Powerline Bushfire Safety Program

Progress Report 2012-19

VICTORIA State Government | Environment, Land, Water and Planning

Acknowledgement

The Victorian Government acknowledges the Australian Aboriginal and Torres Strait Islander peoples of this nation.

We acknowledge the traditional custodians of the lands on which our organisation is located and where we conduct our business.

We pay our respects to ancestors and Elders, past and present. The Department of Environment, Land, Water and Planning is committed to honouring Australian Aboriginal and Torres Strait Islander peoples' unique cultural and spiritual relationships to the land, waters and seas and their rich contribution to society.

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Minister's Foreword

Over the past eight years (2012-2019), the Victorian Government has led a transformational change to reduce the likelihood of bushfires being ignited by power infrastructure.

Following the tragic events of the 2009 Black Saturday fires, the Victorian Government acted to reduce the risk of bushfires started by bare-wire powerlines and implement the recommendations of the 2009 Victorian Bushfires Royal Commission and the Powerline Bushfire Safety Taskforce.

The $750 million Powerline Bushfire Safety Program (Program) has supported the upgrading of Victoria's electricity assets and network controls to keep communities safer and make sure our energy systems can support our State as we continue to grow.

This is a world-leading initiative, using next generation network protection technology and infrastructure upgrades to reduce powerline bushfire risk.

The Department of Environment, Land, Water and Planning (DELWP) has delivered clear, modern regulation to support this infrastructure investment, and we have built strong partnerships with electricity distributors to roll out these vital upgrades.

Over the past eight years, substantial bushfire safety improvements have been progressed including:

- targeted replacement of 541 km of high voltage, bare-wire electric lines with underground or insulated conductors, which reduce ignition likelihood by 98-99% on those lines, in the highest bushfire risk areas of the State;
- the replacement of almost 800 low voltage, private overhead electric lines with underground or insulated conductors, protecting over 193 km of such lines in 33 areas of high bushfire risk;
- in addition, a further 61,000 km of powerlines will be protected through a combination of Rapid Earth Fault Current Limiters (REFCLs) and Automatic Circuit Reclosers (ACRs);
- the installation of REFCLs at 19 zone substations (to date) serving over 15,000 km of 22kV polyphase electric lines in rural and regional Victoria. This program continues to 30 April 2023, at which point REFCLs at 45 substations will protect over 31,000 km of lines and, in some cases, deliver up to a 70% reduction in the likelihood of a powerline-ignited fire;
- the installation of more than 1,700 new generation ACRs on 30,000 km of 12.7kV single wire earth return (SWER) lines in rural and remote Victoria, producing a reduction in bushfire risk of up to 45%;
- the delivery of backup power generators to 343 residential care facilities in high bushfire risk areas, protecting nearly 16,000 Victorians in residential care from potentially life-threatening power outages;
- the delivery of $10 million in research and development funding to develop and test innovative bushfire protection technologies or operational processes; and
- establishing a $10 million fund that provides financial assistance to high voltage customers to assist them with the cost of upgrading their equipment to work compatibly with REFCLs.

Overall these and other initiatives are projected to reduce the electricity network's relative bushfire risk – that is, the chance an electric powerline could start a bushfire – by up to 60% on average on high voltage powerlines across the State, with significantly higher risk reductions in some of the highest bushfire risk areas. This is consistent with the risk reduction target in the Powerline Bushfire Safety Taskforce report.

These are critical outcomes for the safety of our Victorian communities.

The current program will see the installation of 45 REFCLs across Victoria by 30 April 2023. This is an important technology upgrade that helps detect and suppress dangerous faults within milliseconds, delivering significant risk reduction benefits.

We have also committed in the order of $2 million to a second round of research and development funding that will support technologies and systems that will present new opportunities for bushfire risk reduction across the State. Finally, ongoing undergrounding and insulation of powerlines at their end-of-life in designated high-risk areas will continue until all assets have been replaced.

We are unwavering in our commitment to deliver a safer Victoria and will continue to work with our partners across the electricity industry to ensure Victorians have the best possible protection against bushfires.

Following the recommendations of the Victorian Bushfires Royal Commission, the Victorian Government has implemented the Powerline Bushfire Safety Program (PBSP) to make our electricity network significantly safer for communities across the State.

Partnering with communities and the private sector, the PBSP has rolled out a number of initiatives across our State's electricity network to significantly reduce the risk of potential bushfire starts.

> 32%

REDUCTION IN POWERLINE BUSHFIRE RISK

across the state's network today, compared with 2009.

48% risk reduction by 2023 and active regulation to reduce risk by up to **60%** in the coming decades.

33

POTENTIALLY CATASTROPHIC BUSHFIRES AVERTED

by **19** operational REFCLs over the 2019/20 bushfire season.

16,000

OF VICTORIA'S MOST VULNERABLE CITIZENS PROTECTED FROM POWER OUTAGES

by **343** back-up generators in community and aged care facilities.

POWERLINE BUSHFIRE RISK REDUCED BY

up to 99%

in the highest-risk bushfire environments now protected by undergrounding or insulating **734km** of bare-wire powerlines.

VICTORIA'S ENTIRE

30,000 km

SINGLE WIRE EARTH RETURN NETWORK

now protected by Automatic Circuit Reclosers, used to stop power when a fault occurs to prevent fires.

INVESTED

$10 m

IN WORLD LEADING RESEARCH

and development programs to support the next generation of bushfire safety technology.

The Powerline Bushfire Safety Program – Overview

The Program's Genesis: Black Saturday and Victoria's response

Six of the eleven most catastrophic bushfires on Black Saturday were ignited by high voltage electric powerlines. Together these six fires caused 159 of the 173 deaths and 328 injuries. Fires also destroyed 1,832 homes and other property.

The Victorian Government responded to the Black Saturday disaster by establishing the 2009 Victorian Bushfires Royal Commission (Royal Commission) in February 2009.

In its July 2010 report, the Royal Commission made 67 recommendations, eight of which (Recommendations 27-34) directly addressed bushfires ignited by the electricity network.

Recommendations 27 and 32 were particularly important, as they proposed major changes to the design and operation of the electricity distribution network in Victoria (see Key Recommendations, Page 21, Table 1).

In May 2011, the Victorian Government released its response to the 2009 Victorian Bushfires Royal Commission's findings and recommendations.

The Powerline Bushfire Safety Taskforce

In recognition of the challenges in delivering the Commission's Recommendations 27 and 32, a Powerline Bushfire Safety Taskforce (Taskforce) was established in August 2010. The Taskforce further considered how to implement Recommendations 27 and 32.

The Taskforce commissioned customer research and undertook public consultation, including a series of local community meetings, to better understand the trade-off between reducing bushfire risks and the impacts on the cost of electricity, supply reliability and on the environment and landowners that the community would support.

In its final report of September 2011, the Taskforce concluded that the likely cost of burying or insulating all powerlines in Victoria, as per Recommendation 27, was too high:

- $40 billion ($2011) to underground powerlines in all non-urban areas; or
- $20 billion ($2011) to insulate all powerlines in non-urban areas.

Instead of burying or insulating all powerlines, the Taskforce focused on identifying a more cost-effective approach to bushfire reduction.

Based on field testing and research, the Taskforce concluded that the most cost-effective solution to significantly reduce powerline bushfire risk was the widespread deployment of REFCLs and new generation ACRs. This deployment would be coupled with the targeted replacement of bare-wire overhead powerlines with underground or insulated cable in the highest fire loss consequence areas.

The Taskforce recommended an accelerated 10-year schedule of works to significantly reduce bushfire risk on the 22kV and SWER networks (see Key Recommendations, Page 21, Table 2), rather than waiting until 22kV distribution feeders reach the end of the their engineering lives to replace them with underground or insulated lines, as the Royal Commission suggested.

In December 2011, the Victorian Government agreed to the accelerated approach in the rollout of a $750 million package of works under the Powerline Bushfire Safety Program.

February 2009
Black Saturday bushfires; Victorian Bushfires Royal Commission established

July 2010
Victorian Bushfires Royal Commission Final Report

August 2010
Powerline Bushfire Safety Taskforce established

May 2011
Government response to Victorian Bushfires Royal Commission Final Report

September 2011
Taskforce Final Report released

December 2011
Powerline Bushfire Safety Program commences

The Powerline Bushfire Safety Program

In December 2011, the Victorian Government established the Program to guide a $750 million investment in works over 10 years, implementing the recommendations of both the Royal Commission and the Taskforce.

These works reduce the risk of catastrophic bushfires such as those that devastated parts of the State in 2009 and include:

- deploying cutting edge technologies and other works to reduce bushfires from powerlines in high risk areas in rural and regional Victoria;
- funding the development of innovative technologies and information systems to better predict and prevent bushfires from being ignited by the electricity network; and
- protecting vulnerable Victorians from harm associated with bushfire-related power outages.

The Program's Elements

The Program consists of four interrelated elements to broadly reduce bushfire risk. Three of these programs – the Powerline Replacement Fund, the Local Infrastructure Assistance Fund and the Research & Development Fund – were delivered as part of a $250 million ($2011) investment of Government funds.

The fourth element – the Network Assets Project – consists of works that must be undertaken by electricity companies pursuant to changes to the law in 2016-17. The Victorian Government projected the cost of these works at $500 million ($2011).

These costs would ultimately be determined by the Commonwealth Australian Energy Regulator (AER), which approves the levels of expenditures by distribution businesses and authorises those expenditures to be recovered from the businesses' customers. Works under the Network Assets Project will be completed by mid-2023.

When all works have been completed in mid-2023, the relative risk of bushfires being ignited by Victoria's high voltage powerlines is projected to reduce by up to 50% on average across the State. When all legislated works have been completed (i.e. when all high voltage powerline assets in higher-risk Electric Line Construction Areas have been insulated or placed underground at the end of their engineering life), this figure will increase to up to 60%.

The Powerline Bushfire Safety Program's initiatives have strengthened both Victoria's electricity network and electricity distribution businesses' bushfire management processes to reduce the risk of bushfires being started by electric powerlines.

Program Outcomes

Program Outcomes To Date

As a world-first initiative, the Program has been able to rapidly achieve the widespread deployment of advanced bushfire safety technology and practices across nearly two-thirds of Victoria's electricity distribution network. Operating within strict governance constraints, the Program has managed to deliver all of its initiatives on time – many ahead of schedule – and all within or only slightly over projected cost. While it is impossible to completely eliminate the risk of a bushfire being ignited by high voltage lines, the Program will have reduced that risk by up to 60% on average across the State, and an average 70% in Electric Line Construction Areas, when all works have been completed.

Initiative	Performance
Network Assets Project ACRs	30,000 km of SWER lines
Network Assets Project - REFCLs	31,000 km of 22kV polyphase electric lines; 45 zone substations
Powerline Replacement Fund	• 537 km of high voltage lines replaced + 3 Stand Alone Power Systems installed (removing 4.4 km of lines) • 798 low voltage private overhead electric lines (POELs) (193 km of lines)
Local Infrastructure Assistance Fund	Backup generators to: • 343 residential care facilities, protecting • 15,937 aged or disabled residents
Research and Development	Over 15 research projects, including: • Field testing REFCLs at 2 zone substations • Fire loss consequence modelling • Developing new technology and operating measures
F-Factor	Statewide reduction in powerline ignitions
TOTAL	NA

Note 1. Powerline ignition likelihood reduction refers to the relative reduction in ignition likelihood associated with technology changes when compared to a bare-wire overhead electric line.
Note 2. Due to inflation, $1 in 2011 is worth a little over $1.08 in 2015. In order to obtain $2015 values, $2011 dollars were multiplied by 1.08175. See ABS, Consumer Price Index (Catalogue number 6401.0), as presented in a spreadsheet of rates and deflators provided by the Department of Treasury and Finance in its 'Economic forecasting methodology – general approach', published in December 2017.
Note 3. CSIRO estimated a 49% to 55% reduction in risk for bare-wire lines equipped with REFCLs; later independent testing suggests a 70-75% reduction in risk is likely.
Note 4. In its September 2011 final report, the Taskforce indicated that its projected costs of REFCL and ACR deployment were $471 million ($2011) – $432 million for REFCLs and $39 million for ACRs. This was subject to a variance of ± 20% due to the complex and unprecedented nature of works recommended. DELWP has used the upper bound of this variance ($518.4 million, $2011) in its table.
Note 5. This represents the sum AER approved for AusNet and Powercor's Tranche 1 and 2 REFCL works ($436 million, $2015) plus the sum of their proposed Tranche 3 works ($273 million, $2015), less 10%. The 10% reduction assumes the same approximate reduction in funding approved by the AER for Tranches 1 and 2 compared to the companies' funding applications.
Note 6. This entry includes current projected expenditures subject to review by the AER and may be subject to revision.

		Actual Program Costs as at 2019 (in $2015) compared with Original Projected Costs of Program in 2011 (in $2015)			
Powerline ignition likelihood reduction[1]	**Powerline ignition likelihood reduction at finalisation of works**	**Projected Costs in 2011 ($2015)**	**Actual Costs 2019 (in $2015)[2]**	**Scheduled Delivery**	**Delivery date**
Up to 45%	Up to 45%	*$42 million*	**$65 million**	1 Jan 2021	31 March 2020 (nearly 1 year early)
50-70%[3]	50-70%	*Up to $560.8 million[4]*	**$682 million (estimated)[5]**	3 Tranches, 30 Apr: • 2019 • 2021 • 2023	15 substations (Tranche 1) +4 substations as of 1 March 2020 (Tranche 2)
98 to 99%	98 to 99%	*$216.35 million*	**$188 million (estimated)**	30 June 2021	31 March 2020 (more than a year early)
NA	NA	*$43.27 million*	**$28 million (+$10 million re-allocated to HCAP)**	31 Dec 2021	31 May 2018 (more than 2 years early)
NA	NA	*$10 million*	**$10 million**	31 Dec 2016 (later extended)	31 Jul 2019
37% decrease in powerline ignitions observed since 2012	TBD	TBD (penalties/payments vary by year and performance)		Ongoing	Ongoing
32.5% overall statewide relative reduction (as at 30 June 2019) in powerline bushfire risk	Up to 60% overall statewide relative reduction in powerline bushfire risk	*$862.60 million*	**$983 million[6]**	NA	NA

Program Elements

The Network Assets Project

Under this project, electricity distribution businesses have spent, or project to spend, over $650 million ($2015) to incorporate advanced technologies into their high voltage (>1,000 volts) powerline networks to reduce the risk of bushfire ignitions. The Network Assets Project consists primarily of two elements:

- installing new generation ACRs on all SWER high voltage lines; and
- installing REFCLs on all 22kV lines originating from 45 zone substations that serve or traverse high bushfire risk areas.

ACRs on all 30,000 km of SWER lines

New generation ACRs are a type of circuit recloser being installed to protect both 22kV three-phase electric lines and SWER lines in high bushfire risk areas. A recloser is an automatic, high voltage electric switch. Like a circuit breaker on household electric lines, it shuts off electric power when a fault occurs, such as a short circuit. Where a household circuit breaker remains shut off until it is manually reset, a recloser automatically tests the electrical line to determine whether the fault has been removed. And, if the problem was only temporary, the recloser automatically resets itself and restores the electricity flow.

There are many types of circuit reclosers. Older model circuit reclosers found on much of Victoria's rural electricity network could not detect low current faults that were capable of igniting a fire and must have their reclose settings set manually. New generation ACRs can be remotely controlled and are much more sensitive in detecting faults.

Amendments to the *Electricity Safety Act 1998 (the Act)* in 2017 mandated that electricity distribution companies install new generation ACRs on the entire 30,000 km SWER network. As of 1 March 2020, only four ACRs remain to be installed.

On Total Fire Ban and Code Red days, the number of attempts to automatically test the electric line are restricted to reduce the likelihood that re-energising faulted lines will cause ignitions.

What's a SWER line?

A single wire earth return (SWER) line is a single wire transmission line that supplies single-phase electric power from the network to remote areas at low cost. The earth (or sometimes a body of water) is used as the return path for the current. This avoids the need for a second (neutral) wire to act as a return path. The voltage on Victorian SWERs is typically 12.7kV.

REFCLs on over 31,000 km of 22kV polyphase lines

REFCLs are a highly advanced type of network protection device widely used in European networks to improve service reliability. The technology works like a large safety switch on our electricity network, reducing the risk of fires starting from powerline faults.

In a world-first application of the technology for bushfire safety, electricity distributors are installing REFCLs on Victoria's 22kV electricity distribution network to reduce the risk of powerline-ignited bushfires by meeting enhanced safety standards mandated by the Victorian Government in 2017. The Government's action followed field testing demonstrating REFCLs' effectiveness under simulated Black Saturday conditions at Frankston and Kilmore South in 2014 and 2015, respectively.

How does a REFCL work?

When a powerline comes into contact with the ground or a tree, the energy released can cause a large spark. The line can continue sparking if it remains live, increasing the potential for a fire.

The REFCL detects when one line out of a three-phase powerline has fallen to the ground and almost instantly reduces the voltage on the fallen line. At the same time, it boosts the voltage on the two remaining lines in service. This means power can be maintained to homes and businesses while substantially reducing the fire risk. After a few moments, the device checks if the fault is still present. If it is temporary, then power is restored to the line. If it is a continuing fault, power to all three lines will be shut off to protect against fire risk and make it safe until the distribution business can fix the fault.

The 2017 amendments to the Act mandated that 'required capacity' must be met at 45 zone substations supplying electricity to 31,000 km (over half) of Victoria's 22kV distribution network: 22 of these substations are operated by AusNet Services, another 22 by Powercor, and one is operated by Jemena. All 45 substations supply electricity across hazardous bushfire risk areas in rural and regional Victoria.

REFCLs are being delivered progressively in three phases:

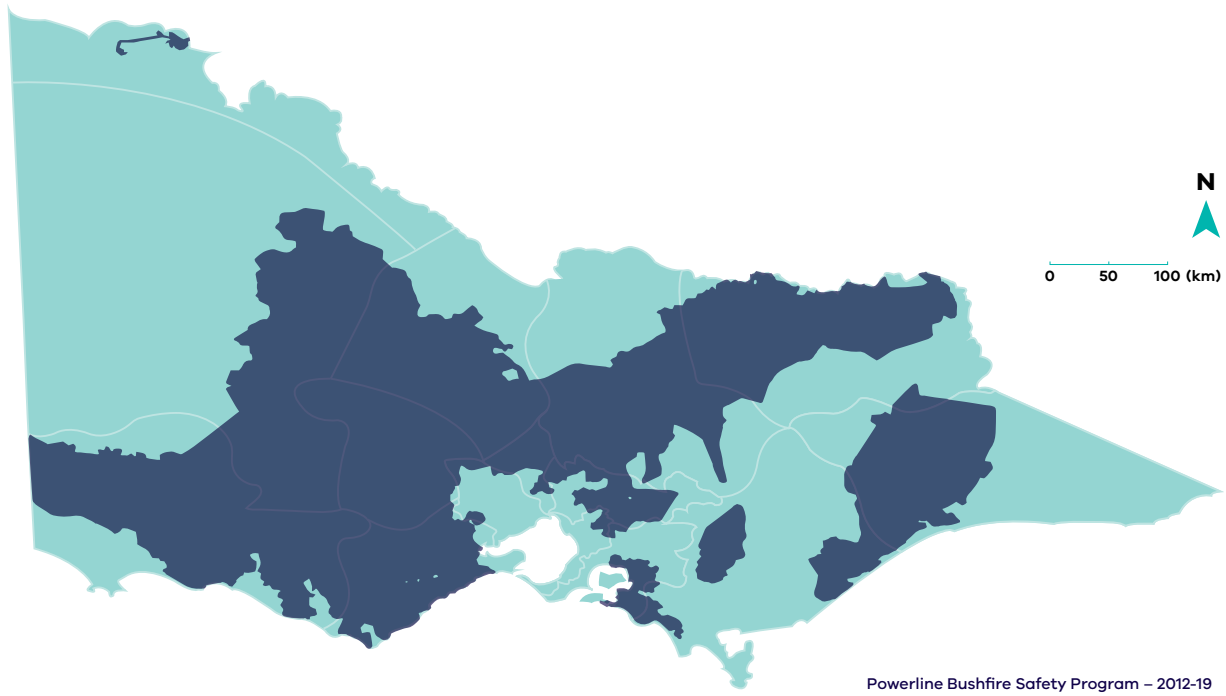
- Tranche 1 by 30 April 2019 (15 zone substations were equipped with REFCLs in Tranche 1);
- Tranche 2 by 30 April 2021 (currently 18 substations are proposed for REFCL deployment by AusNet and Powercor; of these, 4 substations will be operating in the 2019-20 bushfire season); and
- Tranche 3 by 30 April 2023 (currently 12 are proposed for this tranche, including a single Jemena substation).

The areas served by the 45 Zone Substations required to meet 'required capacity' enhanced earth fault standards by mid-2023 are shown below.

What's a polyphase electric line?

The Act defines a polyphase electric line as an 'electric line with more than one phase'. A 'phase' typically means a conductor (or wire). A 22kV polyphase line typically consists of a neutral conductor and 2-3 'live' conductors. There are thus 3-4 wire 22kV polyphase electric lines in Victoria's distribution network.

Area protected by targeted REFCL rollout



REFCL Performance

New powerline fault detection technology is cutting bushfire risk

The rollout of REFCLs, a world-first bushfire mitigation technology, throughout Victoria has helped protect Victorians from potential bushfires sparked by powerlines over the last two summers.

Four REFCLs were installed by the summer of 2018-19 and a further 15 were in place during the 2019-20 summer. In total, 45 REFCLs will be installed within substations by 30 April 2023.

2018-19 summer

REFCLs installed by Powercor and AusNet Services activated in response to faults detected on the network a total of 12 times during Total Fire Ban days during the 2018-19 bushfire season.

On 3 February 2019, a Total Fire Ban day, a REFCL operating at Powercor's Eaglehawk substation near Bendigo detected a permanent fault on the network and cut the power supply. Visual patrols of the powerline could not identify the fault, so power was restored with the Country Fire Authority (CFA) on standby in case the fault caused a fire.

Shortly after re-energising the line, a capacitor mounted atop a power pole failed and sparks from the capacitor started a fire in a nearby paddock which was quickly detected and extinguished by the CFA crew on hand. Without the REFCL being in place, there could have been a fire with serious consequences.

2019-20 summer

On 21 November 2019, for the first time in 10 years, Code Red conditions were declared in Victoria.

Sixteen REFCLs were in operation and they reacted to nine permanent faults, interrupting power and preventing possible bushfire ignitions. They also detected numerous temporary faults but performed as designed and did not interrupt the power supply.

A further three REFCLs came on-line during the 2019-20 bushfire season. These 19 REFCLs activated 57 times during the bushfire season with 33 of those activations in response to the types of electrical faults most likely to start a bushfire, thereby preventing serious bushfires at a time when many were already sweeping across the State.

The Powerline Replacement Fund

The Powerline Replacement Fund (PRF) provided $200 million ($2011) in funds for distribution businesses to replace bare-wire, overhead powerlines with underground or insulated lines in high bushfire loss consequence areas. The PRF is replacing both high voltage powerlines and low voltage, private overhead electric lines (POELs) in such areas. In addition, the PRF has funded three projects for the installation of Stand Alone Power Systems (SAPS) assisting remote landowners to retire long stretches of high voltage powerlines.

The PRF is subject to significant oversight and coordination by the Emergency Management Commissioner, Energy Safe Victoria, DELWP and independent technical experts. Distribution businesses submit designs and costings for a series of reviews, recommendations and approvals, before a PRF project is undertaken. Since 2013, a total of 65 PRF projects have been undertaken. All PRF projects will have been completed by early 2020, nearly two years ahead of schedule.

A total of 734 km of bare-wire, overhead powerlines in high bushfire risk areas have been replaced with safer underground or insulated lines, including:

- 537 km of high voltage bare-wire powerlines in high bushfire loss consequence areas;
- 192.8 km of low voltage private overhead electric lines (POELs) on 798 properties in 33 local government areas; and
- a further 4.4 km of powerlines retired as part of three SAPS projects in the Otways.

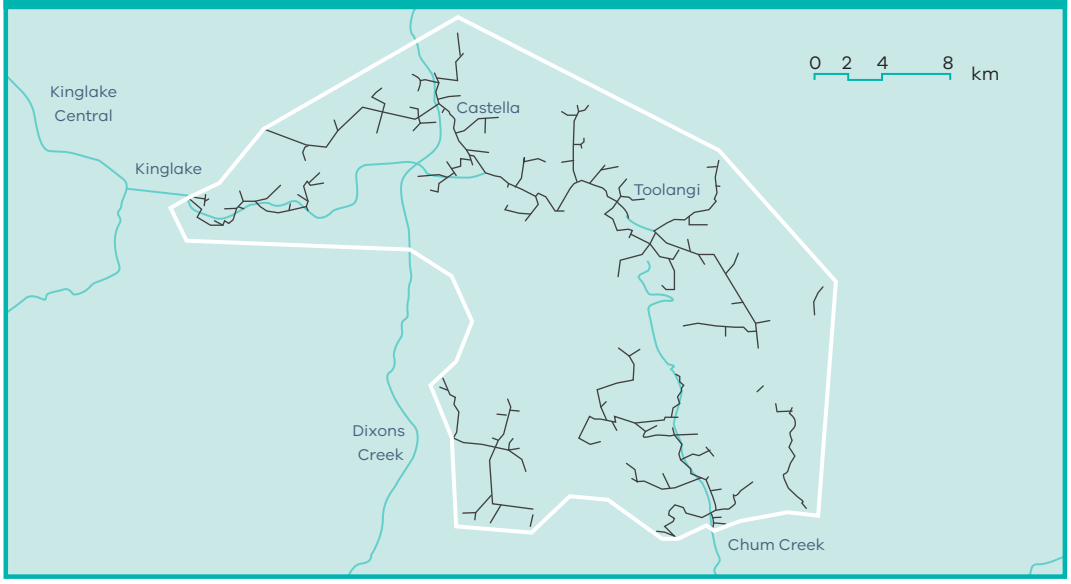
In addition, over 31,000 km of high voltage powerlines are being protected by REFCLs, 30,000 km of SWER lines are being protected by ACRs and, in 33 Electric Line Construction Areas, nearly 3,500 km of high voltage bare-wire powerlines will be replaced with much safer underground or insulated powerlines when they reach the end of their engineering life.

Reduction in relative powerline bushfire risk by Electric Line Construction Area

Electric Line Construction Area	Reduction in relative powerline bushfire risk to summer 2019-20	Reduction in relative powerline bushfire risk to summer 2023-24
Chiltern	45.20%	45.20%
Dandenong Ranges	36.30%	56.20%
Healesville	82.60%	90.80%
Kinglake	60.60%	76.20%
Kyneton	74%	74%
Maldon	89.30%	89.30%
Muckleford Nature Reserve	50.80%	50.80%
Otway Ranges	69.70%	73.10%
Otway Ranges (extension)	62.10%	62.10%
Warburton	48.90%	73.20%
Warrandyte	62.70%	80.80%
Reduction across all targeted ELCAs	**62.90%**	**70.10%**

Examples of Powerline Replacement Fund Project Areas

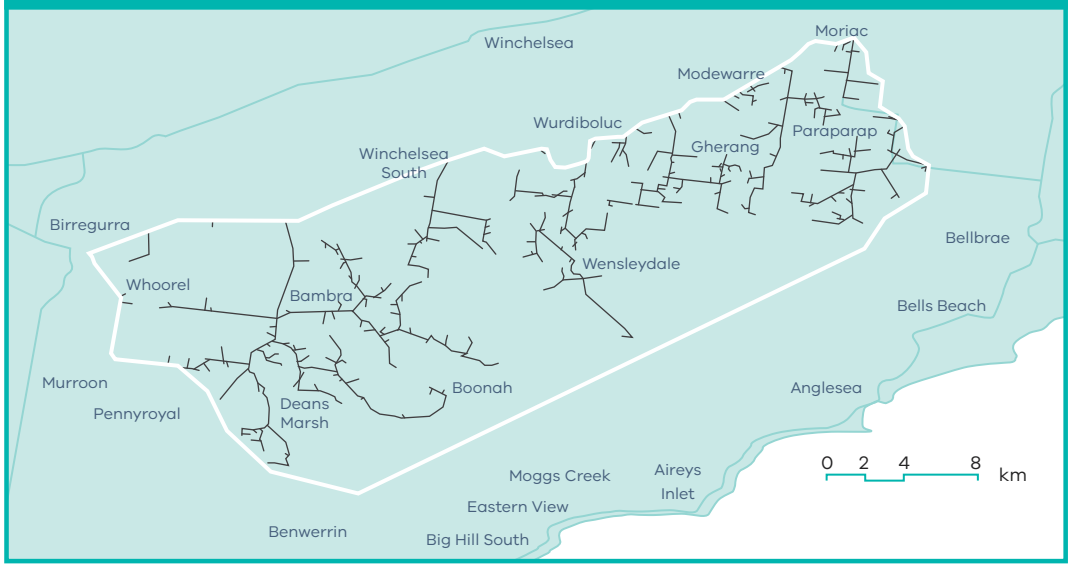
Kinglake



Risk Reduction

76.2%
60.6%

Otway Ranges



Risk Reduction

73.1%
69.7%

— HV Network 2014

Electric Line Construction Area

Reduction in relative powerline bushfire risk to summer 2019-20

Reduction in relative powerllne bushfire risk to summer 2023-24

734 km of (high and low voltage) bare-wire overhead powerlines will have been removed or replaced with insulated or buried lines in some of the State's highest risk locations by 31 March 2020, nearly two years ahead of schedule. The powerlines replaced are equivalent to the distance by road from Melbourne to Mildura.

Case Study #1: Private overhead electric lines (POELs) replacement embraced by residents

The retirement of nearly one kilometre of privately owned, low voltage powerline and its replacement with underground conductor at a working farm in Grassmere, Victoria was the subject of a time-lapse video commissioned by DELWP as part of the PRF project. The video can be viewed at www.energy.vic.gov.au/electricity/powerline-replacement-fund. The largest stretch of POEL replaced under the PRF was associated with a property located in Trawalla, Victoria. Nearly two kilometres of overhead electric lines were replaced with underground conductors in this project, the largest POEL project undertaken as part of the PRF. Landowner feedback was overwhelmingly positive.

Case Study #2: Dangerous high voltage lines replaced in the Otways

A large part of the PRF provided grants to remove dangerous, overhead high voltage electric lines in the iconic Otway Ranges area. The rugged, forested ranges are not only scenic, they also present some of the highest bushfire loss consequence areas in Victoria. The PRF funded the removal of 175 kilometres of high voltage, bare-wire overhead powerline in this region – nearly a third of all the high voltage lines replaced under this element of the Program. In addition, the Otways area saw the trial of new covered conductor technology that can be installed using the existing SWER poles, thus reducing the extra costs associated with adding new poles to install existing covered conductor technology. Video of a high voltage line replacement project in the Otway Ranges shows the extent of works undertaken, including trenching and drilling, laying cable, backfilling, electrical works, decommissioning overhead cable, and finally removal of the power poles. The video can be viewed at www.energy.vic.gov.au/electricity/powerline-replacement-fund.

The Local Infrastructure Assistance Fund

The $40 million Local Infrastructure Assistance Fund (LIAF) protects the most vulnerable Victorians from adverse impacts from electricity supply disruptions associated with powerline faults and bushfires. The LIAF provided grants for the purchase and installation of back-up generators by eligible residential care facilities that house elderly or disabled Victorians.

Back-up generators can maintain critical services for vulnerable Victorians, including air conditioning, medical monitors and equipment, and other life-sustaining equipment, when there is an interruption to the electricity supply.

The LIAF project was completed in May 2018, nearly three years ahead of schedule. Over the course of six years, the LIAF program:

- funded the purchase and installation of back-up generators at 343 residential care facilities; and
- protected 15,937 vulnerable residents from hazardous power outages.

On average, the back-up generators provided under LIAF allowed a residential care facility and its residents to avoid 1.83 supply interruptions and 253 minutes of lost supply each year.

Case Study #3: Back-up generators provide sanctuary during St Patrick's Day fires

High winds in Victoria's southwest on 17 and 18 March 2018 knocked out some of the power supplied by Powercor's Terang, Hamilton, Koroit and Camperdown zone substations. These winds contributed to a number of fires in several communities, the most significant of which were in The Sisters, Yatchaw, Gnotuk, Minjah, Laang and Terang. Cooinda Terang Inc operates four residential care facilities based in Terang, one of which was able to serve as a sanctuary for the company's residents during the Terang 2018 fires. The company's general manager described the LIAF-funded back-up generator's impact when power failed in the area: "The fires started about 9pm in the evening on a dark and windy night. The generators proved invaluable – operating for about 20 hours to provide much needed sanctuary, light, facilities to feed and bathe people, and charge our phones! The power was very reassuring to our residents and to their families."

Case Study #4: Generator protects Kilsyth aged care residents

An automatic start, diesel back-up generator purchased with a LIAF grant kept the power on at the Walmsley Friendship Aged Care facility in Kilsyth after high winds and storms that swept Victoria on 30 September 2014 knocked out the facility's power. The Walmsley facility provides essential care services for 120 elderly residents. The LIAF-funded generator provided uninterrupted power throughout the seven-hour power outage. The importance of improving power reliability for Victorians living in residential care facilities across regional and rural Victoria was proven by the Walmsley experience. As the residential care facility's manager stated: "I am very pleased to report that the emergency generator sprang into life as intended with no disruption to our residents or staff on 30 September. To know that we have back-up power is a big relief and will certainly minimise a lot of risks we have had to manage."

Number of Residential Care Facilities and Resident Beds protected by LIAF generators (By CFA Total Fire Ban district)

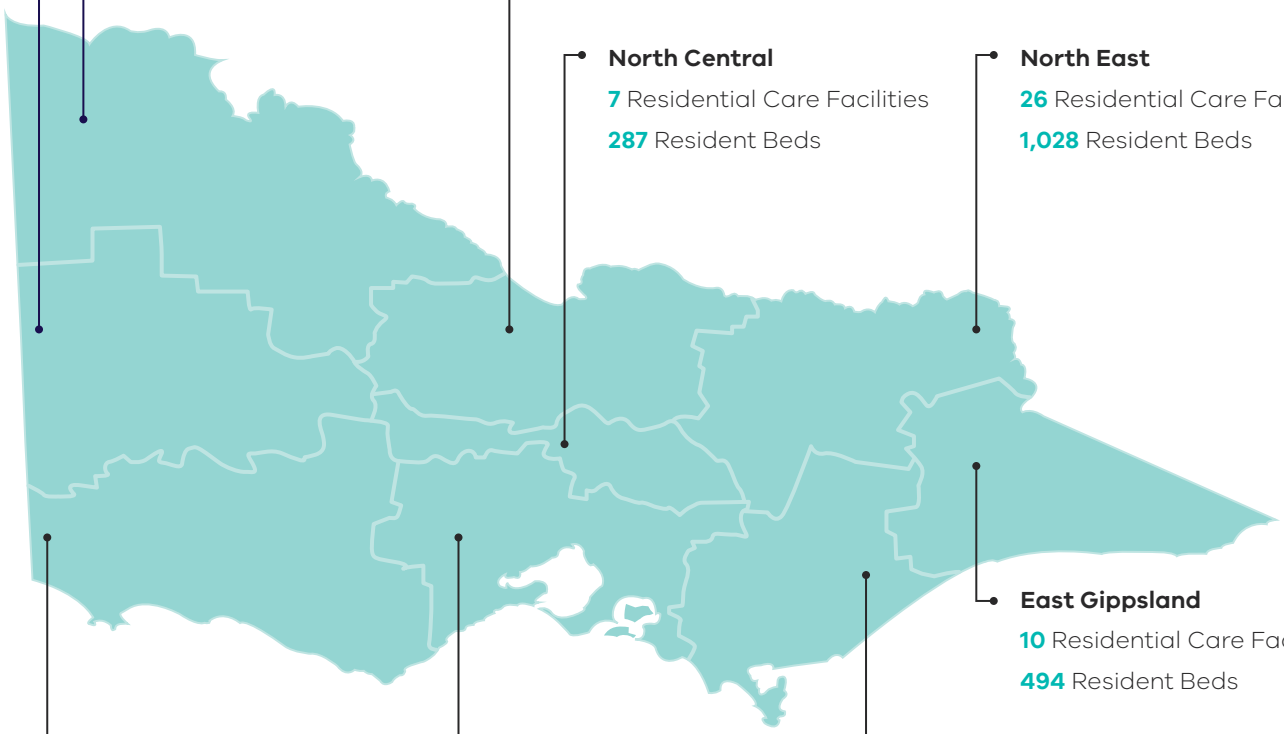
Wimmera
28 Residential Care Facilities
595 Resident Beds

Mallee
20 Residential Care Facilities
612 Resident Beds

Northern Country
65 Residential Care Facilities
2,448 Resident Beds

North Central
7 Residential Care Facilities
287 Resident Beds

North East
26 Residential Care Facilities
1,028 Resident Beds



East Gippsland
10 Residential Care Facilities
494 Resident Beds

West and South Gippsland
34 Residential Care Facilities
1,781 Resident Beds

South West
32 Residential Care Facilities
1,387 Resident Beds

Central
121 Residential Care Facilities
7,305 Resident Beds

The Research and Development Fund

The Royal Commission did not address Research and Development in its recommendations, but the Taskforce's 2011 report urged funding for such efforts. The Taskforce called for funding to support the development and implementation of technologies and systems that have the potential to reduce the risk of powerline ignited business.

Based on the Taskforce's recommendations, the Victorian Government directed $10 million ($2011) in grant funding for high priority research and development projects as part of the Program's Research and Development (R&D) fund. The R&D fund ensured that Victoria's bushfire reduction efforts are informed by the best knowledge and technology available. For example, the R&D program provided funding in 2014 and 2015 to conduct two rounds of field testing of REFCL technologies under conditions simulating those associated with the 2009 Black Saturday bushfires. The results of those tests confirmed REFCLs' effectiveness in reducing bushfire risk associated with earth faults on polyphase electric lines and was the basis for legislation mandating 'required capacity' to be met at 45 zone substations serving more than half of Victoria's 22kV supply network.

The investment in R&D projects has contributed to Victoria's status as the world's leader in bushfire prevention and reduction efforts.

Case Study #5: Early Fault Detection technology shows promise

One of the R&D projects undertaken tested Early Fault Detection (EFD) technology, developed by IND Technology Pty Ltd, on 11 SWER networks operated by Powercor and AusNet in rural Victoria. The technology provides continuous powerline monitoring to detect network asset damage or deterioration, vegetation encroachment and other early onset electric faults that may eventually cause fires, supply outages, or both. During the trial, the technology identified three fire-risk situations in high fire consequence locations: a broken powerline strand and arcing low voltage service line at Ross Creek, and a failing high voltage transformer between Beechworth and Chiltern. All three incidents resulted in the faulty equipment being replaced before it failed. The broken strand at Ross Creek was the same pre-fault condition associated with the disastrous Kilmore East/Kinglake fire that caused significant loss of life and property damage on Black Saturday. The faulty transformer was at an unoccupied residence in a heavily wooded, high fire consequence area northeast of Beechworth. As the result of Victoria's EFD Trial results, distribution businesses and rail companies in New South Wales, California USA and China are piloting EFD devices on their networks and AusNet Services plans an expanded rollout of the technology.

The R&D program also funded several other research and development projects, including:

- testing a number of plant species to identify 'worst case' species for fire risk and their fault signatures, potentially allowing for the detection of individual species when they come into contact with powerlines;
- CSIRO's development of a Risk Reduction Model that identifies the percentage of bushfire risk reduction attributable to each technology being deployed;
- funding a 'vegetation detection challenge' aimed at enticing and rewarding scientists to develop algorithms to identify the specific plant species that cause faults to occur when contacting powerlines;
- funding trials of an early fault signature detection technology on the SWER network; and
- funding trials of a broken conductor detection technology that can detect a break in a SWER overhead conductor and de-energise the circuit before the conductor contacts the ground.

All projects funded through the R&D program were completed by June 2019.

Case Study #6: Vegetation Conduction Testing

The Vegetation Conduction Ignition Testing project sought to identify which plant species commonly found near powerlines in Victoria are most likely to start a fire when electricity from a 22kV powerline fault is conducted through them and develop a database of vegetation fault signatures (i.e. electrical signals caused by vegetation-related faults) to develop additional fault detection technologies. Extensive testing was conducted at Springvale in February and March 2015 and quantified fire risk for three vegetation-related types of fault. Many vegetation-related faults caused fires at electrical current levels below detection by conventional network protection technologies. Research showed that Willow (sp. Salix) presented the worst fire risk for trees while Peppercorn and Drooping Sheoak presented the least fire risk. Among shrubs, Gorse and Burgan presented the highest fire risk while Blackberry performed better and Silver Banksia performed best. Over 50,000 files, comprising 300GB of data, were developed and this vegetation fault signature data has been made available to distribution businesses, academics and the public for further development.

Other initiatives that complement the Program

Legislation and civil penalties

The government legislated in 2016 and 2017 to build on, and improve, the outcomes of the Program. These legislative changes mandated the delivery of several critical Program elements and ensured the timely implementation of the recommendations of the Royal Commission and Taskforce. Some of the key legislation included:

- amending the Electricity Safety (Bushfire Mitigation) Regulations 2013 (in 2016);
- amending the *Electricity Safety Act 1998* (in 2017); and
- enacting the Electricity Safety (Bushfire Mitigation Duties) Regulations 2017.

The amendments to the regulations, for example, specified the 45 zone substations where 'required capacity' would have to be met, the substations' relative bushfire risk profiles, and prescribed the technical performance standards of 'required capacity' that distribution businesses must meet.

The regulations also spelled out elements of the Program that would have to be reflected in bushfire mitigation plans prepared by distribution businesses and operators of 'at risk electric lines' and submitted to ESV for review and approval. Among other things, bushfire mitigation plans would specify the procedures and policies that distribution businesses would follow to reduce bushfire risk on their powerlines.

The legislation enacted in 2017 also established a scheme of civil penalties that apply when a distribution business fails to meet the requirements of the provisions in Part 10A of the *Electricity Safety Act 1998*. These penalties can be significant. For example:

- Civil penalties of $2 million to $10 million may be imposed on any distribution business that fails to comply with 'required capacity' by the Tranche 1 or Tranche 2 deadline, coupled with a civil penalty of $5,500 for each day the company remains out of compliance.
- If a distribution business fails to underground or cover new or substantially reconstructed powerlines in ELCAs, it is subject to a civil penalty of up to $350,000 for each kilometre, or part of a kilometre, of a line that is not covered or placed underground, together with a daily penalty up to $1,000 for continuing contraventions.
- Failure to install an ACR on a SWER line by 1 January 2021 could result in a civil penalty of up to $50,000 plus $150 per day of continuing violations.

The f-factor scheme

Victoria's f-factor scheme complements the Program by providing financial incentives (penalties and payments) for all electricity distribution companies to make full and effective use of new bushfire safety assets to reduce powerline ignitions on their networks.

The f-factor scheme was first introduced in 2012 and was revised in 2016 to enhance the original scheme, which treated all fires equally, regardless of where or when fires occurred (i.e. in high or low risk areas, in winter or summer), and applied the same incentive – $25,000 per ignition.

The f-factor scheme now weights each powerline ignition based on the bushfire risk associated with the location of the ignition and the weather conditions prevailing at the time.

The 2016 changes also implemented a re-designed penalty/payment mechanism. Powerline ignitions now carry a penalty ranging from $300 (for the lowest risk category of ignition) to $1.485 million (for the highest risk category of ignition). These changes have provided a stronger incentive for distribution businesses to invest bushfire safety resources in places, and at times, where bushfire risk is greatest.

Since its establishment in 2011, fire starts on Victoria's electricity network have dropped significantly.

The annual fire starts for 2016-17 and 2017-18 are (on average) 37.6% lower than the number recorded in earlier years. Some of this may be attributed to some cooler, wetter years, but the deployment of new bushfire safety assets is clearly playing an important role in reducing powerline bushfires.

The Victorian Government is currently tightening the f-factor scheme's powerline ignition targets in order to reflect the bushfire reduction benefit associated with the deployment of REFCLs. This reset of ignition targets will encourage distribution businesses to continue investing in bushfire mitigation improvements without providing them a benefit for safety works funded by the Victorian Government and consumers.

How does the f-factor work?

A benchmark ignitions target is set for each distribution business based on its history of fire starts and the distributor's performance is then assessed annually. A performance outcome:

- *below the benchmark results in a payment to the distributor in the form of a small charge on customer bills; and*
- *above the benchmark results in a penalty against the distributor in the form of a credit to customer bills.*

Delivering Safer Communities

The advances ushered in by the Powerline Bushfire Safety Program have brought about a fundamental change, not only in the way the electricity network is regulated, but also in the way electricity businesses design and operate their networks.

The Program, and the requirements of the bushfire legislation enacted since 2016, are driving a paradigm shift in how electricity distribution businesses design their supply networks.

A comprehensive implementation approach has been used to drive investment behaviour that better meets community expectations about powerline bushfire safety. This approach has involved:

- investing strategically in research and development projects capable of early application and that are most likely to yield early safety benefits;
- using pilot projects to bring early momentum to delivery and to provide a base from which asset deployment initiatives could be rapidly upscaled; and
- codifying bushfire safety priorities and standards in Victorian law, to provide a legacy of enhanced safety that will be sustained beyond the life of the program.

Supply networks are beginning to be re-configured into REFCL-equipped substations (that serve overhead 22kV distribution feeders that have an associated high bushfire risk) and non-REFCL equipped substations (serving primarily underground, low risk 22kV supply feeders, usually in more urban areas).

Bushfire reduction is now a key driver in how electricity businesses prioritise bushfire safety and invest in new equipment and facilities.

In deliberately and proactively responding to the 2009 Black Saturday bushfires, in part by developing and implementing the Program, Victoria has become a world leader on powerline bushfire safety.

Victoria is recognised nationally and internationally for its focus on powerline bushfire safety. For this reason, Victoria actively shares information with other Australian states and international jurisdictions that deal with the threat of bushfires.

Key Recommendations

Table 1: Royal Commission's Key Recommendations (July 2010)

Number	Recommendation
27	**The State amend the Regulations under *Victoria's Electricity Safety Act 1998* and otherwise take such steps as may be required to give effect to 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.
32	**The State (through Energy Safe Victoria) require distribution businesses to do the following:** • disable the reclose function on the automatic circuit reclosers on all SWER lines for the six weeks of greatest risk in every fire season • adjust the reclose function on the automatic circuit reclosers on all 22-kilovolt feeders on all total fire ban days to permit only one reclose attempt before lockout.

Table 2: Powerline Bushfire Safety Taskforce Recommendations (September 2011)

Taskforce Recommendation 1 (implementing Commission Recommendation 27)

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.

Recommendation 2 (implementing Commission Recommendation 32)

Electricity distributors implement the 2009 Victorian Bushfires Royal Commission's recommendation 32 by adjusting the protection systems for 22kV and SWER powerlines based on the severity of the day and the fire loss consequence of the area so that at a fault there are:

Area	Total Fire Ban day	Code Red day
Rural powerlines in the worst areas (approximately 20 per cent of rural powerlines)	Two fast protection operations	One fast protection operation
Rural powerlines in remaining areas (approximately 80 per cent of rural powerlines)	One fast and one slow protection operation	One fast and one slow protection operation

For the 2011/12 fire season, to the extent practicable and possible, the electricity distributors change the protection systems at 10am or when the fire danger index exceeds 30, whichever occurs earlier, until the fire danger index falls below 30.

Until the old-style SWER ACRs are replaced, they should be manually changed in the highest fire loss consequence areas of the State during the worst bushfire period as declared by the Fire Services Commissioner.

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