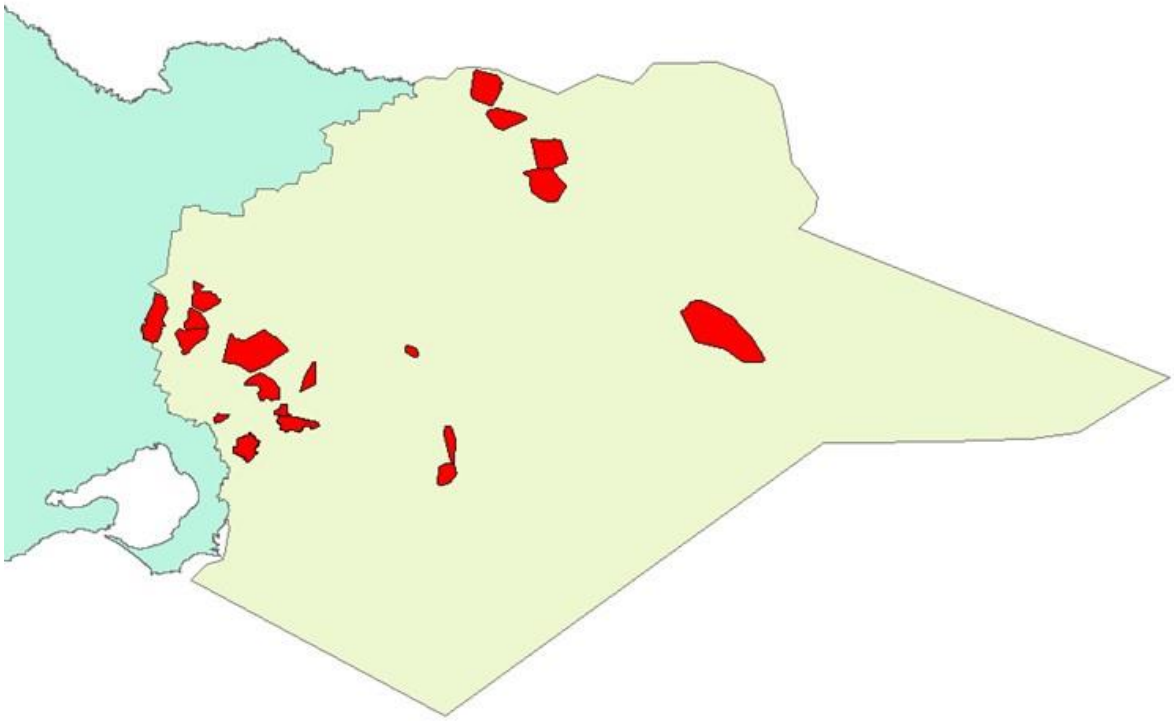

Figure 1: Codified Areas within AusNet Services' distribution network area

Within Codified Areas, the *Electricity Safety Act 1998* requires all new high voltage (HV) lines to be 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 include 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. Sub-transmission lines operating at 66 kV are considered to have a very low risk of causing fire.

2.1.1. Driver for Powerline Replacement in Codified

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 (which we have completed in 2023).
- 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.

The Regulatory Impact Statement (RIS) prepared for the *Bushfire Mitigation Regulations Amendment* found that there is positive net benefit[2] (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 **Error! Reference source not found.**.

2.1.2. 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:

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

- 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.

2.1.3. Conductor in Codified Areas

Table 1: Conductor construction type in Codified Areas

Construction Type	Length[3] (km)
Poly-phase – bare wire	817
Poly-phase – insulated or underground	264
SWER	645
Total	1,728

Most 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 was replaced with insulated covered conductor during the current 2021-26 regulatory period.

2.1.4. 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*. Only 20 km of SWER conductor in Codified Areas is identified as deteriorated conductor requiring replacement over the 2027-31 regulatory period. This represents 3% of the SWER conductor in Codified Areas.

3 At 30 April 2018

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.*

3.1.1. 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 assessment identifies 20 km of SWER conductor in Codified Areas to reach end of life over the 2026-31 regulatory period.

3.1.2. 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

3.1.3. Bushfire risk

A fault on a powerline can release enough energy to start a ground fire 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.4

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.

3.1.4. Minutes of Supply

As insulated aerial conductors are not impacted to the same extent by vegetation, animals and birds as bare aerial conductors, the installation of covered aerial conductor's 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.

3.1.5. Momentary interruptions

Momentary interruptions arise when a temporary fault 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 covered or underground as the conductors are less susceptible to outage causes such as impact from vehicles, falling trees or lightning.

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 inside the codified area would reach end of life within a 25-year period. Furthermore, regulations introduced specifically targeting Codified Areas indicates the Governments 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 20 km of SWER conductor in Codified Areas to be replaced over the 2027-31regulatory period. This represents only 3% 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 proactively replace bare SWER conductor installed within Codified Areas.

Media attention around the 10-year anniversary of Black Saturday focussed on what was considered minimal replacement (15%) of powerlines in the highest risk areas. Thus, there is considerable customer and stakeholder

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

expectation that distribution businesses will proactively cover/insulate powerlines in Codified Areas in accordance with the intentions of the bushfire safety legislation.

5. Risk and Options Analysis

5.1. Approved methods

This section identifies the current approved methods for replacing bare overhead conductor as documented in the Bushfire Mitigation Plan – Electricity Distribution Network[5]. Approved methods - highest to lowest cost.

5.1.1. Underground

Underground cable with equipment such as substations, switches and fusing that are contained within ground mounted, insulated enclosures. Interfaces with an overhead network have insulated or covered leads to surge arrestors.

5.1.2. Hybrid Underground

Underground cable used between above ground structures such as pole type substations, gas insulated switches, automatic circuit reclosers and HV section fuses. The above ground assets, like covered conductor and ABC, includes insulated and covered leads for transformers, automatic circuit reclosers, surge arrestors, HV fuses and gas insulated switches.

5.1.3. Stand-alone Power System (SAPS)

Stand-alone power systems (SAPS) typically consist of Solar Panels, Wind Generator, Battery storage, Inverter and Diesel Generator installed on customers property. The overhead Line is disconnected and removed from service.

5.1.4. Aerial Bundled Cable (ABC)

ABC consists of three insulated, metallic screened cables wound around a bare catenary wire. The catenary wire, like covered conductor, provides the tensile strength and support for stringing ABC between pole or tower supporting structures

5.1.5. Spacer Cable

Spacer cable, consisting typically of three phases, is held in several insulated cradles that are supported by a catenary wire strung between supporting poles or tower structures.

5.1.6. Covered Conductor

Covered conductor with an Extruded Semi Conductive Layer and Cross-Linked Polyethylene Insulation CCSX, that may be constructed in one, two or three phase configurations in a manner like bare wire construction. The basic difference between this and Spacer Cable is that the covered conductor used in Spacer configuration is not under tension as it is supported by insulated cradles.

5.2. 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)

[5] Bushfire Mitigation Plan – Electricity Distribution Network – doc number BFM 10-01 – 24 November 2022

(2) Proactive program of replacement (**Preferred option**)
(3) Remove SWER lines and supply customers using Stand-alone Power Supplies (RAPS)
(4) Use alternative technology to replace powerlines
(5) Conversion of SWER to multiphase line

5.2.1. 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 20 km of SWER conductor within Codified Areas to be replaced over the period 2026-31. 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.

5.2.2. Proactive accelerated program of replacement (Preferred option)

This option involves replacing another section of SWER bare conductor for covered/insulated conductor. The intent is to progressively replace the conductor over a number of regulatory periods.

5.2.3. Disconnect SWER lines and supply customers using Stand-alone Power Systems (SAPS)

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 stand-alone power systems (SAPS) and to disconnect & remove sections of the SWER network.

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

5.2.4. 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.

5.2.5. 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 in Codified Areas any multiphase network constructed would also need to be insulated or undergrounded.

5.3. Analysis of Options

5.3.1. 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	• Defers expenditure until future regulatory periods. • May allow time for alternative technologies to become feasible	• Very little reduction in bushfire risk from SWER networks as technical end of life is not anticipated in the next 15 plus years. • Practically no progress towards the recommendations of the VBRC and PBST as they relate to insulating SWER conductor in high-risk areas.
2. Proactive program of replacement **(Preferred option)**	• 96-98% reduction in bushfire risk for the targeted areas [6](compared to bare conductor) across the codified SWER network as the conductor is replaced for covered/insulated. • 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	• Expenditure incurred over the 2026-31 period that would otherwise be deferred until after 2031.
3. Disconnect lines and supply customers using SAPS	• Eliminates risk of bushfire ignition from powerlines. • Might be cheaper to use SAPS for some customers, than to convert existing network to insulated/underground.	• Could introduce additional safety/bushfire risk from liquid fuel generation. • SAPS requires more maintenance than SWER network.
4. Alternative powerline technology	• Might be cheaper than current methods of insulating conductor.	• 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.)
5. Convert to multiphase lines	• Multiphase lines can be protected by REFCL. • Makes additional capacity available to customers.	• 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.

5.3.2. Options Discussion

The first two options (Condition based and Proactive replacement) and option 5, all result in replacement of bare SWER conductor with insulated or underground conductor.

[6] 6 Regulatory Impact Statement – Bushfire Mitigation Regulations Amendment; ACIL ALLEN CONSULTING, 17 November 2015; p 57.

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 Proactive replacement option brings forward 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:

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

Regulatory[7] changes in 2024 to allow a Distributed Network Service Providers (DNSP) to own generation, increases the viability of a SAPS solution as there is no additional cost to the customer.

An impediment to this option will be the acceptance of all connected customers on a line section to move off grid, allow for SAPS to be installed on their property and accept that this entails the removal of the grid connected network.

SAPS carry a high cost of installation, a low life expectancy (batteries, solar panels etc) and ongoing servicing/maintenance/replacement cost. This solutions viability is determined by the amount of line to be removed, the savings on vegetation management and ongoing operating cost to demonstrate the annualised cost of SAPS is equal to or better than the annualised cost of upgrading and maintaining the existing network over the next 50 years.

Alternative powerline technologies have been trialled and continue to be trialled. They are currently not feasible.

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. 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.

5.3.3. 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 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*.

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.

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.

[7] National Electricity - Victoria - Regulated Stand-alone Power Systems - Regulations 2024_S R No 69-2024

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