

Powerline Bushfire Safety Taskforce

Final Report

30 September 2011

Foreword

The Powerline Bushfire Safety Taskforce (Taskforce) was established in August 2010 to consider how the Victorian Government should implement the recommendations of the 2009 Victorian Bushfires Royal Commission (Royal Commission) related to powerline replacement (recommendation 27) and changing the network reclose function (recommendation 32).

The Taskforce has been supported by a Stakeholder Reference Group and a Victorian Government Interdepartmental Working Group. The members of the Taskforce, Stakeholder Reference Group and Interdepartmental Working Group have a broad range of skills, knowledge and experience, including in network and non-network technology solutions, bushfires, risk management and consumer behaviour. This mix of skills has facilitated a thorough examination of, and robust debate on, all the issues.

The electricity distributors, Country Fire Authority and Energy Safe Victoria have been actively considering how to reduce the likelihood of powerlines starting bushfires, and provided the outcomes of their considerations to the Taskforce.

New information that was not available to the Royal Commission has been gathered and considered. This information related to:

- the energy required to ignite a bushfire under a range of conditions
- variation in fire loss consequence across Victoria
- new technologies that substantially reduce the likelihood of powerlines starting bushfires.

The Taskforce commissioned customer research that provided a better understanding of the trade-off that the community would support between reducing the risk of bushfires and the consequent impacts on the cost of electricity, supply reliability, and on the environment and landowners.

Meetings were held with regional and rural communities at seven centres around Victoria and the Taskforce received written submissions to its Consultation Paper.

Field trials provided valuable information to assist the Taskforce in making its recommendations. I would like to extend my appreciation to those people that participated in the trials. Without your participation, the Taskforce would not have gained the insights that helped inform this report.

The Taskforce's recommendations prioritise actions to reduce the likelihood of bushfire from powerlines to those areas of Victoria that have the highest fire loss consequence. By doing so, the increase in the cost of electricity should be manageable for Victorians, while minimising adverse impacts on supply reliability, the environment and landowners.

Taskforce members have undertaken the necessary due diligence of all the information that is available at the time of writing this report. They have applied their expertise and professional judgement to make the recommendations in this report. However, the Taskforce recognises that new information will become available in the future, and recommend that a further review be undertaken in five years to assess this new information.

I would like to thank the members of the Taskforce, Stakeholder Reference Group, Interdepartmental Working Group and Taskforce Secretariat for the considerable time and effort they have contributed to assist in reducing the bushfire risk from powerlines.

I now commend this report to the Victorian Government for its consideration.



Tim Orton
Chair, Powerline Bushfire Safety Taskforce
30 September 2011

Glossary of terms

This report employs the following terms:

22kV	22,000 volts, the most common voltage for distribution lines (refer section 2.1)
ABC	Aerial bundled conductor – a type of powerline comprising a bundle of insulated wires. For more information, refer to section 4.3
ACR	Automatic circuit recloser – a device that is installed at various points along a powerline to automatically turn the powerline (or part of the powerline) on and off from the electricity supply. For a more detailed description, refer to section 3.4.2
ADF	Australian Defence Force
AER	Australian Energy Regulator
ATA	Alternative Technologies Association
Bare wire	A wire without any insulation or covering. This is currently the most common type of powerline in Victoria.
CB	Circuit breaker – a device that is installed in the zone substation to turn a powerline on and off from the electricity supply grid
CBD	Central business district
CFA	Country Fire Authority
Committee	Electric Line Clearance Consultative Committee
Covered wire	A wire covered with insulation. All underground wires and some of the options considered in this report are covered wire
CRC	Cooperative Research Centre
CUAC	Consumer Utilities Advocacy Centre
DFA	Distribution Feeder Automation – a computer system that analyses data collected from zone substations' protection systems and devices distributed on the power network to deduce the location and type of a fault
DHS	Department of Human Services
DSE	Department of Sustainability and Environment
ESMS	Electricity Safety Management Scheme
ESV	Energy Safe Victoria
FTE	Full time equivalent, in reference to the number of employees
GSP	Gross State Product
Ha	hectare
HBRA	High Bushfire Risk Area
HV	High voltage – for the purposes of this report it refers to more than 1000 volts and up to 66,000 volts
km	kilometre (1000 metres)
km/h	kilometres per hour
kV	kilovolt (1000 volts)
kVA	kilo volt-amperes – a measure that indicates potential power flow on a line
kW	kilowatt – a unit of power flow
kWh	kilowatt hour – a unit of energy (one kilowatt flowing for one hour)
LBRA	Low Bushfire Risk Area
LOC	Loss of control
LV	Low voltage (less than 1000 volts)
m	metre
MFB	Metropolitan Fire and Emergency Services Board
mm	millimetre – one thousandth of a metre
ms	millisecond – one thousandth of a second
NEO	Network Emergency Organisation

NER	Neutral Earthing Resistor – a device to reduce fault current when a fault occurs
NPV	Net Present Value – the present value of an investment’s future net cash flows less the initial investment. The present value is the value of a future stream of payments, discounted at an appropriate rate.
POEL	Private overhead electricity line
Reclose	When a fault is automatically detected, power is switched off and then automatically switched back on (reclosed) to test if the fault is still there. If the fault has gone the power remains on, if not, it is switched off again and then switched back on (reclosed). If the fault does not clear, switching off and on repeats for a specified maximum number of cycles before it ceases with the supply turned off (locked out). If there is lock out, a maintenance call out is required to locate the fault and restore power. Since most faults are transient, the reclose function usually leads to the rapid restoration of the power supply without a maintenance call out, thus avoiding extended power interruptions. In the small number of cases that the fault persists, each reclose (turning the power back on) can release energy that may result in a fire.
Reclose suppression	Reclose (automatic turning on) is not allowed. If the reclose function is suppressed, then any fault, whether transient or not, will result in the power being turned off as soon as the fault is detected. It will remain off until some criteria for turning it on have been satisfied. This is most often inspection and repair if required. Since the system doesn’t test whether the fault is transient or permanent, suppression of the reclose function results in longer duration power interruptions for those faults that would have cleared with reclose on while reducing the risk of electrical energy causing fires for the less frequent permanent faults.
REFCL	Rapid earth fault current limiter – a device to rapidly limit energy release in certain types of powerline faults on multi-wire (not SWER) powerlines. For a more detailed description, refer to section 3.4.1
Royal Commission	2009 Victorian Bushfires Royal Commission, which is discussed in section 1.1
s	second
SAPS	Stand-alone power supply – a local (non-grid) supply system that is more commonly used in remote areas where the cost to connect to the electricity distribution network is high. For a more detailed description, refer to section 4.6
SEAF	Safer Electricity Assets Fund – \$50 million of funding to be provided by the Victorian Government. For a more detailed description, refer to section 6.5
SECV	State Electricity Commission of Victoria
SES	State Emergency Service
SWER	Single wire earth return – a type of powerline with only one wire, as illustrated in Figure 2
Taskforce	Powerline Bushfire Safety Taskforce, which is discussed in section 1.2
TCA	Testing and Certification Australia
UCL	Urban Centre of Locality
V	volts
VCR	Value of customer reliability

Contents

Executive summary.....	1
Improvements in powerline bushfire safety over time	2
Important new information that has influenced our recommendations	2
Addressing Royal Commission recommendation 27 (replace powerlines).....	4
Addressing Royal Commission recommendation 32 (change network reclose function) .	9
Additional precautions to address bushfire risk	12
Paying for the reduction in bushfire risk.....	13
Full benefits can be delivered within 10 years	15
1 What has the Victorian Government asked the Taskforce to do?	17
1.1 The 2009 Victorian Bushfires Royal Commission	17
1.2 The Powerline Bushfire Safety Taskforce	18
1.3 Process undertaken by the Taskforce.....	19
1.4 Structure of this report	21
2 Improvements in powerline bushfire safety over time	22
2.1 Powerlines in Victoria	22
2.2 Powerline history in starting bushfires.....	24
2.3 Actions taken after the 1977 and 1983 bushfires	27
2.4 2009 Black Saturday bushfires	27
2.5 Actions taken since the 2009 Black Saturday bushfires	29
3 Important new information that has influenced our recommendations	38
3.1 Causes of bushfires started by powerlines.....	38
3.2 Powerline faults can start bushfires very quickly under certain circumstances ...	41
3.3 Consequences of bushfires vary across the state.....	44
3.4 New ways to mitigate bushfires	47
3.5 Victorians want balance of bushfire safety, cost, reliability, and impact on landowners and the environment.....	50
3.6 Precautionary approach to bushfire risk reduction	52
3.7 Regulation will drive action by electricity companies to reduce bushfire risk	55
4 Addressing Royal Commission’s recommendation 27 (replace powerlines)	57
4.1 Which powerlines should be replaced?.....	57
4.2 Put powerlines underground.....	58
4.3 Insulate overhead powerlines	62
4.4 Deploy protection technologies.....	67
4.5 Deliberately turn off powerlines on a temporary basis.....	70

4.6	Install stand-alone power supplies and permanently turn off powerlines	77
4.7	Identifying potential packages of measures	78
4.8	Comparative analysis of packages of measures	84
4.9	Recommended package of measures	93
4.10	Distribution companies will act locally to meet regulatory obligations	95
4.11	Case studies.....	95
5	Addressing Royal Commission’s recommendation 32 (change network reclose function).....	99
5.1	Sensitive protection settings	99
5.2	Speed of protection operation	100
5.3	The impacts on supply reliability can be mitigated	105
5.4	Action to be taken for the 2011/12 fire season	111
5.5	Taskforce’s recommendation.....	112
6	Additional precautions to reduce bushfire risk	114
6.1	Change bare wire powerline construction and improve powerline maintenance	114
6.2	Improve vegetation management and fuel control	115
6.3	Install fire detection devices.....	116
6.4	Taskforce’s observations	118
6.5	Further research and development is required.....	119
7	Paying for the reduction in bushfire risk.....	121
7.1	Options for recovering the costs	121
7.2	Options for allocating the Safer Electricity Assets Fund	125
8	Full benefits can be delivered in 10 years	128
8.1	Implementation speed will be determined by many factors	128
8.2	A reporting and compliance framework is required to ensure outcomes are delivered.....	131
Appendix A	The Taskforce	133
A.1	Objective of the Taskforce	133
A.2	Governance arrangements for the Taskforce.....	133
A.3	Taskforce membership	134
A.4	Stakeholder Reference Group	134
A.5	Consultants engaged by the Taskforce.....	135
Appendix B	Community consultation	136
Appendix C	Background information on the electricity supply system.....	138
Appendix D	The ignition process	140

D.1	Fuel factors affecting ignition	140
D.2	Arc ignition testing	141
D.3	Molten metal particles.....	145
Appendix E	Threat-barrier analysis.....	146
E.1	The precautionary approach	146
E.2	Threat-barrier analysis.....	146
E.3	Modelling	148
Appendix F	Assumptions in the costing of replacement options	150
F.1	Commercial assumptions applied to each replacement option.....	150
F.2	Technical assumptions applied for each technology	151
F.3	Avoided cost assumptions	154
Appendix G	Area-specific data relevant to the costing of replacement options.....	156
Appendix H	Advice provided on power outages by the Department of Primary Industries	159
Appendix I	Taskforce's trials	161
I.1	Trial of back-up generators	161
I.2	Trial of stand-alone power supply systems	163
I.3	Trialling a change in the network reclose function.....	165
Appendix J	Results from economics modelling	167
Appendix K	Recommendation on network reclose devices.....	169

Executive summary

On Saturday 7 February 2009 (~~Black Saturday~~), Victoria experienced the most devastating bushfires in its history resulting in catastrophic loss of life and property.

The 2009 Victorian Bushfires Royal Commission (~~the Royal Commission~~) was established on 16 February 2009 to¹:

... inquire into and report on the causes and circumstances of the fires that burned in January – February 2009, the preparation and planning before the fires, all aspects of the response to the fires, measures taken by utilities, and any other matter it considered appropriate.

The Royal Commission concluded that five of the major fires that it investigated were started by powerlines². In its July 2010 Final Report, the Royal Commission concluded that³:

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.

The Royal Commission made 67 recommendations, of which eight (Recommendations 27 – 34) relate to reducing the likelihood of powerlines starting catastrophic bushfires. These recommendations have been accepted by the Victorian Government.

The Powerline Bushfire Safety Taskforce (~~the Taskforce~~) was established to recommend to the Victorian Government how to maximise the value to Victorians from the following two electricity-related recommendations⁴:

Recommendation 27: progressive replacement of 22kV and SWER powerlines

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.

¹ 2009 Victorian Bushfires Royal Commission, *Final Report: Summary*, July 2010, page 2

² 2009 Victorian Bushfires Royal Commission, *Final Report: Summary*, July 2010, page 12

³ 2009 Victorian Bushfires Royal Commission, *Final Report: Volume II, Fire Preparation, Response and Recovery*, July 2010, page 154

⁴ Background information on the electricity supply industry, including a description of SWER and 22kV powerlines, is provided in section 2.1 and Appendix C.

Recommendation 32: disabling or adjustment of powerline reclose functions

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.

The Taskforce's Terms of Reference required it to investigate the full range of options to reduce the risk of the electricity supply system starting catastrophic bushfires and to quantify the benefits and costs of this action, taking into account all measures taken by Government to reduce those risks. It is to recommend a plan to reduce this risk within 10 years.

Improvements in powerline bushfire safety over time

Bushfires can start by natural causes, generally lightning, by human activities such as campfires and burning off, and by powerlines. While the average number of fires started by powerlines is relatively low (around 1–4 per cent in any given year), powerlines are thought to have started a disproportionately high number of the major Victorian bushfires on 12 February 1977, on Ash Wednesday (16 February 1983) and on Black Saturday (7 February 2009).

The primary causes of bushfires started by powerlines in 1977 and 1983 were vegetation touching live wires; fuses that produced hot metal particles when they operated; and clashing wires, primarily low voltage, that emitted hot metal particles. Private overhead powerlines (POELs) were implicated in many of the fires.

Formal inquiries were held after the 1977 and 1983 fires and actions were taken by the former State Electricity Commission of Victoria (SECV) and the Victorian Government based on the best information available at that time. The actions substantially addressed some of the causes of bushfires resulting in a step reduction in the number of bushfires started by powerlines. However, the risk could not be, and was not, eliminated entirely.

Actions have already been taken in response to the 2009 Black Saturday bushfires to further reduce the likelihood that powerlines start bushfires, including responding to the other six electricity-related recommendations made by the Royal Commission. The actions taken include:

- strengthening the electricity distributors' obligation to minimise fire risks from powerlines
- strengthening the provisions relating to the bushfire mitigation regime
- enhancing the vegetation management regime
- enhancing the inspection and maintenance of powerlines
- fitting vibration dampers and spreaders where required.

Important new information that has influenced our recommendations

The Taskforce has undertaken original research and analysis, or drawn on research and analysis that has been undertaken by others. This process has identified new information and developed a deeper understanding of:

- the rate of bushfire starts by multi-wire and SWER powerlines
- how powerlines start bushfires
- how the likelihood of powerlines starting bushfires can be mitigated

- how the consequences of bushfires vary across the state
- how much Victorians are willing to pay to reduce the risk that powerlines start bushfires.

Much of this information was not available to the Royal Commission at the time that it made its recommendations. The information enables the Taskforce to make recommendations based on a wide range of foreseeable events, including the events that occurred on Black Saturday.

The Royal Commission concluded that three of the five major bushfires that were started by powerlines on Black Saturday were started by SWER powerlines. However, the majority of powerline-initiated fires in Powercor's and SP AusNet's areas in 2009 were started by multi-wire powerlines (typically 22kV): approximately 1.6 fires started for each 1000km of multi-wire powerlines compared with 0.3 fires started for each 1000km of SWER powerlines.

The consequence of a fire is not necessarily correlated with the number of fires from a particular cause, so the significance of this result should not be overstated. However, it does contradict a belief held by some in the community that SWER powerlines pose a greater fire risk than multi-wire powerlines.

Powerlines can initiate bushfires by an electric arc, molten metal particles or electric current igniting vegetation or other combustible material. The time in which a bushfire starts is unpredictable, but it is possible for electric arcs and molten metal particles to start bushfires almost instantaneously (two to three hundredths of a second) under certain conditions.

Victoria's current powerline protection and control regime does not operate fast enough to be able to turn off powerlines within the almost instantaneous timeframe required to minimise the likelihood of bushfires starting. However, new protection technologies have been developed that can detect and turn off power at a fault almost instantaneously. Those of most interest to the Taskforce are:

- rapid earth fault current limiters (REFCLs) that operate on 22kV powerlines
- new generation automatic circuit reclosers (ACRs) for use on SWER powerlines.

Testing undertaken by the Taskforce indicates that these new protection technologies can operate fast enough to prevent bushfire ignition in most cases.

Modelling indicates that the fire loss consequence (the likely extent of damage done by a bushfire) varies significantly by fire start location across the state. Although the fire loss consequence varies along a continuum from the point with the highest fire loss consequence to the point with the lowest fire loss consequence, the Taskforce has considered the state in four broad zones ranked by fire loss consequence in assessing options:

- **Extreme** – includes non-urban⁵ powerlines that represent the highest 50 per cent of the state's total possible fire loss consequence. It is estimated this constitutes only 10 per cent of total non-urban powerline length supplying approximately 2 per cent of non-urban electricity customers.
- **Very high** – includes non-urban powerlines that represent the next highest 30 per cent of the state's total possible fire loss consequence. It is estimated this constitutes a further 10 per cent of total non-urban powerline length supplying a further approximately 2 per cent of non-urban electricity customers.
- **High** – includes all remaining non-urban powerlines that represent the lowest 20 per cent of the state's total possible fire loss consequence. This is estimated to constitute the remaining 80 per cent of the state's total non-urban powerline length, and in the order of 96 per cent of non-urban electricity customers.

⁵ For the purposes of this classification, urban only includes those urban built-up areas where the land cannot carry fire.

- **Low** – all urban powerlines (where the land cannot carry fire).

This indicates that a large proportion of the state's fire loss consequence can be mitigated by targeting actions to a relatively small proportion of powerlines supplying a small proportion of Victoria's rural customers. These powerlines are mainly located in the Dandenong Ranges extending north through to the foothills of the Great Dividing Range, the Otway Ranges and the Macedon Ranges.

The Taskforce's Terms of Reference required it to balance the reduction in powerline bushfire risk that could be achieved against the consequent effects on the cost of electricity, the reliability of the electricity supply, the impact on landowners and the impact on the environment. In December 2010, the Taskforce undertook customer research to gain a better understanding of Victorians' views of what would constitute an acceptable balance of these competing objectives.

The customer research indicates that customers want increased safety with minimal cost increases. It revealed that customers, on average, are only willing to pay 8 per cent more (or \$25 per quarter for an average household⁶) with no deterioration in the reliability of the electricity supply. The amount customers are willing to pay, on average, reduces to 2 per cent more (or \$6 per quarter for an average household) if there is a deterioration in the reliability of supply.

From this research the Taskforce concluded that Victorians would support cost-effective reductions in the risk of powerlines starting bushfires, but would not support significant increases in power bills or reductions in supply reliability.

Consistent with contemporary work on risk management, the Taskforce has adopted a precautionary-based risk management framework to identify and assess actions that can be taken to reduce bushfire risk from powerlines. Under the precautionary-based approach, all reasonable practicable precautions are adopted based on the balance of the significance of the risk and the effort required to reduce the risk.

The Taskforce's work only considers bushfires started by powerlines. Implementing the Taskforce's recommendations therefore cannot eliminate bushfires. Indeed, as the Royal Commission acknowledged⁷, the precautions will greatly reduce, but cannot totally eliminate, fires started by powerlines.

Addressing Royal Commission recommendation 27 (replace powerlines)

The Taskforce has considered five broad approaches to address the Royal Commission's recommendation 27 related to powerline replacement, namely to:

- underground powerlines
- insulate overhead powerlines
- deploy the new protection technologies (REFCLs and new generation SWER ACRs) that are referred to above
- deliberately turn off powerlines temporarily on high fire danger days
- install stand-alone power supplies (SAPS) and permanently turn off powerlines.

⁶ Assumes the quarterly electricity bill for an average household is \$315.

⁷ 2009 Victorian Bushfires Royal Commission, *Final Report: Summary*, July 2010, page 12

Placing powerlines underground or insulating overhead powerlines⁸ reduces the likelihood of wire-to-wire faults and reduces the likelihood of live parts of the powerline contacting vegetation that can ignite.

The Taskforce estimates that the relative reduction in the likelihood of a bushfire starting by undergrounding powerlines is approximately 99 per cent, with the reduced likelihood of bushfires starting offset against the risk of electrocution by inadvertent digging into underground cables. The relative reduction in the likelihood of a bushfire starting by insulating overhead powerlines is estimated at approximately 90 per cent, as there is no reduction associated with the auxiliary equipment mounted on power poles.

However, the cost to put powerlines underground and to insulate overhead powerlines is very high. The cost to underground powerlines in all non-urban areas in Victoria is estimated to be approximately \$40 billion and to insulate all powerlines in non-urban areas is approximately \$20 billion. Additionally, wide easements are required for installation, maintenance and repair of underground powerlines, and insulated overhead powerlines are heavy, resulting in the need for more poles that are visually obtrusive and have an impact on the productivity of land in the vicinity of the power poles.

REFCLs reduce the fault energy very quickly when wire-to-earth faults occur on multi-wire powerlines. The Taskforce estimates that the relative reduction in the likelihood of multi-wire powerlines starting bushfires is estimated to be approximately 70 per cent with the installation of REFCLs. REFCLs are not effective with SWER powerlines, however, where it is cost-effective to do so, SWER powerlines can be converted to multi-wire powerlines.

The cost to install REFCLs in all zone substations with powerlines that supply non-urban areas, across Powercor's and SP AusNet's areas, is in the order of \$430 million, noting that customers in Jemena's and United Energy's areas are already paying for REFCLs to be installed in their areas.

Replacing SWER ACRs with new generation devices reduces the fault energy when faults occur on SWER powerlines. The Taskforce estimates that the relative reduction in the likelihood of SWER powerlines starting bushfires with the installation of new generation SWER ACRs, with a change in the network reclose function as discussed in the following section, is estimated to be approximately 50 per cent⁹.

The cost to replace SWER ACRs across Powercor's and SP AusNet's areas is in the order of \$36 million and \$3 million, respectively. Customers in SP AusNet's area are already paying for most SWER ACRs to be replaced in its area and customers in Jemena's and United Energy's areas are already paying to convert all SWER powerlines in their areas to multi-wire powerlines (with REFCLs) and so new SWER ACRs are not required.

The relative risk reduction associated with putting powerlines underground or insulating them is reduced if REFCLs or new generation SWER ACRs are installed.

The Taskforce considers that the adverse impact on the community by deliberately turning off powerlines on a temporary basis generally outweighs the risk of powerlines starting bushfires. Nonetheless, it is of the view that powerlines should continue to be able to be deliberately turned off by the electricity distributors where the conditions are considered to be prohibitively dangerous or where directed to do so when an emergency has been declared under the *Electricity Industry Act 2000*.

The Taskforce has concluded that removing powerlines by installing SAPS is not suitable as a statewide measure to reduce the likelihood of powerlines starting bushfires. They will

⁸ With shielded wires

⁹ Assuming the network reclose function operates with one fast protection operation only. The relative reduction in likelihood is estimated to be 45 per cent if the network reclose function operates with two fast protection operations and 10 per cent if it operates with one fast and one slow protection operation.

continue to be a viable option for informed participants who choose to install a SAPS where it is more cost-effective than to connect to the electricity grid.

The Taskforce has been requested to identify six packages of measures to reduce the likelihood of powerlines starting bushfires for consideration by the Victorian Government with a capital cost ranging from \$200 million to \$10 billion¹⁰.

The Taskforce has concluded that the most cost-effective solution to reduce the likelihood of bushfires starting by powerlines is the widespread deployment of new protection network technologies (REFCLs and new generation SWER ACRs) assuming a change in the network reclose function as discussed in the next section, with the targeted replacement of powerlines with underground or insulated cable in the highest fire loss consequence areas.

The resultant six packages of measures are described in Table 1, together with a summary of the costs, the relative risk reduction and the impact on electricity bills (taking into consideration avoided costs) associated with each package. The impacts on electricity bills do not include the costs associated with the Royal Commission's recommendations that have not been considered by the Taskforce and do not include the costs that are imposed on individual customers by the replacement of powerlines.

¹⁰ In real 2011 dollars, undiscounted

Powerline Bushfire Safety Taskforce: Final Report

	Package 1 \$200 million	Package 2 \$500 million	Package 3 \$1 billion	Package 4 \$2 billion	Package 5 \$3 billion	Package 6 \$10 billion
Description of package						
New generation SWER ACRs	Approximately 1,300 installed in extreme, very high and high fire loss consequence areas	Approximately 1,300 installed in extreme, very high and high fire loss consequence areas	Approximately 1,300 installed in extreme, very high and high fire loss consequence areas	Approximately 1,300 installed in extreme, very high and high fire loss consequence areas	Approximately 1,300 installed in extreme, very high and high fire loss consequence areas	Approximately 1,300 installed in extreme, very high and high fire loss consequence areas
REFCLs ¹¹	39 installed in extreme fire loss consequence areas	108 installed in extreme, very high and high fire loss consequence areas	108 installed in extreme, very high and high fire loss consequence areas	108 installed in extreme, very high and high fire loss consequence areas	108 installed in extreme, very high and high fire loss consequence areas	108 installed in extreme, very high and high fire loss consequence areas
Replacement of powerlines	Nil	Approx 110km of powerlines replaced in extreme fire loss consequence areas	Approx 2,400km of powerlines replaced in extreme fire loss consequence areas	Approx 7,300km of powerlines replaced in extreme fire loss consequence areas	Approx 12,100km of powerlines replaced in extreme and very high fire loss consequence areas	Approx 40,000km of powerlines replaced in extreme, very high and high fire loss consequence areas
Costs¹²						
Capital cost (undiscounted, \$ million, 2011 dollars)	199	500	1,000	2,000	3,000	10,000
Capital cost (NPV ¹³ , \$ million)	135	327	635	1,251	1,867	6,178
Avoided cost (NPV, \$ million)	14	40	106	221	370	1,294
Incremental cost (NPV, \$ million)	122	287	529	1,030	1,497	4,884

¹¹ Actual number of REFCLs installed will depend on the final modelling

¹² Includes operating expenditure of \$4 million for a public awareness campaign

¹³ NPV = net present value over 30 years based on a discount rate of 8 per cent per annum

	Package 1 \$200 million	Package 2 \$500 million	Package 3 \$1 billion	Package 4 \$2 billion	Package 5 \$3 billion	Package 6 \$10 billion
Risk						
Relative risk reduction ¹⁴	48%	60%	67%	77%	83%	91%
Payback period on cost of risk	2.4 years	4.7 years	8.2 years	12.6 years	19.4 years	58.9 years
Maximum impact on average household electricity bills¹⁵						
Costs paid by electricity customers in respective area	0.4%	1.1%	2.4%	4.3%	5.9%	19.7%
Costs paid by all electricity customers	0.2%	0.5%	0.9%	1.8%	2.7%	9.1%

Table 1: Summary of the packages of measures¹⁶

¹⁴ Associated with the distribution lines (multi-wire and SWER lines) only

¹⁵ The impact on electricity bills will increase each year to a maximum in year 11, which is represented in this table. The average household electricity bill is assumed to be \$315 per quarter.

¹⁶ The margin of error in the capital cost estimates is ± 20 per cent. The capital costs exclude corporate overheads that are already recovered by the electricity distributors through network charges and financing costs. The impact on electricity bills includes the incremental operating and maintenance costs, the return of (depreciation) of the incremental capital costs and the return on the incremental capital costs. The assumptions are provided in further detail in section 4 and Appendix F.

The Taskforce considers that a package of measures with a capital cost of between \$500 million and \$3 billion, to be expended over 10 years, appropriately balances the reduction in the likelihood that the powerlines start bushfires with the impact on the cost of electricity, reliability of the electricity supply, landowners and the environment. The most appropriate package will be determined by the Victorian Government balancing funding between precautions to prevent the ignition of bushfires from powerlines, precautions to prevent the ignition of bushfires from other causes, measures to mitigate the development of bushfires and measures to mitigate the consequence of bushfires.

The Taskforce therefore recommends 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 powerlines¹⁷ in the next 10 years (rapid earth fault current limiters)
- (b) targeted replacement of SWER and 22kV powerlines¹⁸ 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.

Low voltage lines are often strung on the same poles as the 22kV powerlines. To ensure the same level of safety on the 22kV powerlines and the low voltage lines, the Taskforce has concluded that the low voltage lines should also be replaced where they are on the same poles as 22kV powerlines that are being replaced.

Addressing Royal Commission recommendation 32 (change network reclose function)

The likelihood of powerlines starting bushfires is reduced significantly if protection systems that automatically turn off powerlines when faults occur are operated with more sensitive settings and are operated more quickly. The energy produced when a fault occurs is then reduced substantially.

However, operating the protection systems in this way has the potential to adversely affect customers' reliability of supply. There are risks to the community associated with a loss of power supply including the welfare of the young, elderly and sick; the ability to monitor and communicate fire activity; the ability to pump water and fuel; and animal welfare.

¹⁷ Includes high voltage multi-wire powerlines operating at different voltage levels

¹⁸ Includes high voltage multi-wire powerlines operating at different voltage levels

The Taskforce has carefully considered the appropriate balance between bushfire safety and reliability of supply, and concluded that when a fault occurs:

- protection systems should operate with one fast operation only in the extreme and very high fire loss consequence areas on Code Red days, which are expected to occur on average one day per year
- protection systems should operate with two fast protection operations in the extreme and very high fire loss consequence areas on other Total Fire Ban days, which are expected to occur on around 10–15 days per year
- consistent with the Royal Commission's recommendation, protection systems in other non-urban areas should operate with one fast and one slow protection operation on Total Fire Ban days
- in all other areas and on all other days, the protection systems will continue to operate with two fast and two slow protection operations.

On Code Red days, under worst-case conditions, up to one in eight rural electricity customers may be exposed to the change in operation of protection systems, although a smaller number of customers are likely to actually experience any adverse effect. Initially it is possible, but unlikely, that the reliability of supply for up to one in 20 rural electricity customers may be adversely affected on Total Fire Ban days by the change in operation. However, the impact of this can be reduced by installing additional automatic circuit reclosers (ACRs) over time and by the strategic replacement of powerlines.

Until the new generation SWER ACRs are installed, the operation of some existing old-style ACRs may not be able to be changed as required on Total Fire Ban days and Code Red days. In the interim, the older style ACRs that are in the highest fire loss consequence areas will need to be manually changed for the highest bushfire risk period, as declared by the Fire Services Commissioner, and will only be able to be changed to operate with one fast protection operation.

Research and analysis is required to determine the period of the day during which the protection systems should be changed, to balance the competing objectives of reducing bushfire risk and supply reliability. The period of the day during which the protection systems will be changed for the 2011/12 fire season will be consistent with the current arrangements.

In summary, the Taskforce recommends that, as a minimum¹⁹:

Recommendation 2

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 index²⁰ 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 Commissioner²¹.

The electricity distributors may choose to operate in a safer regime than these minimum requirements specify.

Recommendation 3

To ensure the greatest benefits are achieved from the Taskforce’s recommendations 1 and 2:

- (a) The electricity distributors act to minimise the potential for recommendation 2 to adversely affect customers’ reliability of supply²².
- (b) Victorians should continue to be advised, as part of the state’s regular fire-preparedness communication program, that they may experience reduced levels of supply reliability on high fire risk days and should take appropriate precautions, including consideration of a back-up power supply if they are highly reliant on a reliable electricity supply.
- (c) The Victorian Government nominate the body responsible for the inputs to, and assumptions for, statewide fire loss consequence modelling.

¹⁹ Further detail relating to this recommendation is provided in Appendix K.

²⁰ The fire danger index is a composite of the grass fire danger index and the forest fire danger index that is published on the Weatherzone website.

²¹ The worst bushfire period is nominally from 1 January to mid March, but may be longer or shorter depending on the circumstances.

²² The actions that can be taken to minimise the effect on reliability of supply are discussed in section 5.3.

- (d) By 31 October 2011, the Fire Services Commissioner ensure there is effective liaison between the electricity distributors and the State Control Centre (including through an industry liaison officer) in the lead up to, and on, high fire risk days, to inform the operation of protection systems.
- (e) Energy Safe Victoria (ESV) seek funding to commission research and analysis on the detailed operation of protection systems on high fire risk days, and issue the framework to be used to make decisions, in the lead up to and on high fire risk days, on the operation of the protection systems.
- (f) The electricity distributors systematically develop a rationale for the circumstances under which a powerline should or should not be patrolled (and to what extent) before it is turned back on after a period of time. The rationale must include consultation with the emergency services to ensure no evidence has been detected of a fire or other dangerous situation.
- (g) Subject to a Victorian Government decision on the Powerline Bushfire Safety Taskforce's recommendations by the end of November 2011, the electricity distributors submit a revised Bushfire Mitigation Plan, which demonstrates how the required outcomes will be achieved, to ESV by the end of March 2012.
- (h) By 30 June 2012, the electricity distributors submit a plan to ESV to reduce the fire risk associated with low voltage lines and service lines where it is cost-effective to do so.

Additional precautions to address bushfire risk

The Taskforce has recognised that there is a number of other precautions that are relevant to reducing bushfire risk from powerlines:

- change the design of bare wire powerlines
- improve powerline maintenance
- improve vegetation management around powerlines
- improve fuel controls underneath powerlines and around power poles
- install fire detection devices.

The Taskforce concluded that the installation of fire detection devices would have no impact on reducing the likelihood of powerlines starting bushfires, or on enabling more rapid response to bushfire starts where they do occur. Current arrangements for detecting bushfires achieve responses of minutes, and more rapid detection would have little additional benefit.

While the other precautions are important to reduce the likelihood that powerlines start bushfires, they will not deliver the large step reduction in the likelihood that bushfires are started by powerlines that can be delivered by the precautions recommended by the Taskforce. Nonetheless, these other precautions should be continued to ensure that the likelihood of bushfires started by powerlines does not increase.

The research and analysis undertaken by the Taskforce has increased the knowledge and understanding of the ignition of bushfires by powerlines, particularly the time within which ignition occurs, and new technologies that can reduce the likelihood of powerlines starting bushfires.

However, it has also revealed that longer term research and development is required, particularly in relation to improved fire loss consequence modelling, the optimum operation of network reclose devices on high fire risk days, new protection technologies, ignition, the construction of bare powerlines, vegetation management, the value to Victorians of supply reliability on high fire risk days, and identifying why powerlines start a disproportionate number of catastrophic bushfires.

To ensure that the required research and development is undertaken, the Taskforce recommends that:

Recommendation 4

The Victorian Government should improve the capacity for ongoing research and development to further reduce the likelihood that powerlines start bushfires and assist Energy Safe Victoria (ESV) to effectively and appropriately regulate the electricity distributors.

- (a) Funding of not less than \$2 million per annum for five years should be provided for research and development.
- (b) Appropriate independent governance arrangements should be established to oversee the allocation of the funding.
- (c) ESV, electricity distributors and other parties should be able to apply for the funding.
- (d) The funding should be provided contingent on the results of the research and development being made publicly available.
- (e) Priority should be given to improved fire loss consequence modelling, research and analysis to optimise the operation of network reclose devices, and developing new protection technologies to reduce bushfire risk and minimise impacts on supply reliability.

Paying for the reduction in bushfire risk

The Taskforce's Terms of Reference required it to advise the Victorian Government on the options for fairly and efficiently recovering the costs associated with implementing its recommendations and to provide advice on the efficient and prudent allocation of the \$50 million Safer Electricity Assets Fund.

Options for recovering the costs

The Taskforce has separately considered the costs associated with the electricity distribution network and the private costs that will be imposed on individuals as a result of changes to the electricity distribution network.

Generally all costs associated with the supply of electricity are recovered through electricity bills. The current arrangements for recovering costs associated with the electricity distribution network have struck a balance based on equity, economic efficiency and administrative simplicity, and are broadly based on a user pays principle.

Costs that are directly attributable to a specific customer, for example costs of connecting to the electricity distribution network, are paid for by that customer. Costs that are not directly attributable to a specific customer, for example replacing part of the network, are paid for by all customers in the electricity distribution area. There are some costs that are partly recovered from individual customers and partly recovered from the rest of the customers in

the electricity distribution area, for example the cost of augmenting the network to connect a new customer.

For administrative simplicity, the options for recovering the network costs associated with implementing the Taskforce's recommendations that have been identified were limited to the following, noting that more than one of these could be combined to form an additional option:

- state – costs are recovered from all Victorians, for example through taxes
- regional – costs are recovered from those in a defined geographical area, for example through electricity bills
- local – costs are recovered from those in a more localised area, for example through electricity bills
- individual customer – costs are recovered from customers at individual premises.

The options available for recovering the private costs associated with service lines and private overhead lines (POELs) that are imposed on individuals by the replacement of powerlines are:

- be paid for by the individual customers or the electricity distributor (consistent with the ownership of the asset), consistent with the current regulatory framework, with assistance to those in financial hardship
- be paid for, in part by the individual customer (through a standard contribution), with the balance (if any) paid for by the electricity distributor (and thereby all electricity customers)
- be paid for by the electricity distributor as part of the project, with the costs associated with customers' assets recovered as operating expenditure
- be paid for by the Victorian Government.

The Victorian Government will need to decide how the costs of improving bushfire safety are paid.

Options for allocating the Safer Electricity Assets Fund

The role of government in funding research and development is well accepted. The Taskforce's research and analysis has revealed that further research and development is required and has recommended that ongoing funding of \$2 million per annum is required. The research and development could initially be funded through the Safer Electricity Assets Fund.

The Taskforce's analysis indicates that an effective package of measures can be implemented at a cost that customers are willing to pay for. However, the Taskforce notes that the package of measures may impose costs on individuals – particularly in relation to the costs associated with service lines and POELs, and the installation of back-up generators where they are necessary to mitigate the adverse impacts of the package of measures on supply reliability.

While some Victorians will have the financial capacity to pay to replace service lines and POELs or to install back-up generators, there are others that do not have the financial capacity.

The Taskforce therefore recommends that:

Recommendation 5

The Safer Electricity Assets Fund should be used to fund, in priority order:

1. Research, development and demonstration (\$2 million per annum over five years) – fund research and development projects that will further reduce the likelihood that powerlines will start bushfires.
2. Private costs that are imposed on individuals by the Taskforce's recommendations to address equity and financial hardship concerns (\$40 million) – contribute to the cost of service lines and private overhead lines, or alternative supply options.

Full benefits can be delivered within 10 years

The Taskforce is of the view that the new protection technologies can be deployed within five to 10 years and targeted powerlines can be replaced in the highest fire loss consequence areas within 10 years. The full benefits associated with the Taskforce's recommendations can thus be delivered within the required 10-year implementation timeframe.

However, whether this will actually occur will be determined by many factors including the size of the program that the Victorian Government chooses, capacity to deliver the program particularly addressing resource and financing constraints, regulatory controls applicable to powerline replacement, and access to easements for replacement powerlines. In this regard, it would be far more difficult to deliver a \$3 billion or \$10 billion capital works program within a 10-year period than a \$500 million or \$1 billion capital works program.

In any case, Victorian Government support may be needed to assist with meeting the 10-year implementation timeframe. This may be in the form of legislation to facilitate the replacement of powerlines, the relaxation of roadside controls, or the use of powers to compulsorily acquire easements.

The Taskforce has made its recommendations by considering the best information currently available. Further research and development has been recommended that may provide new information. It is prudent that the Taskforce's recommendations, and the implementation of those recommendations, are monitored annually and reviewed in five years to ensure that they continue to be the most cost-effective means to reduce bushfire risk from powerlines.

The Taskforce therefore recommends that:

Recommendation 6

- a) Energy Safe Victoria (ESV) implement a reporting and compliance framework to ensure that the recommendations that are accepted by the Victorian Government are implemented by the electricity distributors.
- b) ESV publish the outcomes of the reporting and compliance function and report on the status of the implementation of each recommendation accepted by the Victorian Government in its annual Comparative Safety Performance report.
- c) A review be undertaken by ESV or an independent body at the end of five years to assess whether the Taskforce's recommendations continue to be the most cost-effective means to reduce the likelihood of powerlines starting bushfires, and to assess the effectiveness of the implementation of the Taskforce's recommendations.

1 What has the Victorian Government asked the Taskforce to do?

On Saturday 7 February 2009 (‘Black Saturday’), Victoria experienced the most devastating bushfires in its history resulting in a catastrophic loss of life as well as public and private property.

1.1 The 2009 Victorian Bushfires Royal Commission

The 2009 Victorian Bushfires Royal Commission (‘the Royal Commission’) was established on 16 February 2009 to²³:

... inquire into and report on the causes and circumstances of the fires that burned in January-February 2009, the preparation and planning before the fires, all aspects of the response to the fires, measures taken by utilities, and any other matter it considered appropriate.

The Royal Commission summarised the impact of the Black Saturday fires as follows²⁴:

The most serious consequence of the fires was the death of 173 people. Left behind are families, friends and communities still trying to come to terms with their loss.

Accompanying this loss of life is the fires’ impact on property and the infrastructure that supports communities, as well as the substantial environmental impact, which will take years to fully reveal itself – let alone be ameliorated. It is extremely difficult to quantify the cost of a disaster like this, but the Commission estimates it to be more than \$4 billion.

This was one of Australia’s worst natural disasters. It will be many years before its effects dim. Governments, fire and emergency services agencies and all individuals can learn valuable lessons from those days, so that we might reduce the risk of such destruction occurring again. It would be a mistake to treat Black Saturday as a ‘one-off’ event. With populations at the rural-urban interface growing and the impact of climate change, the risks associated with bushfire are likely to increase.

The Royal Commission concluded that five of the major fires that it investigated were started by powerlines²⁵. In its July 2010 Final Report, the Royal Commission concluded that²⁶:

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.

The Royal Commission made 67 recommendations, of which eight relate to reducing the likelihood of powerlines starting catastrophic bushfires. These recommendations have been accepted by the Victorian Government.

²³ 2009 Victorian Bushfires Royal Commission, *Final Report: Summary*, July 2010, page 2

²⁴ 2009 Victorian Bushfires Royal Commission, *Final Report: Summary*, July 2010, page 1

²⁵ 2009 Victorian Bushfires Royal Commission, *Final Report: Summary*, July 2010, page 12

²⁶ 2009 Victorian Bushfires Royal Commission, *Final Report: Volume II, Fire Preparation, Response and Recovery*, July 2010, page 154

1.2 The Powerline Bushfire Safety Taskforce

The Powerline Bushfire Safety Taskforce (the Taskforce²⁷) was established to recommend to the Victorian Government how to maximise the value to Victorians from the following two electricity-related recommendations²⁷:

Recommendation 27: progressive replacement of 22kV and SWER powerlines

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.

Recommendation 32: disabling or adjustment of powerline reclose functions

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.

The Taskforce's Terms of Reference required it to investigate the full range of options to reduce the risk of the electricity supply system starting catastrophic bushfires and to quantify the benefits and costs, taking into account all measures taken by Government to reduce those risks. It is to recommend a plan to reduce this risk within 10 years.

The options that were required to be examined by the Taskforce include:

- targeted replacement of SWER and 22kV lines in highest bushfire risk areas with other network and alternative technologies that deliver reduced bushfire risk, including aerial bundled cable, underground cable and stand-alone power supplies;
- enhanced fault protection systems to minimise fire starts from fault currents;
- faster identification and location of faults to enable more rapid fire fighting response;
- installation of backup power supplies to enable selective and occasional de-energisation of high risk powerlines on catastrophic fire risk days without compromising power supplies to affected users; and
- the potential for isolated households in selected areas to move to stand-alone power supplies disconnected from the grid. A trial should invite isolated household(s) in selected locations to go "off the grid" to establish whether stand-alone power supplies are a viable and practical measure in some circumstances to minimise fire starts.

²⁷ Background information on the electricity supply industry, including a description of SWER and 22kV powerlines is provided in section 2.1 and Appendix C.

The Taskforce was requested to:

- investigate the technology and operational practices to reduce catastrophic bushfire risk with acceptable effects on cost, supply reliability, landowners and the environment;
- employ analysis, trials, expert advice and community and stakeholder consultation;
- recommend a plan to reduce bushfire risk within the ten-year timeframes recommended by the Royal Commission that maximises value to the Victorian public; and
- advise on options for fairly and efficiently recovering the costs of implementing the plan.

The Taskforce's analysis and report is to include the following:

- the development of a broad range of options to reduce the risks of bushfires associated with electricity assets including replacement of SWER and 22kV lines;
- an explanation of the objective of each option;
- a graduation of options with associated cost profiles reported on an NPV basis;
- an explanation of the level of fire risk addressed by each option and the residual risk following implementation of the proposed options;
- an analysis of the avoided costs of under-grounding powerlines, with the avoided cost methodology including consideration of the net costs of undergrounding powerlines after netting out the expenditure that would have occurred if existing overhead lines were replaced at the end of their engineering lives;
- options for the efficient and prudent allocation of the government's \$50m Safer Electricity Assets commitment with the advice to include consideration of arrangements that apply to the [then] current Powerline Relocation Scheme and the use of competitive tendering for the funds by the electricity distribution businesses.

The Taskforce had an independent Chair and included representatives of a fire-affected community, the CFA and relevant electricity distributors. The Taskforce also included relevant experts in risk management, stakeholder engagement and electrical technology, both mainstream and alternative.

The Taskforce is supported by a Stakeholder Reference Group that is representative of affected stakeholders including community, business and farming representatives.

Energy Safe Victoria (ESV) provided a Secretariat to support the work of the Taskforce.

Further details on the Taskforce are provided in Appendix A.

While the Terms of Reference for the Taskforce refer to bushfires started by the electricity supply system, for simplicity we refer to powerlines in this report. Where powerlines are referred to, we include the poles and wires as well as all auxiliary equipment installed on the poles, including transformers and devices that protect the powerlines such as surge diverters, fuses and automatic circuit reclose or ACR devices.

1.3 Process undertaken by the Taskforce

As required by its Terms of Reference, the Taskforce has undertaken the following research and analysis:

- technology review – to identify the technological and operational measures adopted by other jurisdictions, both locally and overseas, to reduce the likelihood of powerlines starting bushfires

- critical arc ignition research – to understand the amount of arc energy required to ignite a bushfire and the factors that influence the amount of arc energy produced. A literature search was undertaken before conducting testing to address identified knowledge gaps
- fault tree analysis – to understand the number of faults that occur on powerlines, the number of bushfires that are started by powerlines and the causes of the faults and bushfires
- threat-barrier analysis – to understand how powerlines start fires (threats) and how they can be prevented (barriers)
- spatial mapping – to understand how the fire loss consequence and the various characteristics that influence the cost of powerline replacement options vary across the state
- cost-benefit analysis – to undertake a detailed assessment of the costs and benefits (including avoided costs) associated with the powerline replacement options
- customer research – to understand what Victorians regard as an acceptable balance between reducing the likelihood of powerlines starting bushfires and the impact on cost (electricity bills), on reliability of supply, on landowners and on the environment. A total of 1500 people were surveyed in December 2010 across five different areas:
 - Metropolitan – Melbourne and Geelong
 - Ranges – in areas that are relatively hilly and tend to be more vegetated
 - Grasslands – in areas that are relatively flat and tend to be less vegetated
 - Fire-affected areas – in areas that have been affected by bushfires since 2007
 - Larger regional centres – the 15 largest regional centres, excluding Geelong.
- trials – to trial the use of stand-alone power supply systems, back-up generators and changing the operation of network reclose devices, and undertake pre and post trial surveys to:
 - determine the willingness of Victorians to adopt these options
 - determine the participants' responses to the trial
 - identify the impact of the trial on the customers' reliability of supply
 - gain a better understanding of the costs, benefits, risks and implementation issues.

Copies of the reports resulting from these areas of research and analysis are provided on ESV's website at <http://www.esv.vic.gov.au/For-Consumers/Bushfire-Taskforce>.

In addition, the electricity distributors have undertaken trials of a rapid earth fault current limiter (REFCL), new generation SWER automatic circuit reclosers (ACRs) and high impedance protection relays, the results from which have been reviewed by the independent technical expert on the Taskforce.

The Taskforce released a Consultation Paper in May 2011 and conducted a series of consultation meetings during May and June 2011. Further details are provided in Appendix B.

The Taskforce was surprised at the low level of interest in the Consultation Paper and consultation meetings; only 25 submissions were received in response to the Consultation Paper and only a small number of people attended the consultation meetings. The

Taskforce has interpreted that the Consultation Paper was not controversial for the majority of the community – the Taskforce’s preliminary views contained in the Consultation Paper represented a balance between reducing the bushfire risk associated with powerlines and the impacts on the cost of electricity, the reliability of supply, and on the environment and landowners that was considered acceptable to a large proportion of the community.

1.4 Structure of this report

Section 2 of this report provides background information on the powerlines in Victoria, the proportion of bushfires that are started by powerlines, and the actions that were taken following major bushfires in 1977 and 1983, and the 2009 Black Saturday bushfires.

Section 3 sets out the new information that has been identified by the Taskforce on how powerlines start bushfires, how the consequence of bushfires varies significantly across the state, how the likelihood of powerlines starting bushfires may be mitigated, how much Victorians are willing to pay to reduce the risk that powerlines start bushfires, and the precautionary-based risk management approach to identifying and assessing precautions to reduce the likelihood of powerlines starting bushfires.

Section 4 and section 5 consider how the Royal Commission’s recommendation 27 to replace powerlines and recommendation 32 to change the network reclose function should be implemented.

Section 6 considers additional actions that are relevant to reducing the likelihood that powerlines start bushfires.

Section 7 identifies the options for distributing the costs associated with the Taskforce’s recommendations and for allocating the Victorian Government’s Safer Electricity Assets Fund.

Section 8 identifies the practical issues that will need to be addressed to meet the 10-year implementation timeframe, as required by the Taskforce’s Terms of Reference.

2 Improvements in powerline bushfire safety over time

Powerlines can start bushfires. While the average number of bushfires started by powerlines is relatively low, powerlines are thought to have started a disproportionately high number of the major Victorian bushfires on 12 February 1977, on Ash Wednesday (16 February 1983) and on Black Saturday (7 February 2009).

The actions that have been taken to make powerlines safer following the 1977 and 1983 bushfires and following the 2009 Black Saturday bushfires are set out in this section. An overview of the electricity supply system is first provided in section 2.1.

2.1 Powerlines in Victoria

The Victorian electricity supply system is privatised and consists of four elements, as illustrated in Figure 1:

- **Generation** – electricity is predominantly generated in Victoria from brown coal, but also natural gas, hydro, and wind.
- **Transmission** – electricity is transmitted at high voltages on tall steel lattice towers from the major points of generation to major load centres.
- **Distribution** – electricity is transformed to lower voltages for distribution, generally through the “poles and wires” network, to business and residential customers.
- **Retail** – electricity is sold to customers by the retailer.

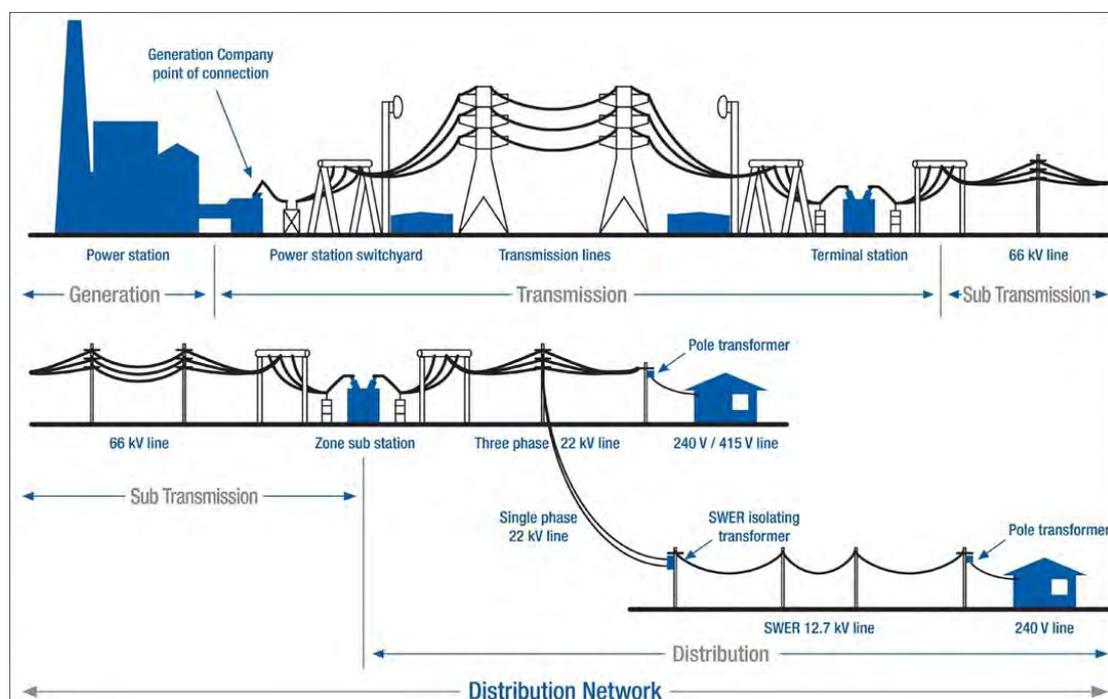


Figure 1: Schematic view of Victoria's electricity supply system²⁸

²⁸ Source: SP AusNet. The Taskforce is primarily concerned with the elements downstream of zone substations.

Only the distribution system was the subject of the Royal Commission's recommendations. The distribution system comprises the following types of powerlines:

- **Sub-transmission lines** – powerlines that carry large amounts of power. They are run at a very high nominal voltage of 66 kilovolts (kV) to reduce electrical energy losses.
- **Distribution lines** – powerlines that carry small to medium amounts of power and are the backbone of the distribution network. The majority run at a high nominal voltage of 6.6kV, 11kV or 22kV and use multiple wires, as illustrated in Figure 2. Distribution lines supply power to distribution substations (pole mounted transformers) that supply individual premises and local low voltage lines serving multiple premises. A single distribution line can supply multiple small rural towns and surrounding areas.
- **Single wire earth return (SWER) lines** – a high voltage distribution powerline that carries comparatively small amounts of power over longer distances than low voltage systems can cover, to supply sparsely populated areas. They are run at a nominal voltage of 12.7kV and use a single wire, as illustrated in Figure 2. The electrical current returns through the ground rather than through a separate wire as occurs in multi-wire distribution lines. As a SWER system uses only a single wire, it is very simple, requires less material, and is cheaper to construct and maintain than multi-wire distribution lines.
- **Low voltage lines** – the low voltage powerlines carry small amounts of power to supply electricity customers over short distances, typically no longer than 1km and often supply only one or two houses. They run at 240 or 415 volts.



Figure 2: Examples of multi-wire high voltage distribution line (on the left) and SWER line (on the right) Distribution and SWER powerlines in rural areas were the focus of the Royal Commission's recommendations.

There are five electricity distributors that own and operate the electricity distribution networks in Victoria, each with a defined area. Two electricity distributors own and operate most of the rural powerlines – Powercor in the west of the state and SP AusNet in the east. Jemena and United Energy own and operate a relatively small number of rural powerlines on the outskirts of Melbourne and on the Mornington Peninsula. CitiPower, which owns and operates the powerlines in the Melbourne CBD and inner suburbs, does not own or operate any rural powerlines.

The length of multi-wire distribution and SWER powerlines in Victoria by electricity distributor (except CitiPower²⁹), is summarised in Table 2.

Electricity distributor	Length of multi-wire distribution lines (km)		Length of SWER lines (km)	
	Total	Rural	Total	Rural
Jemena	2,182	530	13	13
Powercor	33,971	26,691	21,778	21,547
SP AusNet	25,335	21,779	6,469	6,457
United Energy	3,571	1,101	43	43
Total	65,059	50,101	28,303	28,060

Table 2: Length of multi-wire distribution and SWER powerlines in Victoria (excluding CitiPower’s area)

As indicated in Table 2, 77 per cent of multi-wire distribution lines and 99 per cent of SWER lines in Victoria (excluding CitiPower’s areas) are located in rural areas. This report predominantly focuses on the powerlines in Powercor’s and SP AusNet’s areas as these cover most of rural Victoria.

Further background information on the electricity supply system is provided in Appendix C.

2.2 Powerline history in starting bushfires

Bushfires can start by:

- natural causes, generally lightning
- human activities, including by campfires, burning off/agricultural burns, equipment/ machinery or arson
- powerlines.

Only bushfires started by powerlines are the subject of this report.

Historically, powerlines are thought to start a relatively small proportion of bushfires (around 1–4 per cent). Significantly, inquiries following major bushfires and the Royal Commission have concluded that a disproportionate number of the catastrophic bushfires, with major loss of life and property, have been caused by powerlines. Powerlines are thought to have started:

- Nine of the 16 major fires on 12 February 1977
- Four of the eight major fires on Ash Wednesday (16 February 1983)
- Five of the 15 major fires on Black Saturday (7 February 2009) that were considered by the Royal Commission.

²⁹ CitiPower is not shown as its powerlines are all in urban areas and hence not under consideration by the Taskforce.

The customer research conducted by the Taskforce indicated that Victorians perceive that a much larger proportion of bushfires are started by powerlines, as illustrated in Figure 3. Only 19 per cent of participants were of the view that up to 5 per cent of bushfires were started by powerlines, although 90 per cent of them believed that powerlines started less than 50 per cent of bushfires.

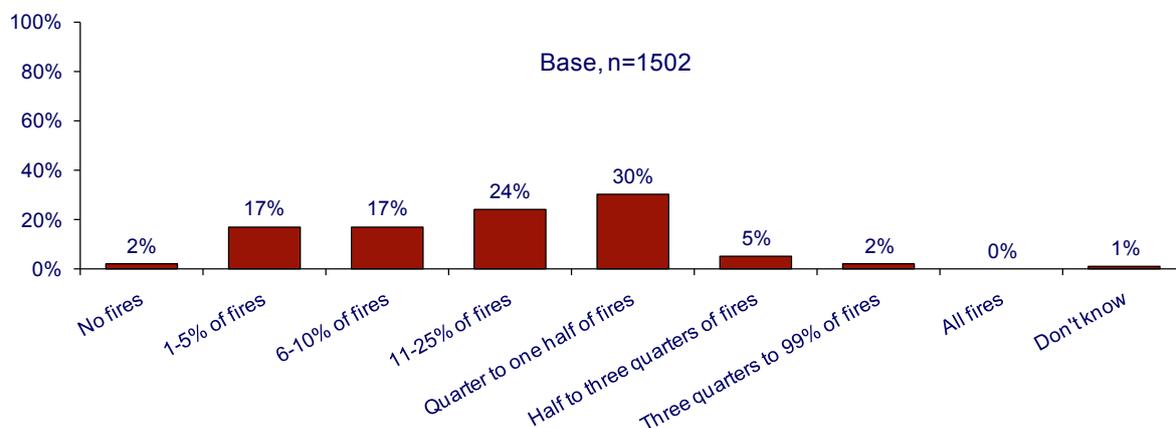


Figure 3: Customer perception of the proportion of bushfires started by powerlines

Regardless of the actual number of fires started by powerlines, it is clear powerlines can start bushfires. Action should be taken to reduce the likelihood that powerlines start bushfires. If the number of bushfires started by powerlines can be reduced, then the fire agencies may have more capacity to fight fires started by other causes³⁰.

The Taskforce undertook some analysis to identify why powerlines start a disproportionate number of the catastrophic bushfires. All fires started on Black Saturday were mapped, refer Figure 4, as well as the fires considered by the Royal Commission, refer Figure 5.

The Taskforce sought to identify whether there were any characteristics of the fires started by powerlines that were different to the other fires, and whether there were any characteristics of the five major fires that the Royal Commission concluded were started by powerlines that were different to the other fires. The Taskforce considered the distance from the fire origin to the nearest road, to the nearest powerline, and to the nearest Urban Centre of Locality (UCL).

The analysis indicated that the characteristics of the five major fires that the Royal Commission concluded were started by powerlines were consistent with the characteristics of the majority of fires, that is they were started within 100m of a road, 250m of a powerline and 10km of a UCL.

No characteristic was identified to explain why powerlines cause a disproportionate number of the catastrophic bushfires. Further research and development is required to investigate this issue further.

³⁰ Their ability to do so will be influenced by the location of the fires and availability of appliances.

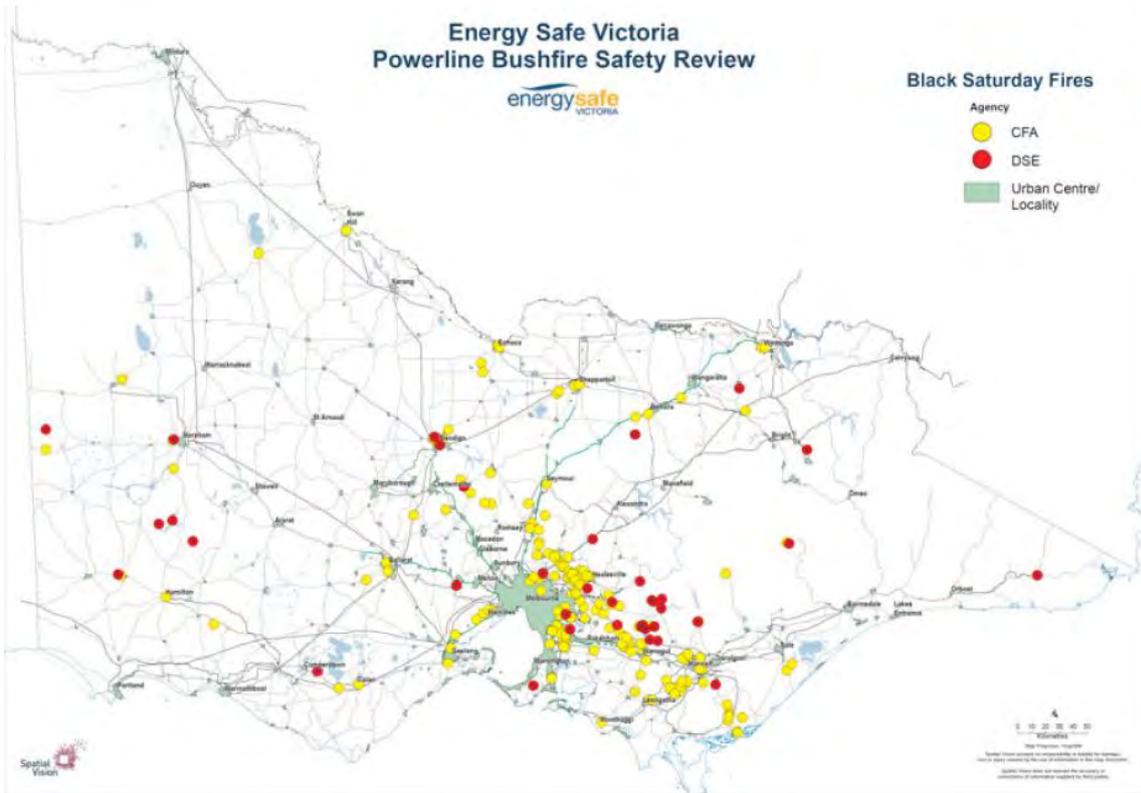


Figure 4: Location of bushfires started on Black Saturday

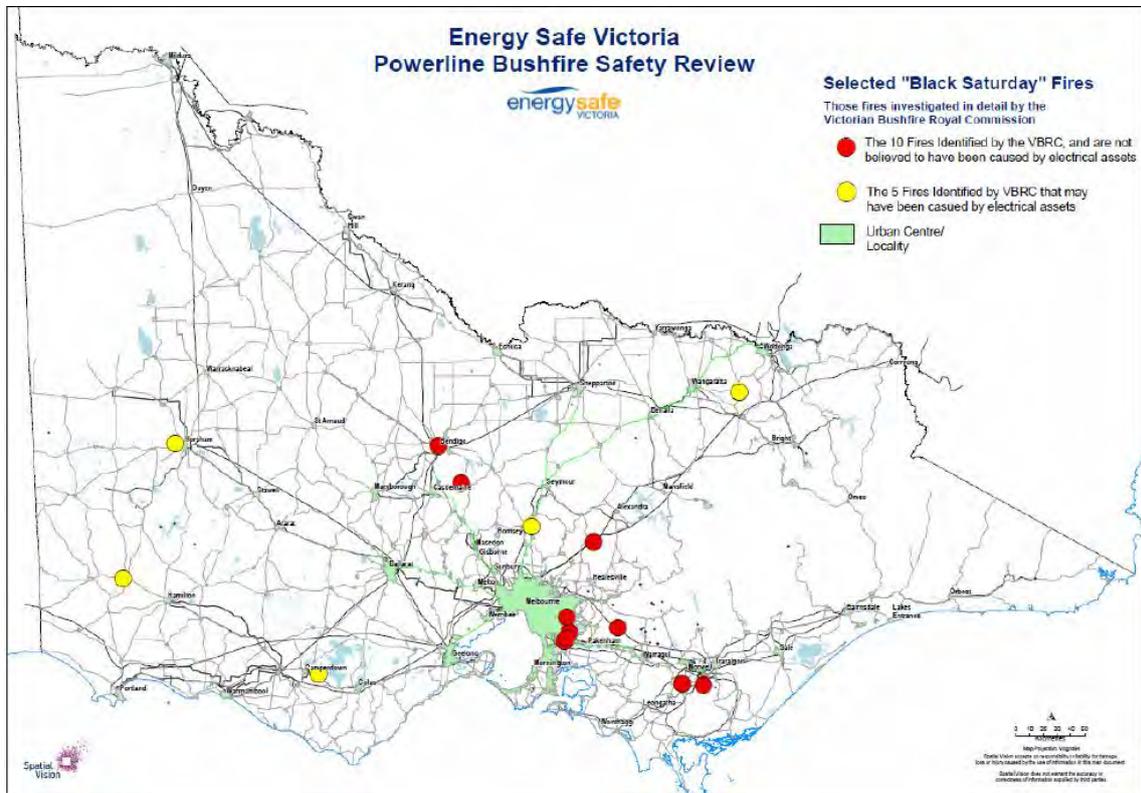


Figure 5: Origin of the 15 fires burning on Black Saturday that were investigated in detail by the Royal Commission

2.3 Actions taken after the 1977 and 1983 bushfires

Powerlines were implicated as the cause of major bushfires in 1977 and 1983. The primary causes of bushfires in 1977 and 1983 were vegetation touching live wires; fuses that produced hot metal particles when they operated; and clashing wires, primarily low voltage, that emitted hot molten metal particles. Private overhead powerlines (POELs) were implicated in many of the fires.

The research and analysis that was undertaken post the 1977 and 1983 bushfires confirmed that there is a high probability of a bushfire igniting if hot molten metal particles are emitted and fall into dry grass.

Formal inquiries were held after the 1977 and 1983 fires and a number of actions were taken by the former SECV and the Victorian Government based on the best information available at that time:

- spreaders – widespread installation of spreaders on low voltage lines to prevent wires clashing and producing molten metal particles
- fuses – many types of fuses that were prone to produce molten metal particles were replaced, new standards of testing were developed, new designs using “fire chokes” to cool any emitted particles were implemented, and many old types of fuses were retired
- Neutral Earthing Resistors (NERs) – installation of NERs in some zone substations in high bushfire risk areas to reduce the fault current and thereby reduce the likelihood of molten metal particles being emitted
- POELs – obligations on customers with POELs to maintain them and keep vegetation clear were given legal force, as well an obligation on electricity distributors to inspect POELs at least once every three years. An obligation was introduced requiring all new POELs and existing POELs that are to be substantially reconstructed to be placed underground in high bushfire risk areas
- vegetation management near powerlines – the obligations of various parties, including electricity distributors, local government authorities, private landowners and VicRoads were clarified and codified, and vegetation clearance standards were established. The comprehensive vegetation management regime that was introduced is described in further detail in section 2.5.2
- a bushfire mitigation regime was introduced.

The actions taken following the 1977 and 1983 bushfires substantially addressed some of the causes of bushfires resulting in a step reduction in the number of bushfires started by powerlines. However, the risk could not be, and was not, eliminated entirely.

The number of bushfires started by powerlines correlates with the reliability of the electricity supply system – the more powerline faults that occur, the more reliability of supply is adversely impacted, and the greater the likelihood of powerlines starting bushfires. The reliability of Victoria’s electricity supply system has improved significantly since 1983.

2.4 2009 Black Saturday bushfires

The Royal Commission concluded that five of the major Black Saturday bushfires were started by powerlines. Table 3 shows the development of each of these bushfires.

Location	Failure of operation	Energy release	Ignition of vegetation	Early detection	Growth to a major fire	Property loss, injury, death
Beechworth – Mudgegonga	Alleged that tree fell onto a three wire 22kV powerline	Arcing between the powerline and pole	Fault occurred at 5.59pm Protection – three slow trips (1.5s each)	Incident controller notified at 6.05pm	Fire-fighters arrived at scene at 6.15pm	33,577 Ha 2 fatalities
Coleraine	Tie wire securing a SWER powerline broke	Contact between the powerline and a tree	Fault occurred about 12.30pm Fuse did not operate (current too low)	Call to CFA at 12.34pm	Response unclear, but aircraft requested at 12.42pm and further tankers requested at 12.43pm	713 Ha 0 fatalities
Horsham	Coach bolts securing a SWER pole top assembly came loose	Arcing between the powerline and ground	Fault occurred at about 12.20pm Fuse operated within 0.3s	Fire reported to 000 at 12.25pm	Horsham brigade attended at 12.30pm	2,346 Ha 0 fatalities
Kilmore East	SWER powerline broke	Arcing between the powerline and pole stay wire	Fault occurred at about 11.45am Assuming fault current was 30 amps, two fast trips (0.07s each) and two slow trips (0.65s each)	Fire spotted at Pretty Sally fire tower at 11.47am and reported to CFA at 11.49am	Kilmore, Broadford, Clonbinane, Wandong and Wallan brigades responded at 11.50am	125,383 Ha 119 fatalities
Pomborneit – Weerite	Alleged that 22kV and 66kV wires may have clashed	Molten metal particles	Fire started at 1.14pm	First emergency call at 1.17pm	Pomborneit and Weerite brigades already turned out at 1.17pm	1,008 Ha 0 fatalities

Table 3: Phases in the development of the five “powerline-related” fires examined by the Royal Commission³¹

³¹ 2009 Victorian Bushfires Royal Commission, *Final Report, Volume 1 The Fires and the Fire Related Deaths*, pages 70, 94, 106, 118 and 210

Table 3 indicates:

- Of the five “powerline-related” bushfires, three were ignited by electric arcs, one by molten metal particles and one by the contact of a live powerline with vegetation or other material.
- Protection and control systems operated in most cases to turn off the power within the normal range of electricity distribution system practice at that time (this did not happen on the Coleraine powerline because the fault current was too low for protection systems to recognise it as a fault). Fault clearing times were generally up to one or two seconds with some attempts to automatically turn the powerlines back on.
- The fires were detected very quickly (within around five minutes) and in most cases, fire authorities responded within minutes of the fire being detected.

The Royal Commission found that the events of Black Saturday called for “a material reduction in the risk of bushfire caused by the failure of electrical assets”³². Specifically, it found that:

- the age of the electricity distribution assets contributed to the Kilmore East, Coleraine and Horsham fires
- the length of the inspection cycle contributed to the Coleraine and Horsham fires
- the efficacy of asset inspections contributed to the Kilmore East fire
- “hazard” trees contributed to the Beechworth-Mudgegonga fire
- the operation of automatic circuit reclosers contributed to the Beechworth-Mudgegonga and Kilmore East fires
- the absence of dampers contributed to the Kilmore East fire
- the absence of spreaders contributed to the Pomborneit-Weerite fire.

2.5 Actions taken since the 2009 Black Saturday bushfires

In July 2010 the Royal Commission made eight recommendations for action to reduce the likelihood that powerlines may start bushfires in the future. These recommendations are discussed further in section 2.5.1.

Actions were taken by the Victorian Government, including ESV, and by the electricity distributors following the 2009 Black Saturday bushfires, to reduce the likelihood that powerlines start bushfires. Some of these actions were taken in response to the Royal Commission’s recommendations, some actions were consistent with the Royal Commission’s recommendations and were undertaken prior to the Royal Commission making its recommendations, and some actions are additional to the Royal Commission’s recommendations. The actions that have been undertaken, which are additional to the Royal Commission’s recommendations, are discussed in section 2.5.2.

2.5.1 Addressing the Royal Commission’s recommendations

The Royal Commission made eight recommendations to reduce the likelihood that powerlines may start bushfires covering the age of assets, length of the inspection cycle,

³² 2009 Victorian Bushfires Royal Commission, *Final Report: Volume II, Fire Preparation, Response and Recovery*, July 2010, page 148

improvement in asset inspection, ~~hazard~~ trees, the operation of automatic circuit reclosers, and the fitting of dampers and spreaders. These recommendations, with a summary of the actions that have been taken or are being taken, are set out in Table 4.

Six of the recommendations have either already been actioned or are being actioned by ESV and the electricity distributors.

The remaining two recommendations have been directly addressed by the Taskforce – recommendations number 27 (replacement of powerlines) and number 32 (changing the network reclose function). This report outlines the Taskforce's recommendations and options on the implementation of these two recommendations.

Rec No	Recommendation	Action that has been or will be undertaken
27	<p>The State amend the Regulations under Victoria’s <i>Electricity Safety Act 1998</i> and otherwise take such steps as may be required to give effect to the following:</p> <ul style="list-style-type: none"> • 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. 	<p>The Taskforce was established to investigate the full range of options to reduce the likelihood of powerlines starting catastrophic bushfires and recommend to the Victorian Government how to implement this recommendation.</p>
28	<p>The State (through Energy Safe Victoria) require distribution businesses to change their asset inspection standards and procedures to require that all SWER lines and all 22-kilovolt feeders in areas of high bushfire risk are inspected at least every three years.</p>	<p>The Electricity Safety (Bushfire Mitigation) Regulations 2003 have been amended to require that the electricity distributors’ Bushfire Mitigation Plans specifically include:</p> <p style="padding-left: 40px;">a plan for inspection that ensures that all of the specified operator’s at-risk lines are inspected at regular intervals of no longer than 37 months.</p> <p>Amendments were made to the <i>Electricity Safety Act 1998</i> in 2010 to provide greater powers to ESV to ensure shorter inspection cycles. ESV is exercising these greater powers in the approval of the electricity distributors’ Electricity Safety Management Schemes and Bushfire Mitigation Plans and in audits of the electricity distributors.</p> <p>ESV has also increased its capacity and capability to review and audit Electricity Safety Management Schemes and Bushfire Mitigation Plans.</p>

Rec No	Recommendation	Action that has been or will be undertaken
29	<p>The State (through Energy Safe Victoria) require distribution businesses to review and modify their current practices, standards and procedures for the training and auditing of asset inspectors to ensure that registered training organisations provide adequate theoretical and practical training for asset inspectors.</p>	<p>The Electricity Safety (Bushfire Mitigation) Regulations 2003 have been amended to require that the electricity distributors' Bushfire Mitigation Plans specifically include:</p> <p style="padding-left: 40px;"><i>details of the processes and procedures for ensuring that only persons who have satisfactorily completed a training course approved by Energy Safe Victoria are assigned to carry out the inspections</i></p> <p>Amendments were made to the <i>Electricity Safety Act 1998</i> in 2010 to provide greater powers to ESV to require registered training of inspectors. ESV is exercising these greater powers in the approval of the electricity distributors' Electricity Safety Management Schemes and Bushfire Mitigation Plans and in audits of the electricity distributors.</p> <p>ESV has also increased its capacity and capability to review and audit Electricity Safety Management Schemes and Bushfire Mitigation Plans.</p>
30	<p>The State amend the regulatory framework for electricity safety to require that distribution businesses adopt, as part of their management plans, measures to reduce the risks posed by hazard trees—that is trees that are outside the clearance zone but that could come into contact with an electric power line having regard to foreseeable local conditions.</p>	<p>The Electricity Safety (Electric Line Clearance) Regulations were remade in 2010. The new regulations increase the clearance space around some electric powerlines and include a provision for the cutting or removal of “hazard” trees. Exemptions that were previously provided to the electricity distributors to allow for “practical compliance” rather than “literal compliance” with the regulations have not been extended.</p>
31	<p>Municipal councils include in their municipal fire prevention plans for areas of high bushfire risk provision for the identification of hazard trees and for notifying the responsible entities with a view to having the situation redressed.</p>	<p>Amendments were made to the <i>Electricity Safety Act 1998</i> in 2010 to require local councils to include procedures and criteria for the identification and notification of “hazard” trees in their municipal fire prevention plan. When the Electricity Safety (Electric Line Clearance) Regulations were remade in 2010, a provision was included for the cutting or removal of “hazard” trees.</p> <p>These provisions will be moving to the <i>Country Fire Authority Act 1958</i>.</p>
32	<p>The State (through Energy Safe Victoria) require distribution businesses to do the following:</p> <ul style="list-style-type: none"> • 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. 	<p>The Taskforce was established to investigate and recommend to the Victorian Government how to implement this recommendation.</p>

Rec No	Recommendation	Action that has been or will be undertaken
33	The State (through Energy Safe Victoria) require distribution businesses to do the following: <ul style="list-style-type: none"> • fit or retrofit all spans that are more than 300 metres long with vibration dampers as soon as is reasonably practical • fit spreaders to any lines with a history of clashing or the potential to do so. 	Amendments were made to the <i>Electricity Safety Act 1998</i> in 2010 to provide greater powers to ESV to ensure the fitting of dampers and spreaders where required. ESV exercised these greater powers by issuing directions to the electricity distributors in January 2011 on the fitting of dampers and spreaders, the approval of the electricity distributors' Electricity Safety Management Schemes and Bushfire Mitigation Plans, and in audits of the electricity distributors. ESV has increased its capacity and capability to review and audit Electricity Safety Management Schemes and Bushfire Mitigation Plans.
34	The State amend the regulatory framework for electricity safety to strengthen Energy Safe Victoria's mandate in relation to the prevention and mitigation of electricity-caused bushfires and to require it to fulfil that mandate.	Amendments have been made to the <i>Energy Safe Victoria Act 2005</i> to improve ESV's governance and planning regime, and to the <i>Electricity Safety Act 1998</i> to include an additional objective for ESV to explicitly promote the prevention and mitigation of bushfire danger, and to strengthen ESV's powers in relation to Bushfire Mitigation Plans. ESV has also increased its capacity and capability.

Table 4: Royal Commission's electricity-related recommendations with action taken or underway³³

³³ 2009 Victorian Bushfires Royal Commission, *Final Report, Volume 1 The Fires and the Fire Related Deaths*, pages 70, 94, 106, 118 and 210

2.5.2 Additional actions taken by the Victorian Government and electricity distributors

The additional actions that have been taken since the 2009 Black Saturday bushfires by the Victorian Government and the electricity distributors to reduce the likelihood that powerlines start bushfires include:

- amendments to the regulatory framework
- enhanced vegetation clearance
- enhanced powerline inspection and maintenance.

2.5.2.1 Amendments to the regulatory framework

There are three broad obligations that are placed on the electricity distributors to reduce the likelihood that powerlines start bushfires:

- a general obligation to minimise hazards and risks
- a requirement to prepare Bushfire Mitigation Plans
- a requirement to prepare Electric Line Clearance Plans.

Following the Black Saturday bushfires, amendments were made to legislation to strengthen these three broad obligations. In addition, the *National Electricity (Victoria) Act 2005* was amended to provide for the introduction of a fire incentive scheme that will encourage improvements in the management of powerlines to reduce the number of fires started by them.

The Victorian Government amended the *Electricity Safety Act 1998* (the Act) to clarify and make explicit the obligations on owners and operators of powerlines to minimise fire risks. In particular, the Act was amended to more explicitly require the electricity distributors to minimise as far as practicable the bushfire danger arising from above ground supply networks that are in a hazardous bushfire risk area.

The Act places an obligation on the electricity distributors to submit a Bushfire Mitigation Plan to ESV by 1 July each year for its approval. With the amendments to the Act, the annual Bushfire Mitigation Plans now form part of their Electricity Safety Management Schemes (ESMS). The ESMS is required to demonstrate to ESV how that company complies with its obligations to minimise hazards and risks.

Amendments to the Act strengthen the provisions regarding Bushfire Mitigation Plans, including:

- increased penalties for failing to submit Bushfire Mitigation Plans
- requirement for compliance with the Bushfire Mitigation Plan, with substantial penalties for non-compliance
- requirement for ESV to accept or provisionally accept the Bushfire Mitigation Plans, including the power for ESV to require the plan to be independently validated, for additional information to be provided, and to determine the Bushfire Mitigation Plan if one is not submitted or has not been accepted
- power for ESV to require an independent audit to be conducted, or for ESV to undertake an audit, of compliance with a Bushfire Mitigation Plan

- requirement for accepted Bushfire Mitigation Plans to be available on the internet as well as at the company's premises.

Trees or tree limbs falling on powerlines are the largest single cause of powerlines starting bushfires. The requirement to clear vegetation around electric lines is a key component of any strategy to reduce the likelihood of powerlines starting bushfires³⁴.

The responsibility for clearing vegetation around powerlines, in accordance with the Code of Practice for Electric Line Clearance (the Code), is:

- the owner of the powerline, where the powerline is not owned by the electricity distributor
- the private landholder, where the powerline traverses the property of that landholder and supplies only that landholder
- the person responsible for the management of public land, where the tree is in a declared area (often the local council)
- VicRoads, where the tree is situated in a rural area in a plantation established by VicRoads or on a freeway or arterial road
- under all other circumstances, the electricity distributor.

The Code is developed in consultation with the Electric Line Clearance Consultative Committee (the Committee). The Act has been amended to include a representative from ESV on the Committee and to allow the Committee to have regard to the reliability and security of supply in performing its functions.

The amendments to the Act provide a power to ESV to make a direction to restrict or cease the planting of certain trees, or to clear certain trees, in the immediate area around a powerline. The Committee is currently considering the most appropriate way to exercise this power.

Consistent with the amendments relating to Bushfire Mitigation Plans, the Act was amended to provide the power for ESV to require an independent audit to be conducted, or for ESV to undertake an audit, of compliance with an Electric Line Clearance Plan.

2.5.2.2 Enhanced vegetation clearance

Vegetation clearance requirements vary depending on whether a powerline is in a "high bushfire risk area" or a "low bushfire risk area" as defined by the CFA. This fire hazard rating determines the clearance space around the powerline and the party responsible for vegetation clearance. ESV will be reviewing the fire hazard ratings and the vegetation clearance regime more broadly, including an assessment of the most appropriate persons to be responsible for vegetation and the declaration of urban areas for the purposes of the Act.

Electricity distributors were previously exempted from literal compliance with the Code during the winter period, but were required to be strictly compliant during the bushfire season. The exemption allowed vegetation to encroach on the clearance space during the non-bushfire season. These exemptions are no longer granted – electricity distributors must now take into consideration any growth during the clearance cycle so clearances are maintained all year round.

³⁴ A diagram illustrating the clearance space around powerlines is provided in section 6.2.

ESV has increased its auditing of vegetation clearance to strengthen compliance with the Code. This has improved the level of compliance, particularly in low bushfire risk areas.

Customer research undertaken by the Taskforce indicates that most customers (especially in non-urban areas) would accept increased vegetation clearance around powerlines and power poles if it meant that there was a reduced risk of fires (see Figure 6).

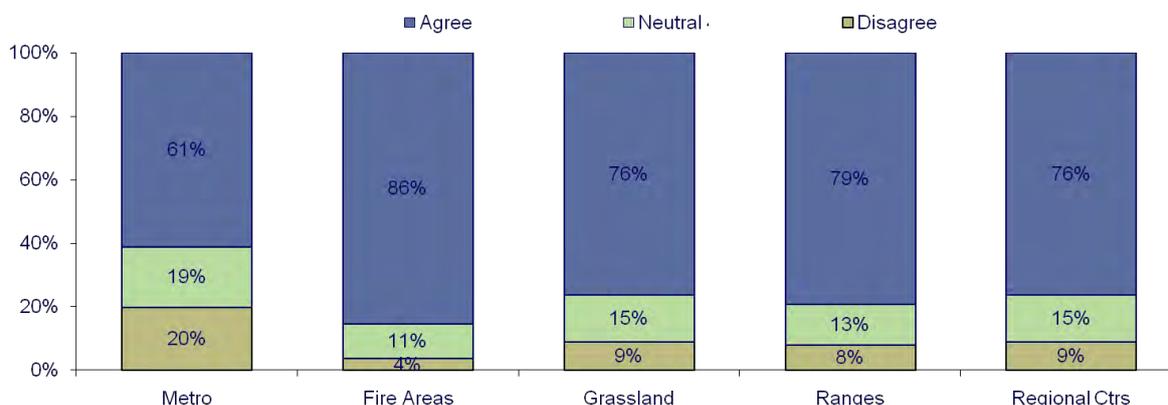


Figure 6: Customer attitudes to increased vegetation clearance to reduce fire risk

2.5.2.3 Enhanced powerline inspection and maintenance

The Taskforce notes that there are a range of tools that may enhance the inspection of powerlines, including:

- high-resolution digital photography – ground level and aerial
- rod or boom-mounted cameras
- unmanned aerial vehicles
- thermal imaging – ground level and aerial
- aerial laser detection and ranging
- digital radiography
- remote cameras
- satellite profiling
- automatic analysis of digital images.

These enhancements are at various stages of development, with some (for example high resolution digital photography) already implemented either partly or wholly across one or more of the electricity distributors' networks, while others (for example digital radiography) are at the research stage.

These initiatives are being driven by the electricity distributors, with different electricity distributors focusing on the techniques that are most applicable to their specific circumstances. Regardless of the outcomes of the Taskforce, it is understood that ESV will continue to work with the electricity distributors to facilitate implementation of these tools once proven effective.

During the process for determining the electricity distributors' revenue for 2011–15, they proposed a number of safety-related initiatives to enhance maintenance of their networks,

in addition to enhancements to inspection and vegetation clearance. The types of programs proposed included neutral condition monitors, overhead mounted switchgear maintenance, non-pole distribution substation routine maintenance, and an increase in the replacement of tie wires.

3 Important new information that has influenced our recommendations

The Taskforce has undertaken original research and analysis, or drawn on research and analysis that has been undertaken by others. This process has revealed new information and developed a deeper understanding of:

- the causes of bushfires started by powerlines, as discussed in section 3.1
- how powerlines start bushfires, as discussed in section 3.2
- how the consequences of bushfires vary across the state, as discussed in section 3.3
- how the likelihood of powerlines starting bushfires can be mitigated, as discussed in section 3.4
- how much Victorians are willing to pay to reduce the risk that powerlines start bushfires, as discussed in section 3.5
- the precautionary-based approach to identifying precautions to reduce the likelihood of powerlines starting bushfires, as discussed in section 3.6.

Much of this information was not available to the Royal Commission at the time that it made its recommendations. The information enables the Taskforce to make recommendations based on a wider range of foreseeable events rather than based only on the events that occurred on Black Saturday.

In addition, the Taskforce has studied the regulatory framework within which its recommendations will be implemented. An overview of this framework is set out in section 3.7.

3.1 Causes of bushfires started by powerlines

Powerlines have the potential to start a bushfire when a fault occurs. As discussed in section 2.2, historically powerlines have started approximately 1–4 per cent of bushfires.

A fault may occur due to:

- the external environment, particularly trees, tree branches, birds, animals or vegetation making contact with powerlines; wind causing powerlines to move into each other or other objects; lightning hitting powerlines; and heat causing powerlines to sag and touch structures below them or reach the ground
- the failure of powerlines, that is breakage of wires, poles, cross-arms, insulators or any of the many other components that make up a typical powerline.

The causes of fires thought to have been started by powerlines on Total Fire Ban days in Powercor's and SP AusNet's areas in 2008 and 2009 are illustrated in Figure 7. Figure 7 shows that the majority of the bushfires (approximately 80 per cent) are started by the wires and poles, with a smaller proportion started by the auxiliary equipment mounted on the poles (for example the transformer, fuse and surge diverter). Of these, 33 per cent are due to the external environment, 53 per cent are due to the failure of powerlines and 14 per cent are not clearly attributable to the external environment or the failure of powerlines.

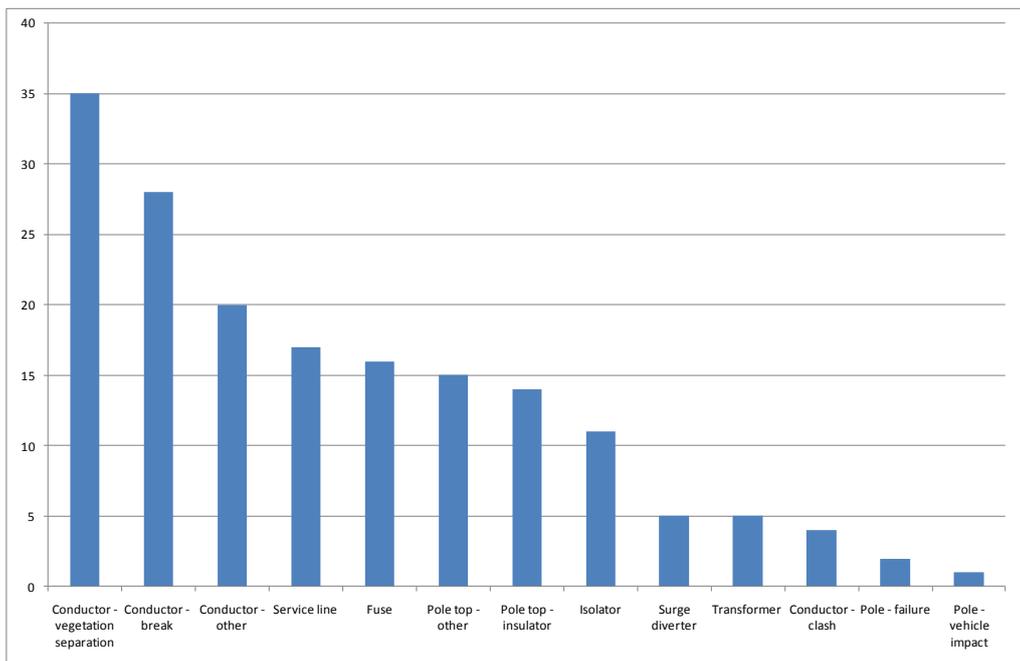


Figure 7: Fires started by powerlines on Total Fire Ban days in Powercor's and SP AusNet's areas, 2008 and 2009³⁵

Figure 8 provides an analysis of fires started by multi-wire powerlines (including 22kV) and SWER powerlines on Total Fire Ban days in Powercor's and SP AusNet's areas in 2009.

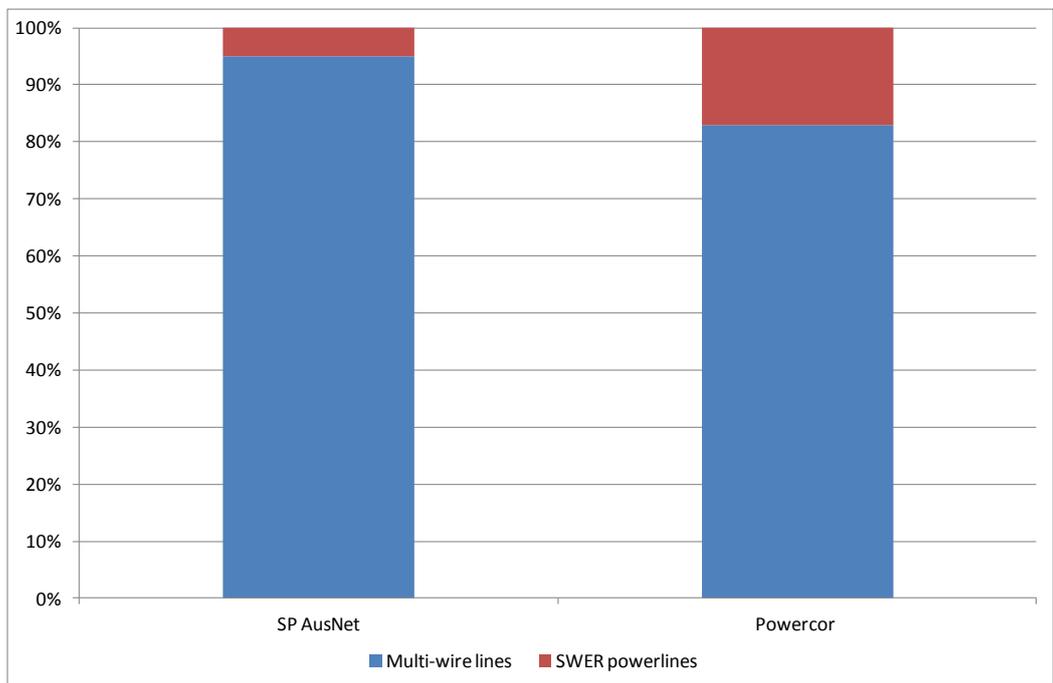


Figure 8: Breakdown of fires started by powerlines on Total Fire Ban days in Powercor's and SP AusNet's areas, 2009, by multi-wire and SWER powerlines

³⁵ Some of these categories, including conductor break, include fires started due to the failure of the powerlines and fires started due to the external environment.

Figure 8 shows that the majority of fires in Powercor’s and SP AusNet’s areas in 2009 were started by multi-wire powerlines – approximately 1.6 fires started for each 1000km of multi-wire powerlines compared with 0.3 fires started for each 1000km of SWER powerlines. The consequence of a fire is not necessarily correlated with the number of fires from a particular cause, so the significance of this result should not be overstated. However, it does contradict a belief held by some in the community that SWER powerlines pose a greater fire risk than multi-wire powerlines.

It tends to confirm views expressed by industry experts in the April 2010 national workshop on fires and rural distribution networks that the simplicity of SWER powerline construction involves fewer potential failure modes likely to start a fire.

The data does not provide a breakdown of the number of fire starts by wire-to-wire faults and wire-to-earth faults. The Taskforce has estimated that 70 per cent of fires are started by wire-to earth faults and 30 per cent of fires are started by wire-to-wire faults. The data also does not provide a breakdown of fires started by electric arcs, molten metal particles and electric current flow. The Taskforce has not been able to estimate this breakdown.

Figure 9 shows that 16 per cent of the fires depicted in Figure 7 were started by the low voltage network and 10 per cent were started by low voltage service lines³⁶. The remaining 74 per cent of fires are started by the high voltage network. Approximately 49 per cent of fires are started by wire-to-earth faults on multi-wire lines, 18 per cent by wire-to-wire faults on multi-wire lines and 7 per cent by faults on SWER powerlines.

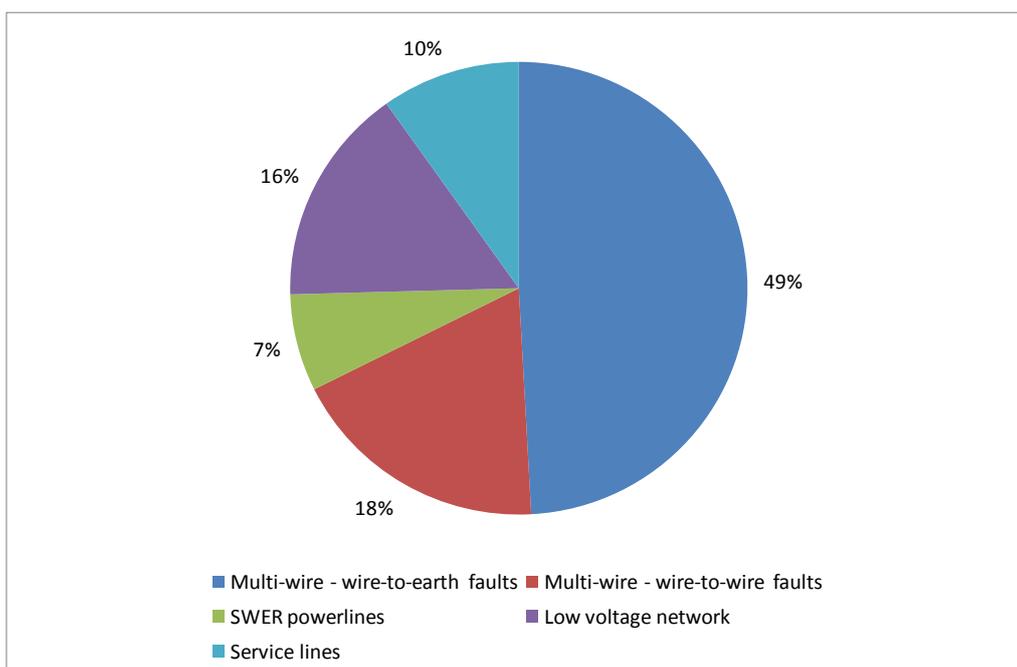


Figure 9: Analysis of fires started by powerlines on Total Fire Ban days in Powercor’s and SP AusNet’s areas, 2008 and 2009

Consistent with the Royal Commission’s recommendations, the Taskforce has not made any specific recommendations in relation to low voltage lines and service lines, other than as a corollary to action to replace high voltage lines. However, the Taskforce is of the view

³⁶ A large proportion of service lines are in urban areas, and therefore a large proportion of fires started by service lines are started in urban areas.

that any cost-effective options to reduce fire risk from low voltage lines should be implemented.

The reporting of the number of fires started by powerlines has improved over the last couple of years. It is expected to further improve with the introduction of a fire incentive scheme into the economic regulatory regime from 1 January 2012 and the development of a transparent data set as part of a new Annual Comparative Safety Performance Report that ESV now publishes on the electricity distributors' safety outcomes.

Historically, there have been inconsistencies in the data reported by CFA and ESV on the number of bushfires started by powerlines. The Taskforce has identified that these differences are largely due to:

- the multiple reporting of fires by the CFA
- the inclusion of electrical fires that are not started by the electricity distributors' assets³⁷.

The Taskforce expects that ESV and CFA will continue to improve the understanding of the data sets, to reconcile data sets and to ensure consistency of data, to the extent possible.

3.2 Powerline faults can start bushfires very quickly under certain circumstances

Powerline faults can release sufficient energy into the environment to very quickly start a bushfire under worst-case conditions. On most days, the moisture content of vegetation and other combustible material near a powerline is high and there is a low likelihood of ignition. However, on days of Total Fire Ban, and particularly on Code Red days, vegetation and other combustible material has a very low moisture content that greatly increases the likelihood of ignition.

Bushfires can be started by powerlines by:

- an electric arc igniting surrounding vegetation or other combustible material, for example if a line falls to the ground
- hot molten metal particles released when two live parts of powerlines make physical contact, for example in wire clashing incidents, igniting dry materials on which they fall
- an electric current that flows through vegetation, animal or other material, causing ignition, when they contact live parts of the network (either between two different live parts or between one live part and the ground).

Extensive research into molten metal particles was undertaken following the 1977 and 1983 bushfires. However, research has not previously been undertaken on the ignition of bushfires by electric arcs that are a common feature of powerline faults. The Taskforce has therefore undertaken its own research to understand how quickly electric arcs can start bushfires under worst-case conditions.

The research undertaken by the Taskforce indicates that, with low vegetation moisture content and little air movement:

- electric arcs can ignite fuel very quickly, in two to three hundredths of a second for relatively high fault currents and a few tenths of a second for relatively low fault currents

³⁷ These are fires in premises that are started by electrical wiring, for example.

- molten metal particles, which have a high probability of igniting fuel, can be emitted within tenths of a second, but only for high fault currents
- electric current flows will ignite fuel in the order of tens of seconds to minutes.

The precise mechanisms by which powerlines may start bushfires can be quite complex and are described in the following sections with further detail provided in Appendix D.

3.2.1 Electric arcs can start fires

While the fundamentals of fuel ignition processes in general have previously been well researched and are understood, most work to date has focused on scenarios that lead to ignition in the order of seconds, rather than considering ignition in hundredths of a second, as may happen with electric arcs.

To address this knowledge gap, an 18-day program of tests was undertaken by the Taskforce at Testing and Certification Australia's (TCA's) high power laboratory in Lane Cove, New South Wales, from April to August 2011. This limited program of arc ignition tests has provided valuable insights and useful preliminary data on the behaviour of electric arcs that may occur in real powerline faults and conditions that may produce ignition of dried grass and other fuels. More precise information applicable to specific conditions will require further tests.

Examples of electric arcs produced during testing are provided in Figure 10.

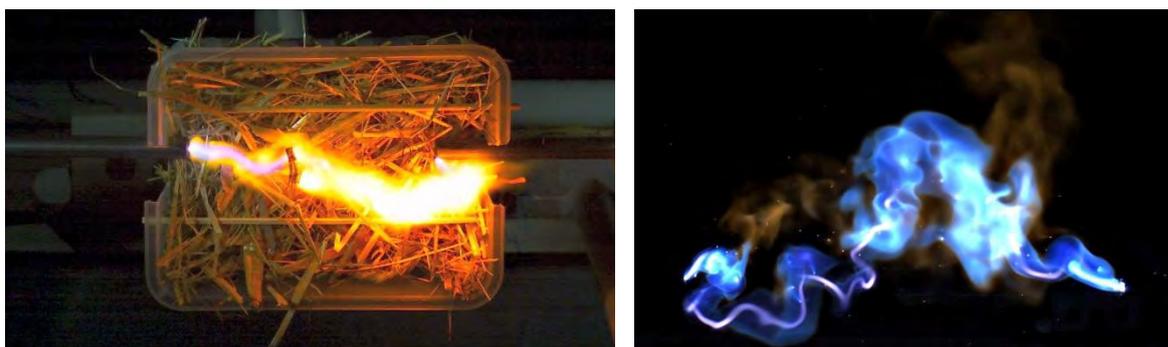


Figure 10: Electric arcs produced during testing – from the 4.2 amp testing on the left, and the 200 amp testing on the right

The key findings from the tests on the probability of ignition from electric arcs include:

- ignition can occur almost instantaneously (in less than one hundredth of a second or 10ms) when the arc/plasma contacts the fuel, even at low currents
- with a wind speed of 10km/h³⁸ at 45°C, sustained ignition is 50 per cent probable for arc durations of around 60ms for a 200 amp arc, 75ms for a 50 amp arc and 155ms for a 4.2 amp arc³⁹
- probability of sustained ignition depends on the following:

³⁸ Wind speed increases exponentially with height – the wind speed at a height of 0.5m is considerably less than the wind speed at a height of 10m. For example while the wind speed at Kilmore Gap at a height of 10m on 7 February 2009 varied between approximately 30 and 80 km/h, the wind speed at a height of 0.5m varied between 10 and 20 km/h. The wind speed at ground level, where bushfires may be ignited, may be considerably lower again.

³⁹ Results for the 4.2 amp test are less certain than for higher currents.

- arc current and duration – as indicated above, ignition is more likely to occur with higher arc currents, and is more likely to occur the longer the arc current is applied
- airflow speed – even a light to moderate breeze can extinguish initial ignition
- fuel type, fuel moisture content, air temperature and relative humidity.

After arc current and duration, airflow is a very important determinant of ignition probability:

- early extinguishment of low current arcs with even moderate airflow speeds indicates that low current arcs may not present a major ignition risk in realistic wind speeds, especially if such arcs occur at height where wind speed is greater
- airflow often extinguishes initial ignition, so the probability of sustained ignition can be much less than the probability of initial ignition.

Testing was also conducted to determine the effect of a reclose operation on the probability of ignition. When a single reclose was simulated after five seconds, the probability of sustained ignition was found to be significantly higher than when the initial fault occurred. That is the reclose attempt appears to be predisposed towards ignition by the initial fault five seconds earlier.

Tests with an increased reclose delay of 30 seconds showed the probability of ignition in the reclose attempt was no higher than in the initial fault. That is any residual effects from the initial fault had diminished to a level that did not predispose the reclose attempt towards ignition, so the fault and reclose attempt can be considered independent events.

In summary, the arc ignition research indicates that electric arcs can ignite fires almost instantaneously (which could be as fast as two hundredths of a second) under worst-case conditions. The probability of bushfires being ignited can be reduced if powerlines are turned off, or the fault current substantially reduced, faster than this ignition timeframe when a fault occurs. While this is an extremely challenging goal, some protection technologies appear to have the potential to achieve it in many circumstances that commonly occur on Victoria's rural powerlines. These technologies are discussed in section 3.4.

The arc ignition research also indicates that if reclose devices are used on the network, the probability of bushfires being ignited can be reduced if the time between turning off powerlines and then turning them on again is increased from five seconds to 30 seconds.

3.2.2 Ejected hot material can start fires

Wire clashes were found to be a major cause of the 1977 and 1983 bushfires that were started by powerlines.

If very large fault currents flow when the wires clash, molten metal particles can be emitted that have a high probability of starting a bushfire. The large fault currents required to emit molten metal particles arise in wire-to-wire faults, that is when two live wires touch. These currents are generally much higher than those that arise in a wire-to-earth fault, that is when a wire touches the ground or a tree. This failure mode does not apply with SWER powerlines as there is only one wire.

Wire clash risk increases as wire-to-wire spacing decreases, that is it is more prevalent on lower voltage lines where wires are closer together. The risk of molten metal particles being emitted from low voltage powerlines has been mitigated through the widespread installation of spreaders to prevent clashing.

The risk of high voltage wires clashing is much lower because of the greater wire spacing. Spreaders can be used on high voltage powerlines in special circumstances but they are complex and introduce other risks. Residual risk has therefore generally been mitigated through the redesign of specific powerlines.

Testing of the fire risk of wire clashing after the 1977 and 1983 bushfires covered copper, aluminium and steel wires. Further detail is provided in Appendix D.3.

3.2.3 Electric current flows

The timeframe in which a fire is started by electric current flows is much longer (in the order of tens of seconds to minutes) than the timeframe in which a fire is started by an electric arc or molten metal particles.

Any actions to reduce the likelihood of a fire starting by arcing or molten metal particles will also reduce the likelihood of a fire starting by the flow of electric current. For these reasons, the Taskforce did not carry out research into ignition by flow of electric current.

3.3 Consequences of bushfires vary across the state

The best available modelling indicates that the consequence of a fire varies significantly by fire start location across the state. The fire loss consequence is the potential impact of a bushfire, in terms of loss of life and property.

Fire loss consequence data has been mapped against the electricity distributors' networks to identify how the consequence of a bushfire varies by the location of a powerline fault. Figure 11 symbolises the fire loss consequence across the state, assuming a fire starts at a particular location on that section of powerline at 1pm on a day with Ash Wednesday-type conditions forced across the state⁴⁰. It does not identify the areas that will be impacted by that bushfire.

A particular location on a powerline is considered to have a high fire loss consequence when a fire starting at that location has the potential for a high loss of life and property. A particular location on a powerline is considered to have a low fire loss consequence when a fire starting at that location has the potential for a relatively low loss of life and property.

The fire loss consequence data was produced by Phoenix – a fire characteristic mapping model developed by Dr Kevin Tolhurst and colleagues at the Bushfire Cooperative Research Centre (CRC). The inputs to the model include fuels, weather, topography, fire suppression levels, assets and their values, and scenario conditions. The outputs from the model vary with the input conditions specified.

The Taskforce identified Phoenix as the best available tool to assess fire loss consequence at this time. The Phoenix model relies on a large number of assumptions, which will evolve over the next few years. A Working Group has been established within the Victorian Government to coordinate improvements to the model. In the meantime, the Taskforce has accepted the map in Figure 11 as a useful guide to inform its recommendations. It recognises that fire loss consequence data will improve over the next few years as input assumptions are refined and worst-case conditions are identified, and has designed its recommendations to accommodate these improvements.

⁴⁰ Some parts of the state experienced more severe conditions than others on Ash Wednesday. Ash Wednesday-type conditions are therefore forced across all parts of the state to produce a worst-case scenario for the purposes of the modelling.

When implementing the Taskforce’s recommendations, the electricity distributors should use the best information available at the time investment decisions are made by them.

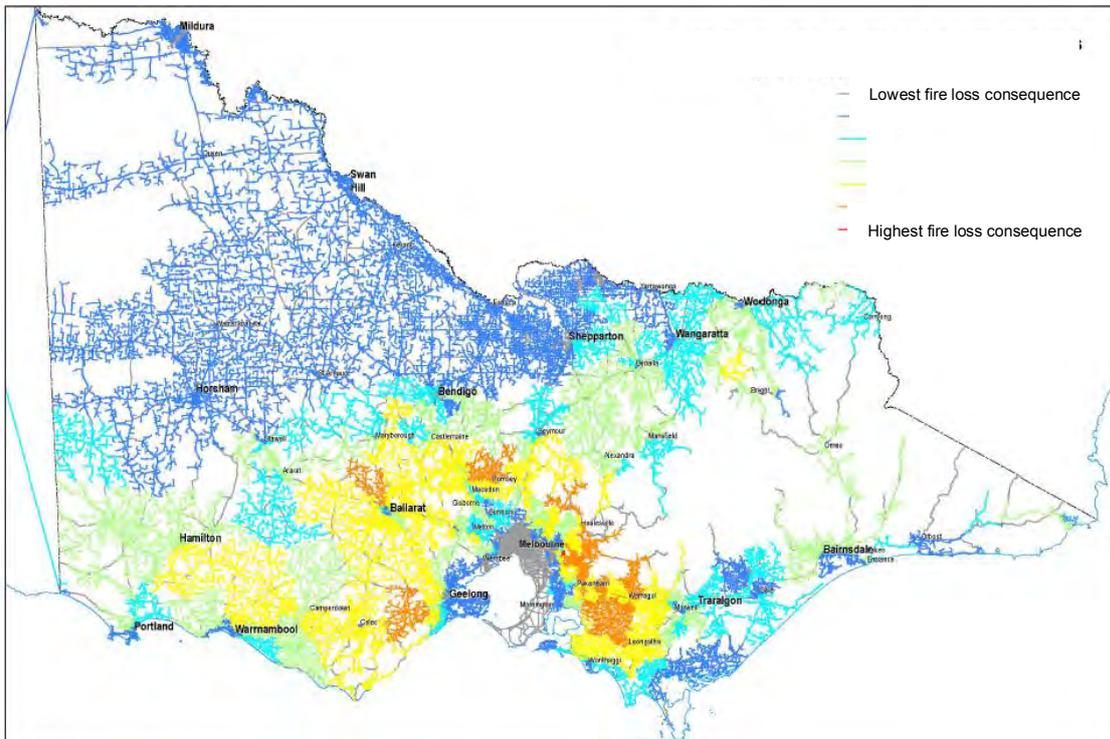


Figure 11: Fire loss consequence by powerline section based on forced Ash Wednesday conditions with fires starting at 1pm

An analysis of the fire loss consequence data has revealed that, based on forced Ash Wednesday conditions with fires starting at 1pm:

- fire risk associated with approximately 10 per cent of powerlines in rural areas that supply electricity to approximately 18,000 customers (that is less than 2 per cent of rural customers), represents the highest 54 per cent of the state’s fire loss consequence
- the highest 80 per cent of the state’s fire loss consequence is associated with fire risk from approximately 16,450 kilometres of powerlines (about 21 per cent of total rural powerline length) that supply electricity to approximately 40,000 electricity customers (about 4 per cent of total rural customers)
- the remaining 62,000 kilometres of rural powerlines (about 79 per cent of total rural powerline length) that supply approximately 900,000 electricity customers (more than 90 per cent of total rural customers) is associated with the last 20 per cent of the state’s fire loss consequence.

This indicates that a large proportion of the state’s fire loss consequence can be mitigated by targeting actions to a relatively small proportion of rural powerlines supplying a small proportion of Victoria’s rural customers. These powerlines are mainly located in the Dandenong Ranges extending north through to the foothills of the Great Dividing Range, the Otway Ranges and the Macedon Ranges.

The fire loss consequence across the state is a continuum from the point with the highest fire loss consequence to the point with the lowest fire loss consequence. However, for the

purpose of assessing the precautions, the Taskforce has considered the state in four broad zones ranked by fire loss consequence:

- **Extreme** – includes non-urban⁴¹ powerlines that represent the highest 50 per cent of the state’s total possible fire loss consequence. It is estimated this is only 10 per cent of total non-urban powerline length.
- **Very high** – includes non-urban powerlines that represent the next highest 30 per cent of the state’s total possible fire loss consequence. It is estimated this is about a further 10 per cent of total non-urban powerline length.
- **High** – includes all remaining non-urban powerlines that represent the lowest 20 per cent of the state’s total possible fire loss consequence. This is estimated to be 80 per cent of the state’s total non-urban powerline length.
- **Low** – all urban powerlines (where the land cannot carry fire).

The geographical areas contained in each zone are defined by fire loss consequence modelling of the whole state’s electricity supply network.

The characteristics of the three non-urban fire zones are summarised in Figure 12.

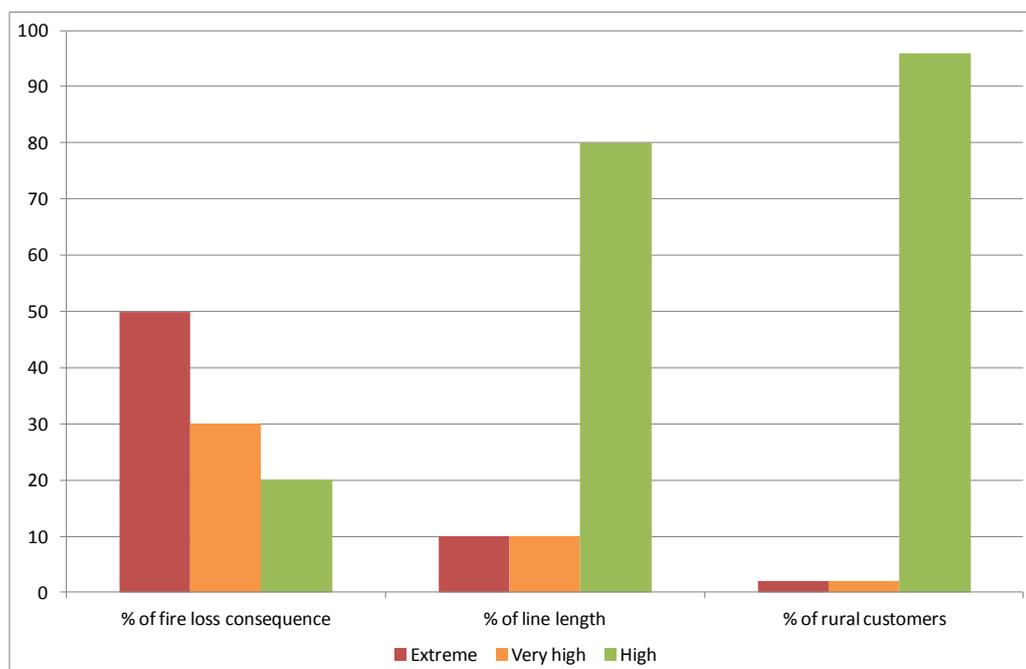


Figure 12: Characteristics of the three non-urban fire zones

The Taskforce notes that ESV will be undertaking further analysis to determine whether these are the most appropriate zones to use on an ongoing basis for bushfire mitigation purposes.

The fire loss consequence map provided in Figure 11 is based on the fire loss consequence under worst-case conditions. This information is relevant in the long-term strategic decision-making for investment in assets. The key output from the model is not so much the

⁴¹ For the purposes of this classification, urban only includes those urban built-up areas where the land cannot carry a fire.

definition of territories – it is the priority ranking of powerlines so the most effective action is taken to modify them to reduce fire risk.

Fire loss consequence modelling can also be run at shorter timescales. For example:

- an annual map using forecasts for the prevailing conditions for the coming fire season, including information on the effect of recent bushfires and controlled fuel reduction burning and possibly on the curing of grass, can be used to inform annual Bushfire Mitigation Plans
- a daily map using forecasts of the prevailing conditions for the following day can be used to inform daily operational decisions.

3.4 New ways to mitigate bushfires

The arc ignition research has identified that electric arcs can ignite fires almost instantaneously (which could be as fast as two hundredths of a second) under worst-case conditions.

Traditional protection technology in Victoria detects faults and turns off the affected powerline within a time that allows the action of switches along the powerline to be coordinated, to minimise the number of customers that lose supply when a fault occurs. However, this regime does not operate fast enough to be able to turn off powerlines within the timeframe required to minimise the likelihood that a fire will be ignited.

There are new protection technologies that can detect and respond to many powerline faults within this demanding timeframe. Those of most interest to the Taskforce are:

- Rapid earth fault current limiters (REFCLs) – these devices reduce the fault current to very low levels within a few hundredths of a second so that the likelihood of ignition is negligible. While they achieve this for wire-to-earth faults (about 70 per cent of all powerline faults), they cannot fully mitigate more complex faults involving more than one wire of the powerline, nor do they operate for SWER powerlines that start around 10 per cent of fires caused by high voltage powerlines.
- New generation SWER ACRs – these automatic network switches can operate much faster and are more sensitive than the old-style hydraulic models that are currently used in some areas. They can also be remotely controlled so they can be set to maximise fire safety on high fire risk days and to maximise customer supply reliability on other days.

Further information on these technologies is provided in the following sections.

3.4.1 Rapid earth fault current limiters

A REFCL is a relatively new technology⁴² that is able to reduce the fault current almost instantaneously when wire-to-earth faults occur. An example of a REFCL is provided in Figure 13.

The first REFCL in Australia, Swedish Neutral's Ground Fault Neutraliser, was installed at United Energy's Frankston South zone substation in late 2009. REFCLs have been used in Europe since the early 1990s to improve supply reliability, mainly on underground cable

⁴² A REFCL is based on an old technology (Petersen Coil 1916) now using digital power electronics to reach new levels of performance. It is an adjustable inductor installed between the zone substation transformer neutral point and ground which self-adjusts (tunes) to resonate with the total distribution network capacitance at 50Hz so the neutral voltage can float and allow the voltage of any wire anywhere on the network to be set to zero with respect to ground.

networks. The primary purposes of REFCLs have been improvements in supply reliability and reduction of cable damage from faults. Fire safety has not been a material concern in parts of Europe.

The independent technical expert on the Taskforce has developed a simulation of the REFCL based on data obtained from the Frankston South installation. This simulation was used in the arc ignition research to understand the likelihood of a bushfire starting with a wire-to-earth fault on a REFCL-protected powerline.

The arc ignition testing indicated that REFCLs may reduce ignition probability to levels close to zero. Ignition did not occur with simulated REFCL arcs under conditions designed to be “worst-case realistic”. Ignition in the REFCL simulation only occurred under conditions that were outside the realistic worst-case by a factor of two or more.

Discussion with the manufacturer’s technical experts indicates it is possible that the likelihood of a bushfire starting for wire-to-earth faults on REFCL-protected powerlines could be even further reduced through enhancements to the design of the REFCL. The design could be optimised prior to the installation of further REFCLs.

The REFCL only operates on multi-wire powerlines, which comprise 67 per cent of Victoria’s rural powerlines by length. It does not operate on SWER powerlines. However, SWER powerlines can be converted to multi-wire distribution powerlines if that is a cost-effective option to reduce fire risk.

The REFCL only operates for wire-to-earth faults (around 70 per cent of faults on multi-wire powerlines) and not wire-to-wire faults. Fire risk from wire-to-wire faults not mitigated by REFCLs will still occur where:

- wires clash – as discussed in section 3.2.2, this event has a high probability of emission of molten metal particles that may ignite a bushfire. Actions are therefore required to prevent wires clashing
- objects such as animals and vegetation fall across two wires of a powerline – typically, the time to ignition in such cases is tens of seconds to minutes, which is sufficient time for other protection technologies to detect the fault and turn off the powerline.

The Taskforce has estimated that the risk of a multi-wire powerline starting a bushfire with a REFCL installed is in the order of 70 per cent lower than the current risk, given the frequency and risk of wire-to-earth faults compared to wire-to-wire faults.

On the 96 per cent of days that are not high fire risk days, the REFCL will allow the powerlines to remain energised when transient faults occur (which comprise approximately 70 per cent of faults). The REFCL will therefore result in an improvement in the reliability of supply for electricity customers on those days.



Figure 13: Example of a REFCL

3.4.2 New generation SWER ACRs

To reduce the amount of time that people may be without power when faults occur, automatic switches called auto circuit reclosers (ACRs) are installed to protect powerlines, both multi-wire and SWER. When a fault occurs, these devices turn off the powerline. After a period of time, the ACR tries to turn the power back on to see whether the problem still exists.

- If the problem still exists (for example a car has run into a pole and a wire is on the ground) the power will be immediately turned off again.
- If the problem no longer exists (for example the fault is a lightning strike or debris has blown across the line and has fallen away) the power will remain on.

This sequence usually occurs several times.

Many ACRs on Victoria's electricity distribution system, particularly on rural SWER powerlines, do not detect low fault currents, have long operating times and cannot be controlled remotely to change settings on high fire risk days.

New generation SWER ACRs, an example of which is illustrated in Figure 14, are able to be remotely controlled so that the settings can be changed on high fire risk days. The fault currents detected can be reduced by setting the ACR more sensitively based on the actual load on the powerline on that day, the operating time can be reduced, and the number of times the device turns the powerline on and off when a fault occurs can be limited, that is the number of reclose attempts can be reduced. The likelihood of a SWER powerline starting a bushfire can be lower with a new generation SWER ACR installed than with the older style of ACR.

If new generation SWER ACRs are installed and set to minimise fire risk on high fire risk days (more sensitive settings and shorter operating times), there may be an adverse effect on customer supply reliability. The Taskforce must therefore carefully consider the most appropriate balance between bushfire safety and supply reliability.



Figure 14: New generation SWER ACR (pictured on the right hand side of the pole)

3.5 Victorians want balance of bushfire safety, cost, reliability, and impact on landowners and the environment

The Taskforce's Terms of Reference required it to balance the likelihood that powerlines will start bushfires on:

- the cost of electricity
- the reliability of the electricity supply
- impact on landowners
- impact on the environment.

This balance is illustrated below in Figure 15.

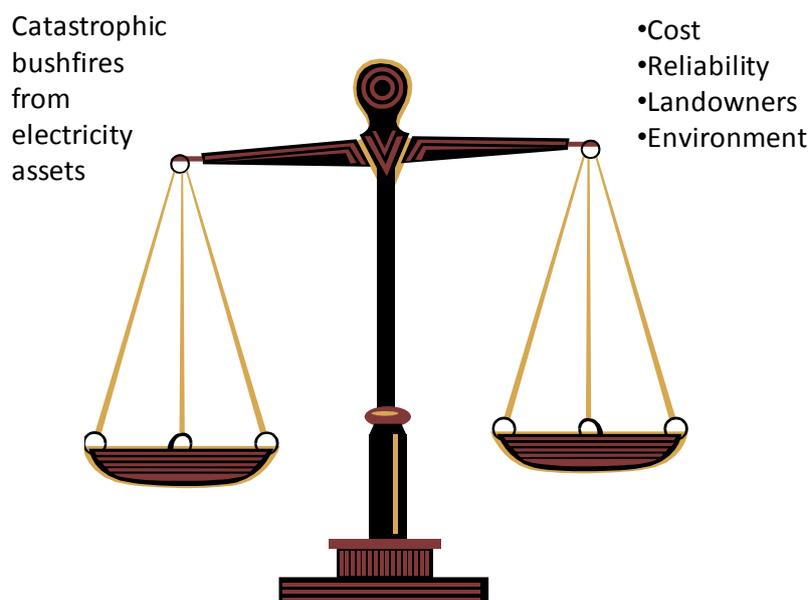


Figure 15: Balancing competing objectives

In December 2010, the Taskforce undertook customer research to get a better understanding of what Victorians regard as an acceptable balance of these competing objectives.

A total of 1500 people were surveyed in December 2010 across five different areas:

- Metropolitan – Melbourne and Geelong
- Ranges – in areas that are relatively hilly and tend to be more vegetated
- Grasslands – in areas that are relatively flat and tend to be less vegetated
- Fire-affected areas – in areas that have been affected by bushfires since 2007
- Larger regional centres – the 15 largest regional centres, excluding Geelong.

The sample in each area included 200 residential and 100 business electricity customers.

The customer research revealed that participants in the survey were overwhelmingly of the view that it is important to reduce the bushfire risk associated with powerlines when there was no cost associated with this.

When cost was added to the equation, participants indicated that, on average, they are only willing to pay a little more to reduce the likelihood of bushfire starting by powerlines – 8 per cent more (or \$25 per quarter for an average household⁴³) with no deterioration in the reliability of the electricity supply, reducing to 2 per cent (or \$6 per quarter for an average household) if there is a deterioration in the reliability of supply.

The survey results, which are illustrated in Figure 16, indicate that customers want increased safety with minimal cost increases.

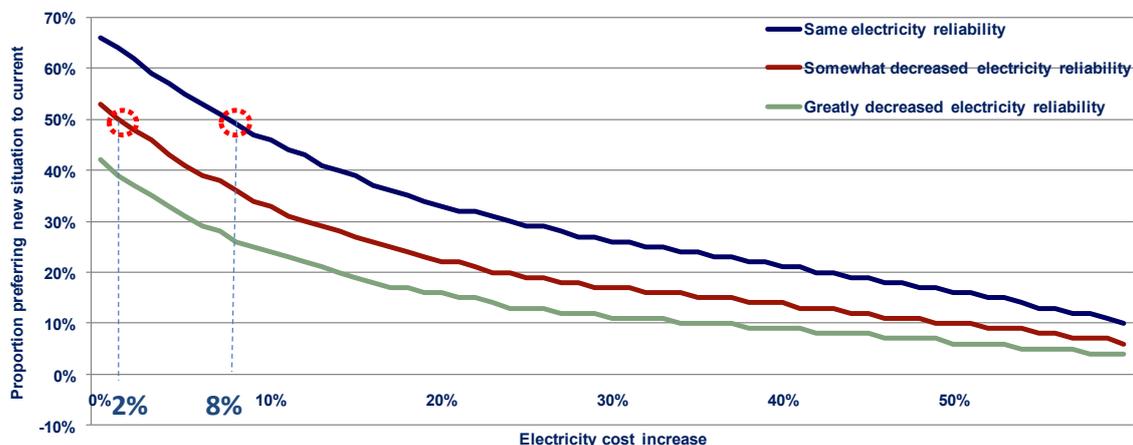


Figure 16: Willingness of Victorians to pay for reduced bushfire risk from powerlines

The customer research was undertaken prior to the announcement that a carbon tax will be introduced in July 2012 and prior to substantial increases in electricity bills from 1 January 2011 arising from renewable energy schemes and network investment cost recovery.

⁴³ Assumes the quarterly electricity bill for an average household is \$315.

The customer research also indicated that Victorians value the following attributes of electricity, in descending order of priority:

- cost of electricity
- the convenience of “flicking a switch” to get electricity
- improved bushfire safety
- reliability of supply
- environmental friendliness
- visual amenity.

The customer research indicated that the biggest gaps between the value placed on a particular attribute of electricity and the assessment of current performance in that attribute were the cost of electricity followed by improved bushfire safety. The participants in the survey generally appeared to be satisfied with the convenience and reliability of the electricity supply, and the visual amenity. These results were similar across all customers.

The survey results confirmed that Victorians will be sensitive to any increase in costs associated with reducing the likelihood of powerlines starting bushfires, and will be sensitive to any reduction in supply reliability and the convenience of being able to “flick a switch”.

3.6 Precautionary approach to bushfire risk reduction

The Taskforce has adopted a precautionary-based risk management framework to identify and assess actions that can be taken to reduce the risk that powerlines start bushfires. The precautionary-based risk management framework is currently considered to be the best practice risk management approach, consistent with the *Work Health and Safety Act 2010*, which commences operation in Victoria in January 2012, and other legal precedent.

Under the precautionary-based risk management approach, all reasonable practicable precautions are adopted based on the balance of⁴⁴:

- the significance of the risk – magnitude of risk, probability of occurrence, severity of harm
- the effort required to reduce it – expense, difficulty and inconvenience, and utility of conduct.

This is consistent with section 98 of the *Electricity Safety Act 1998*, which states that:

A major electricity company must design, construct, operate, maintain and decommission its supply network to minimise as far as practicable—

- a) the hazards and risks to the safety of any person arising from the supply network; and
- b) the hazards and risks of damage to the property of any person arising from the supply network; and
- c) if that network is an at-risk supply network, the bushfire danger arising from that network.

where practicable is defined as having regard to:

⁴⁴ Sappiden, C., Stillman, R.H., *Liability for Electrical Incidents: Risk, Negligence and Tort*, EA Books, 1995, page 22

- a) the severity of the hazard or risk in question; and
- b) the state of knowledge about the hazard or risk and any ways of removing or mitigating the hazard or risk; and
- c) the availability and suitability of ways to remove or mitigate the hazard or risk; and
- d) the cost of removing or mitigating the hazard or risk.

The precautionary-based risk management approach is in contrast to the likelihood-consequence risk management approach that is in common use. Under the likelihood-consequence risk management approach, low cost options to address foreseeable high consequence but low likelihood events are often not given priority. These options will be prioritised under the precautionary-based risk management approach because the effort required to reduce the risk is low and therefore it constitutes a reasonable practicable precaution in all circumstances.

Consistent with the precautionary-based risk management framework, the Taskforce has developed a threat-barrier model to illustrate the threats that may result in the ignition of bushfires by powerlines and the barriers that prevent the ignition of bushfires by powerlines. A simplified threat-barrier diagram is shown in Figure 17; a more detailed threat-barrier diagram is provided in Appendix E.

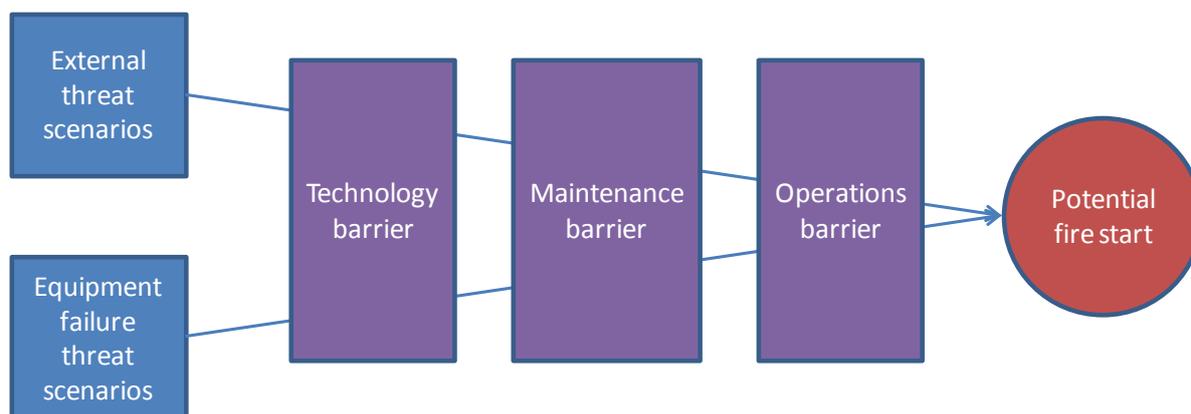


Figure 17: Threat-barrier diagram for the ignition of bushfires by powerlines on a Code Red day

Figure 17 indicates that the threats arise from faults on powerlines caused by:

- the external environment, particularly trees, tree branches, birds, animals or vehicles making contact with powerlines; wind causing powerlines to move into each other or other objects; lightning hitting powerlines; and heat causing wires to sag and touch structures below them or reach the ground
- the failure of powerlines, that is breakage of wires, collapse of poles, breakage of cross-arms, insulators or any of the many other components that make up a typical powerline.

The barriers to prevent powerlines starting bushfires are:

- technology barrier, which prevents the faults through the design of the assets
- maintenance barrier, which prevents the fault through the maintenance of the assets
- operations barrier – if the fault cannot be prevented, to detect the fault and to reduce the fault energy or turn off powerlines fast enough so that ignition does not occur.

For two main reasons, these barriers are less effective on Code Red days than on other days:

- **Weather:** Powerlines are designed for a maximum loading based on temperature and wind. On a Code Red day, the network may be operating at higher stresses due to the combination of very high temperatures, winds and loads, as occurred on Black Saturday. This is forecast to occur more frequently with the effects of climate change. New and replacement assets could be designed for higher temperatures and stronger winds, but as powerlines have a long asset life (typically 50 years), it will take many years before the entire system is upgraded to the new designs that match the environmental conditions expected with the effects of climate change.
- **Fuel:** Ignition of a fire becomes more likely as fuel dries. The speed with which the powerlines can be turned off when a fault occurs is usually adequate to prevent a fire if fuel moisture content is in the normal range. However, in worst-case conditions experienced on Code Red days, the fault current must be eliminated much faster if a fire is to be avoided with certainty. As discussed in section 3.4, the current protection and control regime does not operate at speeds required to avoid ignition under worst-case conditions.

The precautions that can be undertaken to reduce the likelihood of bushfires, and that lie within the scope of the Taskforce's Terms of Reference, are:

1. precautions to address the Royal Commission's recommendation 27 to replace powerlines with undergrounding, insulated powerlines or other technology:
 - a. underground powerlines
 - b. insulate overhead powerlines
 - c. deploy protection technologies
 - d. deliberately turn off powerlines on a temporary basis
 - e. install stand-alone power supplies and permanently turn off powerlines
2. precautions to address the Royal Commission's recommendation 32 to change the operation of powerlines by changing the reclose function
3. other precautions including:
 - a. change the design of bare wire powerlines
 - b. improve powerline maintenance
 - c. improve vegetation management
 - d. improve fuel controls
 - e. install fire detection devices.

The precautions to address the Royal Commission's recommendation 27 are discussed in more detail in section 4, the precaution to address the Royal Commission's recommendation 32 are discussed in more detail in section 5, and the other precautions are discussed in more detail in section 6.

The Taskforce has focused its efforts on strengthening precautions that prevent ignition of bushfires by powerlines. However, it notes that there are other precautions that will prevent any fire once ignited developing into a major bushfire, whether started by powerlines or by other causes. The Victorian Government must ultimately decide the best balance of precautions to prevent ignition, to mitigate development, and to mitigate the consequences of bushfires.

The Taskforce has only considered bushfires started by powerlines. Implementing the Taskforce's recommendations cannot eliminate bushfires. Indeed, as the Royal Commission acknowledged⁴⁵, the precautions will greatly reduce, but cannot totally eliminate, fires started by powerlines.

3.7 Regulation will drive action by electricity companies to reduce bushfire risk

The electricity distributors are regulated businesses subject to both safety regulation and economic regulation. The Taskforce's recommendations must be implemented in a way that is consistent with the regulatory regime.

Safety is regulated by ESV. The Victorian Government's approach to technical and safety regulation is based on risk management concepts and principles. It balances two forms of regulation:

- "outcomes-based" regulation, which requires enterprises to carry the responsibility to identify, assess and respond to risks with regulatory oversight
- prescriptive regulation, where the responsibility of the enterprise is solely to comply with the prescribed standards.

The state-based regulatory regime is largely outcomes-based with some prescriptive elements, for example:

- the obligations placed on the electricity distributors to clear vegetation around powerlines
- the requirement to inspect all at-risk supply networks at least once every three years
- the directions issued by ESV in response to the Royal Commission's recommendation 33 to fit armour rods and vibration dampers on the high voltage network, fit spreaders on the low voltage network, and ensure appropriate inter-wire spacing on the high voltage network.

Consistent with principles for best practice regulation and the current regulatory regime, the Taskforce has sought, wherever possible, to make recommendations that are outcomes-based rather than prescriptive. However, it is recognised that some prescriptive elements may be appropriate.

Economic regulation is done nationally⁴⁶ by the Australian Energy Regulator (AER). The AER's objective in determining the electricity distributors' revenues is to promote investment in, and efficient operation and use of, electricity services for the long-term interests of electricity consumers⁴⁷. This can include assessment of the efficient cost of compliance with statutory obligations such as the electric line clearance regulations administered by ESV.

In 2010, the AER made a determination on the revenues to be earned by the electricity distributors during the 2011–15 period. If a new obligation is placed on the electricity

⁴⁵ 2009 Victorian Bushfires Royal Commission, *Final Report: Summary*, July 2010, page 12

⁴⁶ Except Western Australia and Northern Territory

⁴⁷ National Electricity Law, section 7

distributors during the 2011–15 period, they can apply to the AER to pass through the costs associated with that new obligation to their customers.

The Taskforce expects the Victorian Government will implement the recommendations in this report by making a change to a regulatory obligation or requirement so that the electricity distributors are able to pass through the costs to electricity customers. The Taskforce further expects the incremental costs of its recommendations will be assessed by the AER through the normal economic regulatory process, which:

- ensures that only efficient and prudent incremental costs are passed through by the electricity distributors to their customers
- takes into consideration the costs avoided by the electricity distributors
- may include a mechanism to ensure that costs passed through are based on volumes actually delivered.

4 Addressing Royal Commission's recommendation 27 (replace powerlines)

The Taskforce has considered five broad approaches to address the Royal Commission's recommendation 27 related to powerline replacement, namely:

- underground powerlines, refer section 4.2
- insulate overhead powerlines, refer section 4.3
- deploy protection technologies, refer section 4.4
- deliberately turn off powerlines temporarily, refer section 4.5
- install SAPS and permanently turn off powerlines, refer section 4.6.

Each of the precautions is described in detail in this section, including its objective, effectiveness in reducing bushfire risk, and the cost.

4.1 Which powerlines should be replaced?

As discussed in section 2.1, the electricity distribution network comprises sub-transmission lines, multi-wire distribution lines, SWER lines and low voltage lines. The Royal Commission's recommendations addressed only 22kV and SWER powerlines. The Taskforce is of the view that its recommendations should include all distribution powerlines, whether they operate at 6.6kV, 11kV, 12.7kV (for SWER powerlines) or 22kV.

The transmission and sub-transmission networks are more critical than the distribution network – a smaller network of lines supplies a much greater number of customers. An interruption on the transmission or sub-transmission network has the potential to impact far more customers than an interruption on a distribution or SWER powerline.

The design, operation and maintenance of transmission and sub-transmission powerlines are commensurate with the criticality of those powerlines. As a result, the number of bushfires started by transmission and sub-transmission lines is less significant on a per kilometre basis (and in total) compared to distribution lines. The Taskforce concluded that its scope should not extend to include transmission lines.

However, in some cases the sub-transmission lines are strung on the same poles as distribution lines.

The Taskforce has therefore concluded that electricity distributors may choose to replace sub-transmission lines when they replace distribution lines on the same poles, but they will not be required to do so.

Low voltage lines were not the subject of the Royal Commission's recommendations. However, the fire start data provided in section 3.1 indicates that approximately 16 per cent of bushfires started by the electricity distributors' powerlines are started by low voltage lines, although most low voltage lines are in urban areas and therefore most of the fires started by low voltage lines are started in urban areas.

Low voltage lines are often strung on the same poles as distribution lines, as illustrated in Figure 18.

The Taskforce has concluded that, to ensure the same level of safety on the high voltage distribution lines and the low voltage lines, the low voltage lines should also be replaced where they are on the same poles as high voltage lines that are being replaced.



Figure 18: Power pole with high voltage lines at the top of the pole and low voltage lines underneath

Private overhead electric lines (POELs) are defined in the *Electricity Safety Act 1998* as low voltage electric lines that take electricity from the point of supply (attachment to the distribution network) to the customer's premises. In the case of overhead lines, the point of supply is the first point of connection of that line on the customer's land. Most customers do not have a POEL – the first point of connection to the distribution network is their premises. However, those people whose premises are further away from the distribution network will have a POEL on their land.

There are approximately 43,000 POELs in Victoria.

Customers are responsible for maintaining the POELs and for clearing vegetation around them. There is an obligation on the electricity distributors to inspect the POELs every three years to ensure that customers are maintaining them and clearing vegetation as required.

In high bushfire risk areas there is currently a requirement for new POELs, and existing POELs that are to be substantially reconstructed, to be placed underground⁴⁸.

ESV is separately considering the definition of a POEL, whether the requirement to underground POELs continues to be appropriate in light of the Taskforce's recommendations, and the need for requirements on any connections between the primary premise and other buildings (for example a POEL from farmhouse to shed or pump-house).

As there is already a requirement to replace POELs with technology that has a very low fire risk, the Taskforce encourages ESV to continue to enforce the existing obligations, consistent with the intent of this report.

4.2 Put powerlines underground

To reduce the likelihood of powerlines starting bushfires, the existing bare overhead SWER and 22kV powerlines could be placed underground as illustrated in Figure 19.

⁴⁸ Electricity Safety (Installations) Regulations 2009, s.220



Figure 19: Typical high voltage underground cable, installation trench, termination structure to connect to overhead lines, and ground level auxiliary equipment associated with underground cable

Undergrounding powerlines reduces the risk of bushfires starting in two ways: it eliminates the risk of wires clashing due to high wind (with emission of molten metal particles) and it reduces the risk of contact between live electricity powerlines and other materials (resulting in electric arcs). Additionally, only wire-to-earth faults will be experienced with an underground wire and therefore, if a REFCL is installed, the fault current will be reduced almost instantaneously to a very low level for all faults.

Underground cable is a mature technology. Powerlines are currently placed underground in a range of specific circumstances:

- in many new residential estates
- where there is a financial benefit to do so
- where projects have been initiated by local communities (generally for streetscape enhancement), with joint funding by the local community, Victorian Government and electricity distributor
- where projects have been initiated by individuals and those individuals pay the costs
- where POELs are replaced.

4.2.1 Benefits and risks of placing powerlines underground

It is estimated that the likelihood of powerlines starting bushfires is reduced by around 99 per cent by undergrounding cables. The safety benefits from reduced risk of bushfires are offset somewhat by the likelihood of electrocution through inadvertent digging into underground cables.

In addition to the reduced likelihood of bushfires, benefits associated with underground cable options include reduced number of supply interruptions (particularly transient interruptions), reduced maintenance, improved visual amenity, reduced safety risk of contact with live overhead wires and improved resilience of the supply system to fires.

Some of the benefits of underground cables are not as clear-cut as they appear.

- While customers may experience a reduced number of supply interruptions with an underground system, the time to find and repair faults is longer and this results in longer supply interruptions. There are few published studies that compare the reliability performance of overhead and underground networks, though a UK study indicates their overall average performance (average minutes off supply) is almost the same.
- Fault currents can also be much greater than with bare overhead wire, leading to safety issues if underground cables are inadvertently dug up.

- Installation of underground cable is more disruptive than for overhead lines. A cleared work space up to 10 metres wide is required to lay the cables initially and again when the cables are due for replacement, for access by heavy trenching and cable laying vehicles (refer Figure 20). An easement must also be retained for ongoing maintenance and repair. This has significant implications for vegetation clearance, cultural heritage values, native vegetation and access where cables are on private property.
- Underground cables are more vulnerable to flooding than overhead bare powerlines and may also be damaged by intense fires, especially near the entry and exit points to above ground auxiliary equipment.



Figure 20: Plough for undergrounding cable

Technology for undergrounding SWER lines is not mature. If SWER lines were to be replaced with underground cable, a single wire or two wire line would most likely be used. This may have side-benefits in improved voltage stability and supply capacity in the network.

4.2.2 Cost to put powerlines underground

Despite the benefits associated with placing powerlines underground, the large majority of powerlines in Victoria remain above ground. The reason is cost – undergrounding of powerlines is very expensive even in the most ideal conditions.

The capital cost to put powerlines underground varies significantly across the state based on:

- The terrain – the costs are higher in hillier terrain than flat terrain. If the terrain is hilly, the powerline route length is longer as the cable must follow the terrain rather than using long spans from one ridgeline to another.
- The soil conditions – underground cables require a 600–750mm deep trench. If the ground is rocky, the cost increases substantially. If the soil is sandy, the trenching cost is much lower.
- Dwelling density – the costs are higher on a kilometre basis, where there are more connections to the electricity distribution system.

The terrain, soil condition, vegetation, dwelling density, and other constraints across the state have been mapped. These maps are provided as Appendix G.

Preliminary indicative costs that were used by the Taskforce in its Consultation Paper were based on average costs across the state. To improve the accuracy of the estimates, and to be able to factor in changes in route length, five representative areas of approximately 100 square kilometres were each surveyed.

The areas surveyed are representative of the areas that are identified as being in extreme and very high fire loss consequence areas. Areas that are representative of high and low fire loss consequence areas were not surveyed as the Taskforce had concluded that it was unlikely that powerlines would be replaced across the state due to the high cost and alternative options available. Rather, it was more likely that powerlines would be replaced on a targeted basis to the powerlines with the highest fire loss consequence.

The characteristics of the five areas surveyed are summarised in Table 5.

Area number	Terrain	Soil conditions	Dwelling density
1	Undulating	Generally sandy	Medium
2	Undulating-hilly	Generally average	Generally high
3	Undulating-hilly	Generally average	Low-medium
4	Flat	Average	Low
5	Flat	Average	Low

Table 5: Characteristics of the five areas surveyed⁴⁹

Detailed cost estimates were derived for each area. The location and routing of the replacement technologies were optimised to take into account the specific circumstances of the terrain, soil condition, vegetation, access to easements, and any other constraints.

The cost estimates included all associated work, for example removal and disposal of superseded assets, connection of customers, and replacement of substations where required. The cost estimates assumed that all ground mounted substations and associated equipment were fire proofed, for example by locating them in steel enclosures on concrete pads.

The cost estimates include the direct costs only. Indirect overheads that are already paid for through network tariffs and financing costs were not included. Further details on the assumptions are provided in Appendix F.

On a per kilometre basis, the capital costs varied significantly by area, as set out in Table 6.

Powerline replacement option	Range of unit capital costs (2011 dollars)
Underground existing SWER lines	\$252,870 – \$389,980 per km
Underground existing HV lines	\$261,950 – \$649,870 per km

Table 6: Unit capital cost to put powerlines underground

The capital cost to underground all powerlines in non-urban areas of the state is estimated to be in the order of \$40 billion⁵⁰.

The Terms of Reference required the Taskforce to consider the avoided costs associated with undergrounding. A discounted cash flow methodology has been applied, whereby the cash flow with the replacement option is compared to the cash flow assuming a continuation of the current asset management practices from 2012 to 2065, discounted to

⁴⁹ Area numbers 4 and 5 are representative of a large proportion of the state. Two areas were surveyed to increase the size of the sample, given the significance of this type of area to the estimated costs.

⁵⁰ In real 2011 dollars, undiscounted

2011 based on three discount rates (high – 10 per cent per annum, medium – 8 per cent per annum and low – 6 per cent per annum).

The differences between the cash flows relate to:

- the timing of the replacement of the asset – when an asset is replaced earlier than it would have otherwise, it avoids the replacement that would have occurred under business as usual. However, the service life of underground cable is much shorter than that of overhead powerlines (45 years as compared to 70 years), so there is a higher cost of replacement over time. The age profile of the existing assets has been averaged across the entire network and applied to each representative area to estimate the avoided costs associated with premature replacement of existing assets
- the differences in the maintenance costs between the replacement option and business as usual
- the benefit (or cost) to customers of an improvement (or deterioration) in reliability based on a value of customer reliability (VCR) of \$16.33 per kWh.

Further details on the avoided cost assumptions are provided in Appendix F.

The incremental cost of putting powerlines underground was determined by subtracting the avoided cost from the capital cost.

The net present value (NPV) of the avoided and incremental costs to put powerlines underground, on a per kilometre basis, is set out in Table 7.

Powerline replacement option	Range of unit avoided costs (NPV, 2011 dollars)	Range of unit incremental costs (NPV, 2011 dollars)
Underground existing SWER lines	\$13,690 – \$60,930 per km	\$160,140 – \$258,320 per km
Underground existing HV lines	\$13,690 – \$47,390 per km	\$166,510 – \$408,750 per km

Table 7: NPV of unit avoided and incremental cost to put powerlines underground

To be able to apply the incremental costs to powerlines in other areas, an algorithm was developed for each technology to link the costs to one or more of terrain, soil condition and dwelling density.

4.3 Insulate overhead powerlines

To reduce the likelihood of powerlines starting bushfires, the existing bare overhead SWER and 22kV powerlines could be replaced with insulated overhead powerlines.

Replacing bare wire powerlines with insulated overhead powerlines reduces the risk of bushfires starting in two ways: it eliminates the risk of wires clashing due to high wind (with emission of molten metal particles) and it reduces the risk of contact between live electricity powerlines and other materials (resulting in electric arcs). If each wire of the line is shielded, then only wire-to-earth faults will occur and therefore, if a REFCL is installed, the fault current will be reduced almost instantaneously to a very low level for all faults.

The extent to which the fire risk is reduced depends on the extent to which the bare wire system is replaced with these technologies. If some assets, such as transformers and fuses, remain above ground and are uninsulated, or the insulation on the powerline deteriorates over time and becomes ineffective, some risk remains.

The Taskforce has specifically considered three forms of insulated overhead powerlines:

- aerial bundled conductor (ABC)
- covered wire
- covered wire with support wire.

The Taskforce is also aware of other technologies that are under development through submissions and representations made to the Taskforce, and improvements that are being made to existing technology. The Taskforce's recommendations are not based on any one particular insulated powerline technology and allow for the most appropriate technology to be selected for the particular application by the electricity distributors.

ABC is a bundle of fully insulated wires, as illustrated in Figure 21. It has been used extensively in Victoria at low voltage level, but much less so at the higher voltage levels of powerlines under consideration by the Taskforce.



Figure 21: Typical high voltage ABC powerline in a heavily forested area

Covered wire is less expensive than ABC but more expensive than bare wire. Covered wire powerlines have insulated⁵¹ wires but they are not bundled, that is they look like normal bare wire powerlines but with heavier black plastic-covered wires, as illustrated in Figure 22.



Figure 22: Covered wire

A covered wire can be strung with a support wire, as illustrated in Figure 23. The wires are held in a triangular arrangement under a support wire that provides superior protection from branches, trees and other forces that commonly bring down overhead wires during storms. The support wire is earthed so it also protects the powerline from lightning.

The covered wire with support wire, which has been used in Western Australia but has not been used in Victoria, is more visually obtrusive than ABC.

⁵¹ The insulation thickness in covered wires is generally less than that used for ABC.



Figure 23: Covered wire with support wire

4.3.1 Benefits and risks of insulated overhead powerlines

The risk of bushfires starting with ABC is greater than for underground cable as there is a greater likelihood that any energy release, for example when a wire is pulled down by falling tree branches, will ignite vegetation. It is estimated that the likelihood of powerlines starting bushfires is reduced by around 90 per cent by insulating overhead wires if the auxiliary equipment such as transformers and fuses, which can emit molten metal particles, remain mounted on the power poles.

The Taskforce has also considered an option in which the auxiliary equipment is enclosed so that failure of this equipment is less able to ignite nearby fuel. The likelihood of powerlines starting bushfires is estimated to be reduced by around 99 per cent by insulating overhead wires and enclosing auxiliary equipment in steel cabinets. The reduction in the likelihood of powerlines starting bushfires associated with this option is close to that of underground cable.

The benefits of ABC, other than the reduced risk of bushfires, include reduced vegetation clearance, reduced number of supply interruptions and reduced safety risk of contact with live overhead wires.

However, ABC is very heavy. As a result, spans are shorter (around 100–200 metres compared to more than 1000 metres for SWER lines) and more poles are required to support it. The shorter distance between poles has the visual effect of a “picket fence” and reduces land area available for cropping where it is strung across private land. A confidential submission received by the Taskforce advised that GPS navigation systems used with heavy agricultural machinery “would not cope with more power poles than already exist”.

Customer research undertaken by the Taskforce reveals some acceptance of more visible electricity infrastructure if it reduces fire risk, as illustrated in Figure 24.

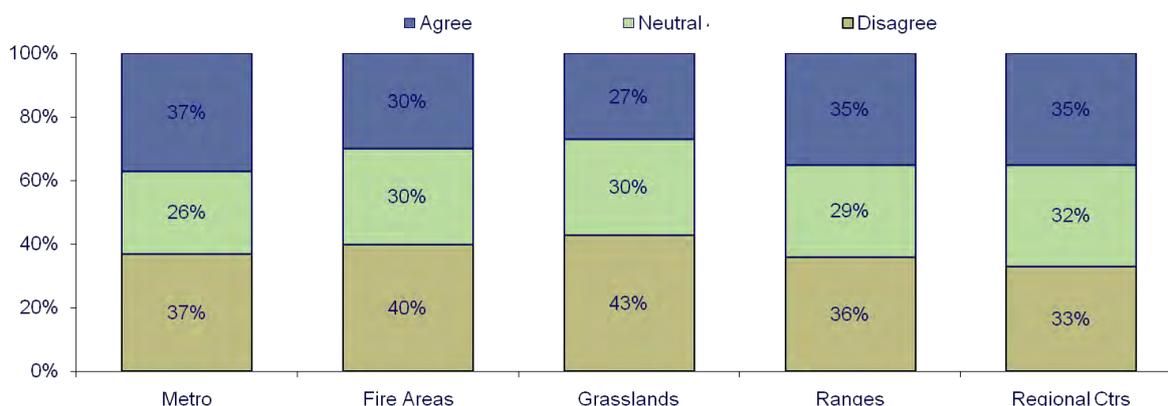


Figure 24: Proportion of customers that would accept more visible poles and larger wires

ABC is unlikely to be suited to heavily vegetated areas, despite its cost advantage over underground cable, for the following reasons:

- When trees or branches fall onto or across the ABC powerline, major damage results when the wire is torn off the poles. This damage can extend well away from the point of tree impact and repair costs can be very high. This problem is exacerbated when damage to the wire is not visible under the insulating covering.
- Though energy release is less frequent, when it does occur (for example due to heavy tree or branch impact), the amount of energy released can be very high as the fault is wire-to-wire with almost zero fault resistance. This means faults have a high ignition probability when forest fuel moisture content is low.
- ABC is not robust in fires – high intensity fires will destroy the insulation and render the cable inoperable. ABC powerlines would most likely need complete replacement after a high intensity bushfire passes and could not be used pending replacement.

The benefits associated with covered wire relative to bare wire are less than those of ABC. The required vegetation clearance spaces are greater though still less than for bare wires. Spans of covered wire are longer than ABC, but shorter than bare wire, reducing the “picket fence” appearance and effects on landowners.

Covered wire is also more resilient than ABC to fires. The fire may destroy the insulation, but the wire spacing may be sufficient for the line to operate temporarily until it is replaced.

4.3.2 Cost of insulated overhead powerlines

As with undergrounding powerlines, the capital cost of insulated overhead powerlines varies significantly across the state based on:

- the terrain – the costs are higher in hillier terrain than flat terrain
- dwelling density – the costs are higher on a kilometre basis, where there are more connections to the electricity distribution system.

Soil conditions have less influence on the costs of insulated overhead wires than on the costs of underground cables.

The approach to estimating the costs of insulated overhead powerlines was the same approach to estimating the costs for undergrounding powerlines, as discussed in section 4.2.2.

On a per kilometre basis, the capital costs varied significantly by area, as set out in Table 8.

Powerline replacement option	Range of unit capital costs (2011 dollars)
Insulated overhead wire – auxiliary equipment mounted on poles	
Replacement of SWER lines with covered wire	\$112,490 – \$221,910 per km
Replacement of HV lines with covered wire	\$111,900 – \$221,910 per km
Replacement of SWER lines with ABC	\$221,720 – \$320,100 per km
Replacement of HV lines with ABC	\$223,760 – \$318,880 per km
Replacement of SWER lines with covered wire with support wire	\$90,170 – \$202,320 per km
Replacement of HV lines with covered wire with support wire	\$90,490 – \$164,610 per km
Insulated overhead wire – auxiliary equipment enclosed	
Replacement of SWER lines with covered wire	\$124,030 – \$259,930 per km
Replacement of HV lines with covered wire	\$124,050 – \$252,430 per km
Replacement of SWER lines with ABC	\$233,020 – \$357,820 per km
Replacement of HV lines with ABC	\$234,850 – \$344,550 per km

Table 8: Unit capital costs of powerline replacement options

The capital cost to insulate all powerlines in non-urban areas of the state is estimated to be in the order of \$20 billion⁵².

On a per kilometre basis, the NPV of the avoided and incremental costs for each replacement option are set out in Table 9.

Powerline replacement option	Range of unit avoided costs (2011 dollars)	Range of unit incremental costs (2011 dollars)
Insulated overhead wire – auxiliary equipment mounted on poles		
Replacement of SWER lines with covered wire	\$12,470 – \$58,010 per km	\$63,100 – \$141,600 per km
Replacement of HV lines with covered wire	\$12,470 – \$38,280 per km	\$63,270 – \$141,300 per km
Replacement of SWER lines with ABC	\$12,470 – \$58,010 per km	\$127,410 – \$210,530 per km
Replacement of HV lines with ABC	\$12,470 – \$38,280 per km	\$121,150 – \$206,160 per km
Replacement of SWER lines with covered wire with support wire	\$12,540 – \$58,540 per km	\$47,400 – \$101,530 per km
Replacement of HV lines with covered wire with support wire	\$12,540 – \$43,200 per km	\$47,630 – \$101,290 per km
Insulated overhead wire – auxiliary equipment enclosed		
Replacement of SWER lines with covered wire	\$12,470 – \$58,010 per km	\$71,210 – \$168,290 per km

⁵² In real 2011 dollars, undiscounted

Powerline replacement option	Range of unit avoided costs (2011 dollars)	Range of unit incremental costs (2011 dollars)
Replacement of HV lines with covered wire	\$12,470 – \$38,280 per km	\$71,220 – \$163,030 per km
Replacement of SWER lines with ABC	\$12,470 – \$58,010 per km	\$146,280 – \$215,930 per km
Replacement of HV lines with ABC	\$12,470 – \$38,280 per km	\$148,990 – \$207,390 per km

Table 9: NPV of unit avoided and incremental costs of powerline replacement options

To be able to apply the incremental costs to powerlines in other areas, an algorithm was developed for each technology to link the costs to one or more of terrain, soil condition and dwelling density.

4.4 Deploy protection technologies

Protection technologies are installed to detect when there is a fault on a powerline and then to turn off the part of the powerline on which a fault has occurred.

The arc ignition research undertaken by the Taskforce, and described in section 3.2.1, indicates that the likelihood of powerlines starting bushfires is substantially reduced if the sensitivity and speed of protection equipment is improved so that more faults are detected, and are detected more quickly.

The Taskforce has identified the following three protection technologies that could detect more faults and/or detect them more quickly:

- REFCLs – very substantially reduce the fault current on the 22kV network (and other parts of the multi-wire network) when a wire-to-earth fault occurs
- new generation SWER ACRs – enable more faults on SWER lines to be detected and for them to be detected more quickly than the existing protection technologies
- high impedance protection relays – enable high impedance faults (with low fault currents) to be detected. These are currently not detected.

Each of these technologies is described in further detail in the following sections.

4.4.1 Rapid earth fault current limiters

As discussed in section 3.4.1, a REFCL is installed in a zone substation to reduce the energy released in wire-to-earth faults on the multi-wire powerlines that are supplied by that zone substation. The Taskforce estimates that a REFCL reduces the likelihood of multi-wire powerlines (not SWER powerlines) starting bushfires by around 70 per cent⁵³.

If a REFCL is installed at all zone substations in Victoria, the state's bushfire risk is reduced by around 50 per cent. If a REFCL is installed at all zone substations that have at least part of one powerline that is in an extreme fire loss consequence area, the state's bushfire risk is reduced by around 35 per cent. The state's bushfire risk can be reduced further if SWER powerlines are replaced by multi-wire powerlines so that the REFCL is effective on those powerlines.

⁵³ This estimate was verified by analysing historical faults experienced by Powercor and SP AusNet and assessing the proportion of these faults that would be mitigated by the REFCL.

Following the successful trial of a REFCL at Frankston South, Jemena and United Energy will be installing REFCLs at the following zone substations that serve high bushfire risk areas (as currently defined in the regulatory framework):

Year	Jemena	United Energy
2012/13	Sunbury, Tullamarine	Frankston, Carrum
2013/14	Coolaroo	Mornington, Dromana
2014/15		Hastings
2015/16		Rosebud, Sorrento

Table 10: Planned REFCL installations

Jemena and United Energy will also be converting all their SWER powerlines to bare wire multi-wire lines so that the REFCLs will be effective in all their high bushfire risk areas (as currently defined in the regulatory framework), that is 13 km and 44 km of SWER lines, respectively.

Powercor and SP AusNet currently have no funding to install REFCLs in the 108 zone substations in their electricity distribution areas that have powerlines that enter non-urban areas.

The cost of the REFCL itself (approximately \$600,000 - \$800,000) can be small relative to the cost of the associated ancillary works that may be required⁵⁴. The cost for each zone substation will vary considerably based on:

- the number of surge arresters that need to be replaced
- the extent to which the feeders need to be rebalanced
- whether it is prudent to also replace some old-style slow circuit breakers in the zone substation, particularly in extreme and very high fire loss consequence areas.

The total costs are estimated to range from around \$1 million per zone substation to around \$9 million per zone substation, depending on the amount of ancillary work required.

Assuming an average cost of around \$4 million per zone substation for the REFCL and associated works, the cost to install REFCLs in all zone substations in the state that supply non-urban areas would be in the order of \$430 million. This is substantially less than the cost to replace powerlines across the state.

It is estimated that the incremental cost of a REFCL is in the order of \$3 million, with the installation of the REFCL bringing forward the replacement of other substation and line equipment.

Current powerline protection systems ensure powerline faults remain energised long enough for protection systems along the line to disconnect only the faulted part of the line and beyond. As indicated previously, the arc ignition research has indicated that powerline faults will need to be detected more sensitively and powerlines disconnected more quickly on high fire risk days, making it more likely that:

- powerlines will be automatically turned off when a fault occurs

⁵⁴ Ancillary works include rebalancing load and capacitive current on feeders, replacing surge arresters, reconfiguring capacitor banks and replacing protection equipment.

- the whole powerline will be automatically turned off with little information available to electricity distributors on the location of the fault resulting in longer delays before powerlines are turned back on
- there are more instances of powerlines automatically turning off with more customers affected in each instance.

The situation is likely to be less severe with RECFLs installed, particularly in areas of lower fire loss consequence.

Powerlines are currently automatically turned off for a short period when transient faults occur. With a REFCL installed, the powerlines may not need to be turned off when transient faults occur. Electricity customers that are supplied by 22kV powerlines (and other multi-wire powerlines) with a REFCL installed may therefore experience an improvement in supply reliability on the 96 per cent of days (on average) when the bushfire risk is not high and a less adverse impact on supply reliability on high fire risk days.

Additionally, if powerlines are placed underground and a REFCL is installed, the powerline may continue to be energised when a fault has occurred if safety outcomes are not threatened, as occurs in Europe.

4.4.2 New generation ACRs for SWER powerlines

An overview of the new generation SWER ACR was provided in section 4.3.2. The replacement of older style SWER ACRs with the new generation SWER ACRs will facilitate the change in network reclose function that is discussed in section 5.

SP AusNet has successfully trialled the new generation SWER ACR, and Jemena and United Energy have already installed a small number. Initial indications are that these devices can achieve fault clearance in hundredths of seconds.

The estimated cost of the new generation ACRs with remote communications is approximately \$30,000 each. SP AusNet has received an allowance to replace its SWER ACRs (approximately 500) during the 2011–15 period. Powercor has no allowance to replace its SWER ACRs (approximately 800). If all SWER ACRs are to be replaced, it is also proposed to replace 400 fuses in Powercor's area and 100 fuses in SP AusNet's area with the new SWER ACRs. The cost to replace the SWER ACRs and fuses in Powercor's and SP AusNet's area is approximately \$36 million and \$3 million, respectively.

With the installation of new generation SWER ACRs and the change in the network reclose function to one fast protection operation, the Taskforce estimates that the likelihood of SWER powerlines starting bushfires will be reduced by 50 per cent. The likelihood of SWER powerlines starting bushfires will be reduced to approximately 45 per cent or 10 per cent if the network reclose function is changed to two fast or one fast and one slow protection operation, respectively.

4.4.3 High impedance protection relays

While new generation ACRs on SWER powerlines can be set more sensitively than current ACRs, they may still not detect faults if the fault current is close to normal levels of load current. Low fault currents can occur if a powerline falls onto dry sandy soil or a dry tree branch touches a live powerline.

New high impedance protection relays have recently been developed for use on multi-wire powerlines. These monitor the current waveform (rather than measure the magnitude of the current) to detect anomalies that indicate electric arcing. Unfortunately the operating time of

the high impedance protection relays is currently too long (in the order of tens of seconds) to reduce the likelihood of bushfires starting.

Additionally there are currently no high impedance protection relays for use on SWER lines, although the Taskforce is aware of a research project in Queensland to develop such a device.

Further research and development is required, which is discussed further in section 6.5.

4.5 Deliberately turn off powerlines on a temporary basis

One of the most effective options to minimise the risk of powerlines starting bushfires is to deliberately turn the powerlines off on a temporary basis on high fire risk days. If this occurs, these powerlines could not ignite bushfires on these days. While this option is effective in reducing the likelihood that powerlines start bushfires, there is a substantial trade-off in terms of the adverse impact on reliability of supply.

Under the Electricity Distribution Code, electricity distributors have the power to deliberately turn off the electricity supply if it⁵⁵:

... otherwise would potentially endanger or threaten to endanger the health or safety of any person or the environment or an element of the environment or if there is otherwise an emergency.

In his submission to the Taskforce, Michael Gunter was of the view that the Chief Fire Officer has the power to order "rural blackouts"⁵⁶ through the following provision in section 30(1)(i) of the *Country Fire Authority Act 1958*:

Where the Chief Officer believes on reasonable grounds that there is danger of fire occurring or where a fire is burning or has recently been extinguished in any urban or rural district the Chief Officer for the purpose of preventing the occurrence of a fire, of extinguishing or restricting the spread of the fire or of protecting life or property shall have and may exercise the following powers and authorities:

...

- (i) The Chief Officer may take such other measures as appear necessary for the protection of life and property.

CFA has received advice that the power of direction referred to in Michael Gunter's submission is only conferred on the Minister for Energy and Resources under Part 6 of the *Electricity Industry Act 2000* following a proclamation by the Governor in Council made under section 95 of that Act at the relevant time.

CFA is of the view that the electricity distributors are responsible for the safe operation of their powerlines. Mitigation of bushfire risks from powerlines is the responsibility of the electricity distributor, in the context of the relevant integrated fire management plan. The CFA, through the Chief Officer and the Board, can direct specific mitigation actions if specific bushfire risks are identified associated with powerlines.

Customer research undertaken by the Taskforce indicates that there is a relatively low acceptance of the concept of deliberately turning off powerlines on high fire risk days.

⁵⁵ Essential Services Commission, *Electricity Distribution Code*, section 12.2.1

⁵⁶ Submission by Michael Gunter to the Taskforce, dated 24 June 2011, page 7

Figure 25 shows only about one third of customers would actively support this approach and one third would actively oppose it.

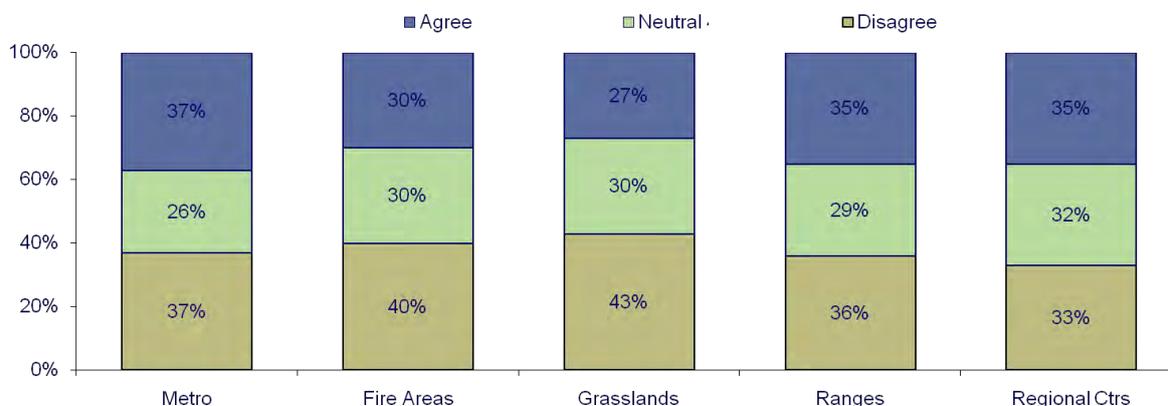


Figure 25: Customer attitudes to on high risk days to reduce bushfire risk

There are risks associated with deliberately turning the power off. Communities would not have power for equipment such as computers, radio scanners or telephones that rely on a power supply (as most modern models do) to monitor and communicate fire activity, for refrigeration of food supplies, or for pumps for fuel or water.

These risks were identified by Upper Goulburn Community Radio Inc.⁵⁷:

There are numerous other radio and TV broadcast locations around the state that are connected to supply by SWER lines. These broadcast services are vital to the safety of lives and property in times of emergency. Many of these sites also house the communications systems used by emergency services and provide vital links from day to day especially in emergencies. Most of these communications services do have limited battery back up supply; however this is not possible for broadcast services due to large power load requirements.

Power supply providers need to be very aware of these locations before power is disrupted which should be as a last resort due to the vital nature of service they provide linking the community with emergency information.

Many people rely on the internet for emergency information as well along with the many telephones that require mains power for operation as well, so turning power off is a real issue for these people especially in remote locations.

Important local infrastructure such as mobile phone base stations and local food storage may require additional back-up supply capacity to last a day without power or even longer if the high fire risk period lasted multiple days.

The welfare of vulnerable members of the community, particularly the very young, elderly and the sick may be threatened without power for medical equipment and air conditioning. A Department of Human Services (DHS) report on the effects of Victoria's January 2009 heatwave found that during the week 26 January – 1 February 2009⁵⁸:

⁵⁷ Submission by Upper Goulburn Community Radio Inc to the Taskforce, page 2.

⁵⁸ Department of Human Services, *January 2009 Heatwave in Victoria: an Assessment of Health Impacts*, 2009, page 4

There were 374 excess deaths over what would be expected: a 62% increase in total all-cause mortality. The total number of deaths was 980, compared to a mean of 606 for the previous 5 years. The greatest number of deaths occurred in those 75 years or older, representing a 64% increase.

The Victorian Farmers Federation also raised concerns regarding the welfare of animals⁵⁹:

... in regional areas of Victoria, there are over 50 dairy processing facilities, 5000 dairy farms, 40 egg farms and 1000s of livestock producers; all of which rely on electricity as a vital part of their business. Electricity reliability is essential for proper animal welfare, such as cooling chickens – both meat and egg production, cooling of pigs and water delivery to troughs. ... If there is a total loss of electricity to a chicken meat barn, the animal losses can begin within ten minutes on a hot day.

Deliberately turning the power off might be considered if communities were evacuated on high risk days, but is potentially problematic if they do not evacuate. The customer research undertaken by the Taskforce revealed that a relatively small proportion of people plan to evacuate on high risk days, as illustrated in Figure 26.

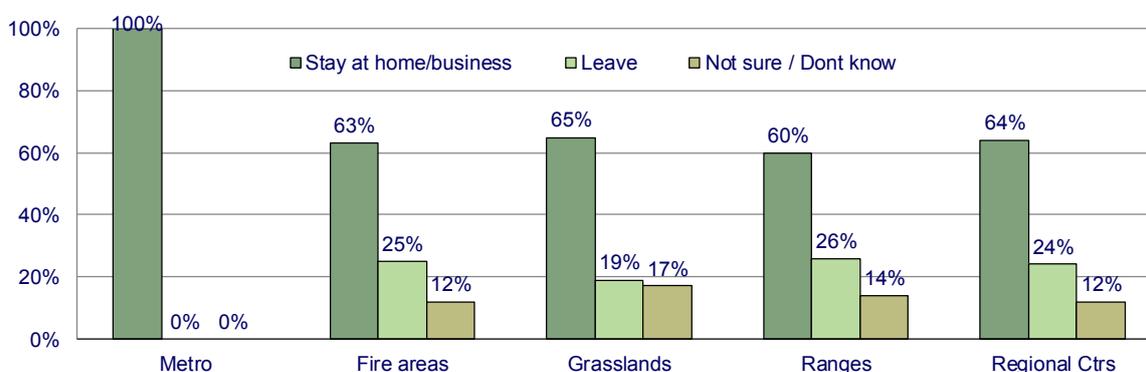


Figure 26: Proportion of customers that would stay or leave on Code Red days

The Taskforce recognises that there is a trade-off between the risks of energised powerlines starting bushfires and the risks to Victorians of deliberately turning off powerlines.

This balance has also been recognised in South Australia. Section 53 of the *Electricity Act 1996* allows the South Australian electricity distributor to deliberately turn off powerlines to reduce the risks that powerlines start bushfires:

- (1) An electricity entity may, without incurring any liability, cut off the supply of electricity to any region, area, land or place if it is, in the entity's opinion, necessary to do so to avert danger to person or property.
- (2) If an electricity entity proposes to cut off a supply of electricity in order to avert danger of a bush fire, the entity should, if practicable, consult with the Chief Officer of the South Australian Country Fire Service before doing so.

This power has been used infrequently in South Australia, and only in small areas where required due to the state of vegetation clearance or mechanical defects. The use of the power has also been accompanied by an awareness campaign over several weeks in the lead up to the temporary disconnection to ensure that the community can prepare.

⁵⁹ Submission by the Victorian Farmers Federation to the Taskforce, page 2

The Taskforce has reviewed a selection of published material on the trade-off between bushfire risk and the deliberate turning off of powerlines, including:

- Reports of the Californian Public Utilities Commission in response to applications by San Diego Gas and Electric (SDG&E) for rule changes to allow power to be turned off to reduce bushfire risk (referred to as the Shut-Off Plan)
- Research by VENCORP into the economic value of customer supply reliability to non-urban businesses and homes.⁶⁰

The Californian Public Utilities Commission concluded that⁶¹:

SDG&E's Power Shut-Off Plan would impose significant costs, burdens, and risks on the customers and communities in the areas where power is shut off. In light of these hardships, SDG&E's Power Shut-Off Plan should be adopted only if SDG&E demonstrates that its Plan will improve public safety. While the Power Shut-Off Plan will eliminate power lines as a source of ignition during hazardous fire conditions, it will create many new sources of ignition and exacerbate the risk to public safety from fires that occur in areas where power is shut off. ... Based on our review of the record, we believe that it is more likely than not that SDG&E's Power Shut-Off Plan would, on balance, negatively affect public health, safety, and welfare.

The Californian Public Utilities Commission suggested that SDG&E should assess whether reclose devices, similar to those discussed in section 5, could be used instead of the drastic step of shutting off power⁶².

The cost to Victorians of deliberately turning off powerlines can be estimated by reference to the value that electricity customers place on a reliable electricity supply, that is the direct cost incurred by customers if there is no electricity. This is referred to as the Value of Customer Reliability or VCR.

A report published by VENCORP (a predecessor organisation to the Australian Energy Market Operator) quantifies the VCR, by customer type, for outages ranging from 20 minutes to 24 hours. However, it does not distinguish the value based on the time of day of the interruption and the type of day, that is whether it is a high fire risk day or a benign day in spring.

In the absence of objective evidence and analysis on the value of supply reliability, on high fire risk days, the VCR published by VENCORP is considered to be the best information available to the Taskforce.

The estimated VCR for an eight-hour outage across rural Victoria is set out in Table 11. Consistent with the submission from the Victorian Farmers Federation, the VCR for agricultural customers is considerably higher than for residential customers.

⁶⁰ CRA International, *Assessment of the Value of Customer Reliability (VCR)*, 12 August 2008

⁶¹ Public Utilities Commission of the State of California, Decision Denying Without Prejudice San Diego Gas & Electric Company's Application to Shut Off Power During Periods of High Fire Danger, Decision 09-09-030, September 10, 2009, page 57

⁶² *ibid*, page 59

Customer type	VCR for an 8 hour interruption (\$/kWh, \$June 2007) ⁶³
Residential	8.69
Industrial	28.45
Commercial	42.87
Agricultural	120.78

Table 11: Estimated Value of Customer Reliability for an 8 hour outage

In calculating the benefits associated with putting powerlines underground and insulating powerlines, an aggregate VCR of \$16.33 per kWh has been assumed.

If the same VCR of \$16.33 per km is assumed, and the electricity was deliberately turned off to customers in rural areas for a period of eight hours (from 10am to 6pm), the direct cost to those customers is estimated to be in the order of \$170 million. With the inclusion of indirect costs and flow-on effects, the cost of deliberately turning off the powerlines for eight hours is in the order of \$360 million. The cost of deliberately turning off the powerlines for eight hours on Code Red days would exceed the cost of a \$1 billion package of measures after three years, assuming there is one Code Red day per annum.

The Taskforce has concluded that, under most circumstances, the potential impact on the community that may result from the deliberate turning off of powerlines on a temporary basis outweighs the risk of leaving them in service. There will only be limited circumstances where deliberate turning off of powerlines on a temporary basis is warranted on a “lowest overall risk” basis. However, this precaution may be “reasonable and practicable” in those limited circumstances.

The Taskforce therefore concludes that the electricity distributors should continue to be able to deliberately turn off powerlines on Code Red days where the conditions are considered to be prohibitively dangerous or where directed to do so when an emergency has been declared under the *Electricity Industry Act 2000*, noting that powerlines may automatically turn off where faults occur.

The Taskforce notes that, if the powerlines are deliberately turned off temporarily, the electricity distributors are required to inform the Victorian Departments of Human Services and Health when a residential customer is expected to be off supply for more than 24 hours⁶⁴. This ensures that the welfare of these customers can be protected, where required. The Taskforce also notes the advice that is provided on power outages to electricity customers by the Department of Primary Industries, which is provided as Appendix H.

4.5.1 Back-up generators can reduce risk of turning off powerlines temporarily but are expensive and have other risks

An option that would allow powerlines to be deliberately turned off temporarily with lower risk would be to supply customers with a back-up generator or battery/inverter system to provide electricity when grid power is turned off.

⁶³ CRA International, *Assessment of the Value of Customer Reliability (VCR)*, 12 August 2008

⁶⁴ Essential Services Commission, *Electricity Distribution Code*, section 5.7.1

Customer research indicates 12 per cent of customers already have a back-up generator of some form. The proportion increases to around 21 per cent in fire-affected and high fire risk areas. Of the 183 survey participants who currently have a back-up generator, only 18 per cent have a back-up generator that meets the full electricity needs of their household or business, that is most are sized to meet essential needs only.

Of the customers who do not currently have a back-up generator, only one third would be willing to install a back-up generator to allow electricity to be turned off on high risk days. The proportion was slightly higher for those living in high risk areas (42 per cent). The main reason customers are unwilling to install a back-up generator was cost, as illustrated in Figure 27.

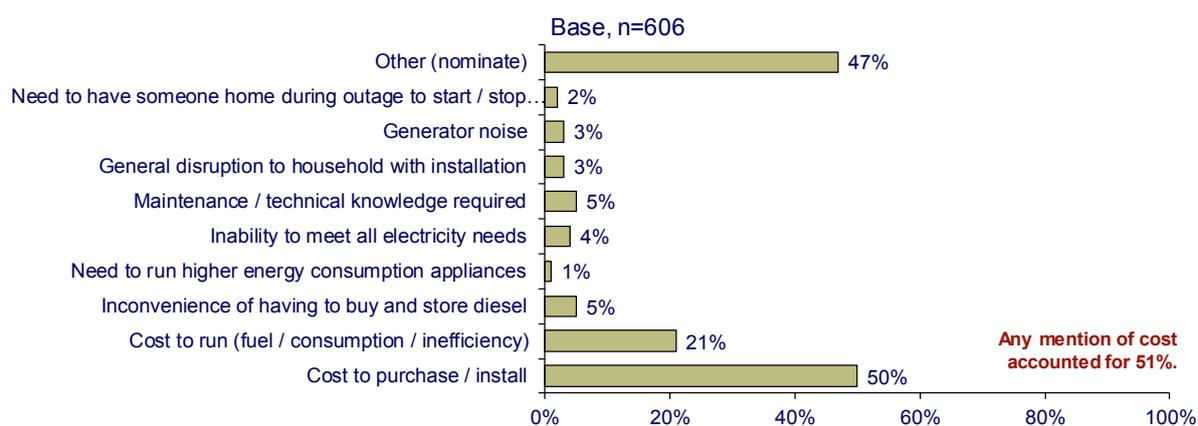


Figure 27: Reasons given for unwillingness to install a back-up generator⁶⁵

The Taskforce conducted a trial of back-up generators during summer 2010/11. The back-up generator that was used in the trial is illustrated in Figure 28. Further details on the trial are provided in Appendix I.



Figure 28: Back-up generator used in the Taskforce's trial

⁶⁵ The "Other nominate" category in Figure 27 included a variety of responses. The most common was: I do not believe this is necessary or I do not need this in this area (about 20 per cent). Others included: Already have a generator, Generator itself could be a fire risk, Do not have the space for a generator, Underground power is a better alternative, Not my decision e.g. renting, body corporate etc. Concerns re how long mains power would be off, Believe that if my electricity company maintained the infrastructure this would not be necessary, Do not believe electricity causes many fires, Would cope with power cuts/could manage without electricity, We pay for a service/electricity should always be provided, Generators pollute the environment, Believe that undergrowth clearing/clearing of vegetation would be more effective, Need to look at alternative power e.g. solar, Only a short-term issue/high fire danger days only a few a year, Need more information/need to look at this further, Difficulty in starting a generator e.g. physically difficult for the elderly.

The total capital cost for the supply, delivery and installation of the back-up diesel generators purchased for the trial was about \$20,000 per residential installation. The capital cost to supply all rural customers⁶⁶ with a back-up generator for residential use would likely exceed \$20 billion⁶⁷.

The cost to install a back-up generator would be much higher for small business and agricultural customers than for residential customers, as noted by the Victorian Farmers Federation⁶⁸:

... the cost of back-up generation for all small business and farms would be an enormous impost

Cheaper back-up generators are available, however, the lower cost flows from compromises on safety features, generator life, quality of the electricity produced, reliability and servicing requirements, and noise.

The running costs of the generator are dependent on the number of Total Fire Ban days and how many hours it is operated. Unplanned network outages (other than for bushfire risk mitigation) will also add to the running time of the generator. Under reasonable assumptions, annual fuel costs could equate to an increase in an annual average residential electricity bill of 20 per cent to 80 per cent. The cost of equipment servicing must also be added to this, and would typically be as much again.

Other options have been suggested to the Taskforce for consideration:

- A battery (with inverter) – this could normally be charged from the grid and used to supply electricity when powerlines are turned off. A relatively large battery may be required where the essential energy requirements are high or if power is to be turned off for more than a day.
- A battery (with inverter) and a solar panel charger – the battery could normally be charged by the grid or solar panel, and by the solar panel alone if the power is turned off for more than a day, assuming sufficient solar radiation on those days.

The capital costs of these alternatives would be higher than a back-up generator, but operating costs would be lower. Based on costs for the Taskforce's trial of stand-alone power supplies, the cost of a battery/inverter alone could be in the order of \$40,000 and the cost of a battery/inverter and solar panel could be in the order of \$60,000.

Households using back-up diesel generators on high risk fire days do not have the convenience of flicking a switch for electricity – they must monitor the system and ensure that the generator has sufficient fuel. There are also new potential safety risks associated with installing, operating and maintaining the back-up generator and storing liquid fuel.

The economy of an area can be negatively impacted if the powerlines are deliberately turned off frequently. The cost for households or businesses to install and operate back-up power supplies will be higher than for those with reliable supply from the electricity grid.

The Taskforce has concluded that there are more cost-effective options to reduce the bushfire risk associated with powerlines than to provide back-up generators to electricity

⁶⁶ Estimated to be approximately 1 million back-up generators

⁶⁷ In real 2011 dollars, undiscounted

⁶⁸ Submission by the Victorian Farmers Federation to the Taskforce, page 2

customers in rural areas and to deliberately turn off powerlines temporarily on high fire risk days.

4.6 Install stand-alone power supplies and permanently turn off powerlines

One of the most effective options to minimise the risk of powerlines starting bushfires is to turn off powerlines permanently, by providing customers with a stand-alone area power supply (SAPS) and removing the powerline that previously supplied them. If a SAPS is installed and the powerline is removed, there is no longer a risk that the powerline will ignite bushfires.

However, while this option is effective in reducing the likelihood that powerlines start bushfires, there is a substantial trade-off in terms of cost and the convenience of “flicking a switch”, noting the importance that customers place on having an electricity supply that is affordable and the convenience of “flicking a switch”, as discussed in section 3.5.

A typical SAPS system for a remote property includes multiple types of electricity generation, energy storage facility and conversion equipment to supply electricity at the normal mains voltage. Storage is typically implemented as a battery bank. Energy sources that can be used to charge a battery include diesel, LPG, solar, wind, natural gas, hydro or biofuel. The suitability of energy sources are site specific.

A relatively small number of Victorians⁶⁹ have independently installed a SAPS as a cost-effective alternative to connecting to the local electricity distribution network. A properly designed, good quality SAPS can provide a more cost-effective and better quality of supply than powerlines but generally only in the more remote areas of the state where the cost to connect to the electricity distribution network is high.

To better understand the impact of a large scale rollout of SAPS on Victorians, the Taskforce conducted a trial of 10 SAPS. The SAPS installed for one participant is illustrated in Figure 29.



Figure 29: SAPS installed for one participant in the Taskforce’s trial

The trial participants were surveyed, as were members of the Alternative Technology Association (ATA) that had voluntarily installed SAPS systems. Further details on the trial and survey are provided in Appendix I.

⁶⁹ In the order of hundreds

The key issues identified with the installation of the SAPS systems were:

- Overall management of the system – all SAPS systems require a certain level of expertise and management and were not entirely “set and forget”. The solar resource was poor in one of the areas in which the trial was conducted and there were battery failures requiring the back-up generator to run frequently. Some participants had physical difficulties refuelling the back-up generator.
- Need to understand monitor and adjust household consumption – SAPS owners need to have a higher awareness of overall power usage than those connected to the electricity distribution network. They need to monitor and adjust household consumption within the constraints of their SAPS. There are SAPS that require less attention, but these cost significantly more than those that do require closer attention for their day-to-day operation. The ATA members surveyed, who had significantly lower cost SAPS, did not have air conditioning, and some used gas-powered fridges or had them converted to run off a 24V DC supply.
- The need for some technical expertise – the ATA members surveyed are generally more technically minded and have a better understanding of the SAPS than the trial participants. For those not technically minded, technical skills can be hard to resource in rural locations.
- They are not suitable for a large scale roll-out – as different customers have different energy needs, SAPS must be designed and constructed to industry best practice, by suitably qualified installers, taking into account the needs of the customer. Additionally, a powerline can only be removed when all customers on the powerline install a SAPS. The trial indicated the difficulties in getting all customers on a powerline to install a SAPS, given their different circumstances.
- Cost – the cost of the SAPS used in the trial was \$120,000 each. The cost was high as the battery technology is new and not yet produced in volume. According to the manufacturer, the cost could decrease to perhaps \$90,000 with volume production of the batteries. More cost-effective SAPS are available using a conventional battery technology and if customers are prepared to trade-off safety features, quality and quantity of the electricity produced and local noise levels. Operating costs are additional and include fuel for the back-up generator and annual equipment servicing. The high up-front cost of SAPS systems means that this option is only cost-effective where the cost to supply an individual customer using powerlines is higher than the cost of a suitable SAPS for that location.

The removal of the local electricity distribution network can affect future local economic and population growth. The incremental cost for households or businesses to relocate to areas without an electricity grid will generally be higher than to relocate to areas with an electricity grid.

The Taskforce has concluded that permanently turning off powerlines by installing SAPS may be a suitable alternative to some of the more expensive measures to reduce the likelihood of powerlines starting bushfires at some of the more remote locations. However, they are not suitable as an involuntary, statewide measure.

4.7 Identifying potential packages of measures

The Taskforce was requested to identify six packages of measures to reduce the likelihood of powerlines starting bushfires, for consideration by the Victorian Government:

- Package 1: Capital cost of precautions in the order of \$200 million
- Package 2: Capital cost of precautions in the order of \$500 million
- Package 3: Capital cost of precautions in the order of \$1 billion
- Package 4: Capital cost of precautions in the order of \$2 billion
- Package 5: Capital cost of precautions in the order of \$3 billion
- Package 6: Capital cost of precautions in the order of \$10 billion.

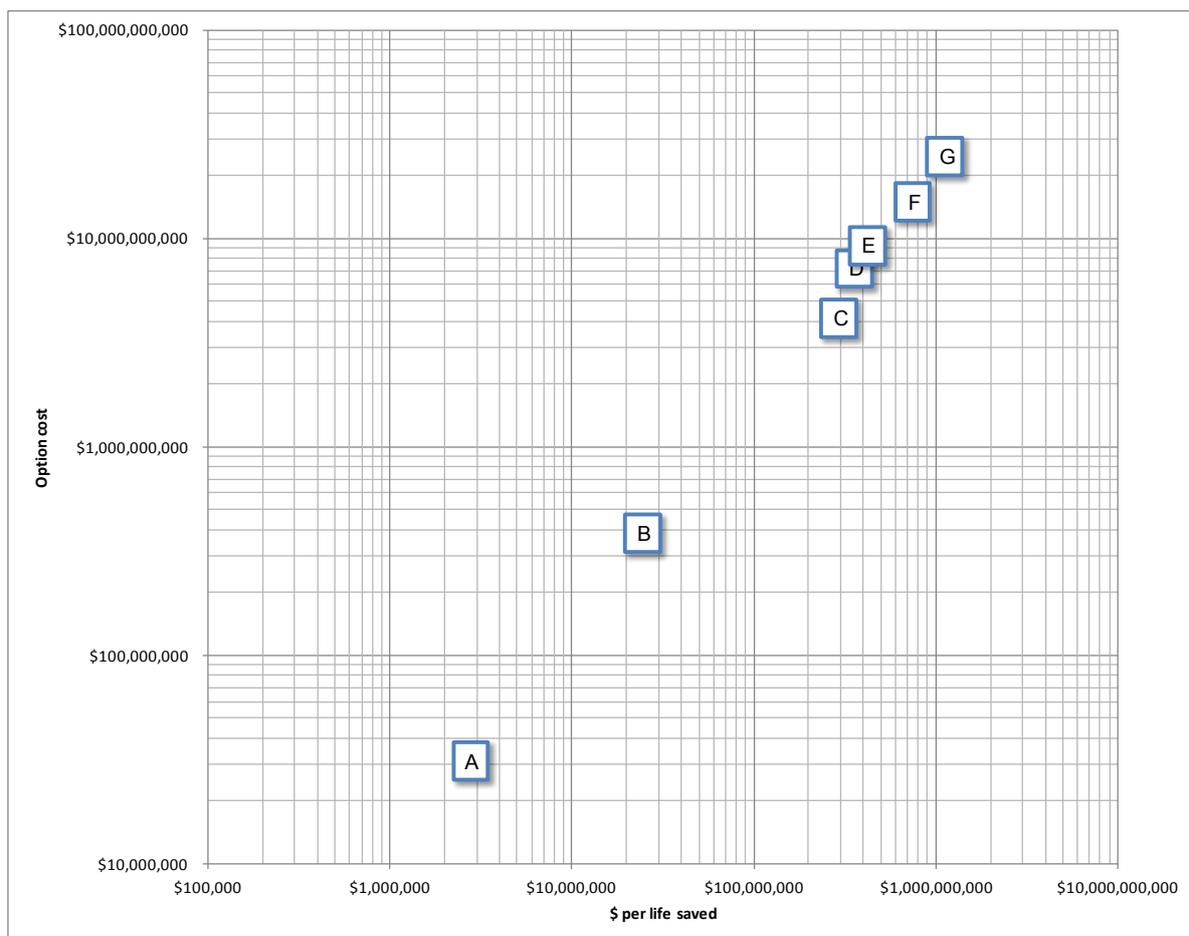
Using the precautionary-based risk management approach that is described in section 3.6, the Taskforce has identified the following bushfire risk reduction precautions that could be implemented on a statewide basis:

- underground powerlines
- insulate overhead powerlines
- deploy protection technologies.

To compare the precautions, the Taskforce has considered:

- the relative risk reduction associated with each precaution
- the cost of each precaution.

A comparison of the precautions is illustrated in Figure 30 on the basis that the precautions are implemented independently and statewide. The most cost-effective precautions to reduce bushfire risk are those with the lowest cost per life saved.



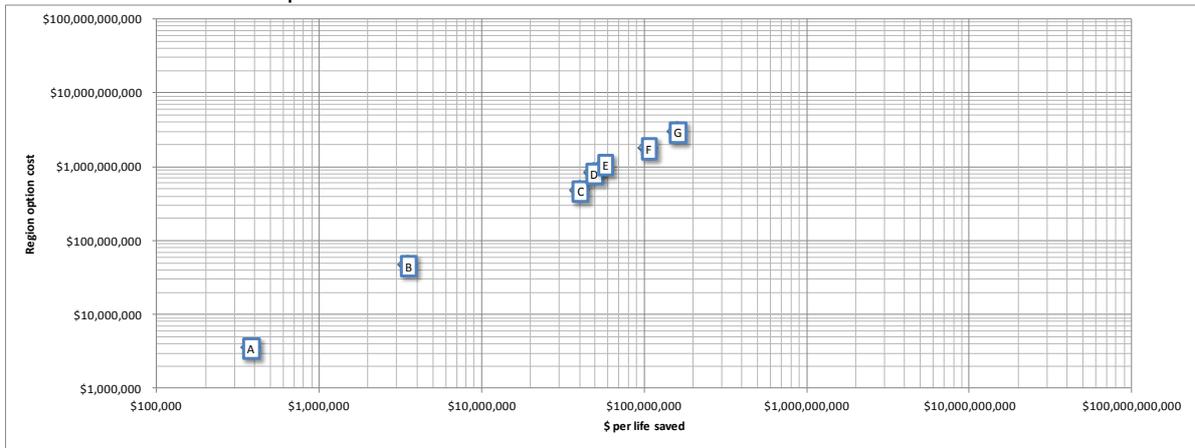
- A – New generation SWER ACRs
- B – REFCLS
- C – Convert SWER to multi-wire (with REFCL)
- D – SWER - insulated wire
- E – SWER - underground
- F – Multi-wire - insulated wire
- G – Multi-wire - underground

Figure 30: Statewide comparison of effectiveness of precautions, with each precaution considered independently

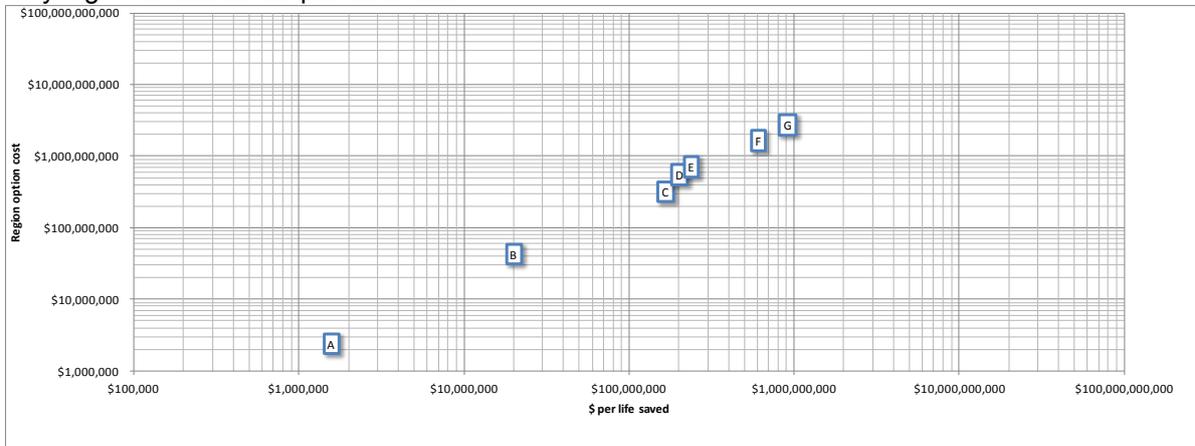
From Figure 30 it can be seen that the new protection technologies (REFCLs and new generation SWER ACRs with a change in network reclose function) have a much lower cost per life saved than the powerline replacement options.

The cost and risk reduction associated with each option varies significantly across the state. The Taskforce has therefore considered the precautions by zone – extreme, very high and high fire loss consequence areas, as illustrated in Figure 31, to identify how the precautions when implemented independently could be targeted to achieve the highest reduction in risk across the state for the lowest cost. The Taskforce notes that the cost and risk reduction associated with each option varies within the zone, but the variation is less than across the whole state.

Extreme fire loss consequence areas



Very high fire loss consequence areas



High fire loss consequence areas

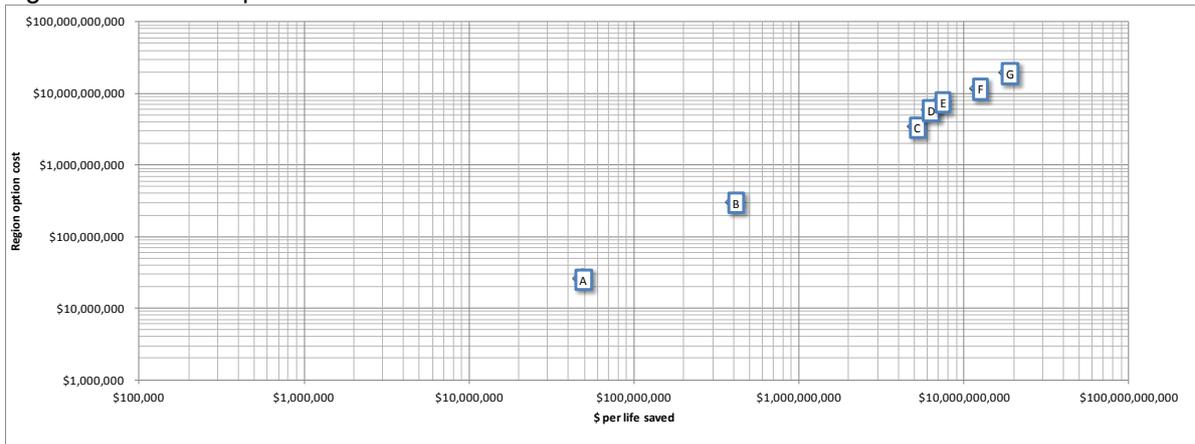


Figure 31: Comparison of the effectiveness of precautions by fire loss consequence zone, with each precaution considered independently

Figure 31 indicates that, if each precaution is considered independently, the greatest potential reduction in life and property loss can be achieved for a given cost by implementing the precautions in the sequence as set out in Table 12.

Priority	Zone	Precaution
1	Extreme	New generation SWER ACRs with change in network reclose function
2	Very high	New generation SWER ACRs with change in network reclose function
3	Extreme	REFCLs
4	Very high	REFCLs
5	High	New generation SWER ACRs with change in network reclose function
6	Extreme	Replacement of powerlines (assuming no new ACRs or REFCLs installed)
7	Very high	Replacement of powerlines (SWER) (assuming no new ACRs installed)
8	High	REFCLs
9	Very high	Replacement of powerlines (multi-wire) (assuming no REFCLs installed)
10	High	Replacement of powerlines (assuming no new ACRs or REFCLs installed)

Table 12: Most effective risk reduction sequence of precautions, with each precaution considered independently

However, the sequence of precautions changes when the interdependencies between the precautions are taken into consideration. The incremental risk reduction benefits of the higher cost precautions (powerline replacement) are eroded significantly by the risk reduction benefits of the lower cost precautions (REFCLs and new generation SWER ACRs with a change in network reclose function).

For example the reduction in the likelihood of multi-wire powerlines starting bushfires is estimated to be 70 per cent by installing a REFCL, 90 per cent by insulating overhead wires and 99 per cent by undergrounding powerlines. The incremental reduction in the likelihood of a multi-wire powerline starting bushfires is therefore estimated to be reduced to 20 percentage points by insulating powerlines following the installation of a REFCL, and 29 percentage points by undergrounding powerlines following the installation of a REFCL.

Similarly, the reduction in the likelihood of SWER powerlines starting bushfires is estimated to be 50 per cent by installing a new generation SWER ACR with a change in network operations on high fire risk days⁷⁰. The incremental reduction in the likelihood of a SWER powerline starting bushfires is therefore estimated to be reduced to 40 percentage points by insulating powerlines following the installation of a new generation SWER ACR, and 49 percentage points by undergrounding powerlines following the installation of a new generation SWER ACR.

By taking the interdependencies into consideration, the installation of REFCLs in high fire loss consequence areas is a higher priority precaution than the replacement of some

⁷⁰ Assuming the network reclose function operates with one fast protection operation only. The relative reduction in likelihood is estimated to be 45 per cent if the network reclose function operates with two fast protection operations and 10 per cent if it operates with one fast and one slow protection operation.

powerlines in extreme fire loss consequence areas and all powerlines in very high fire loss consequence areas.

By considering the sequence of precautions identified in Table 12 and the interdependencies between the precautions, the recommended packages of measures are as set out in Table 13.

Package	Capital cost (\$ million, 2011 dollars, undiscounted)	New generation SWER ACRs and change in network reclose function ⁷¹	REFCLs ⁷²	Powerline replacement
1	200	Approximately 1,300 in extreme and very high fire loss consequence areas	39 in extreme fire loss consequence areas	Nil
2	500	Approximately 1,300 in extreme and very high fire loss consequence areas	108 in extreme, very high and high fire loss consequence areas	Approx 110km of powerline replacement in extreme fire loss consequence areas
3	1,000	Approximately 1,300 in extreme and very high fire loss consequence areas	108 in extreme, very high and high fire loss consequence areas	Approx 2,400km of powerline replacement in extreme fire loss consequence areas
4	2,000	Approximately 1,300 in extreme and very high fire loss consequence areas	108 in extreme, very high and high fire loss consequence areas	Approx 7,300km of powerline replacement in extreme fire loss consequence areas
5	3,000	Approximately 1,300 in extreme and very high fire loss consequence areas	108 in extreme, very high and high fire loss consequence areas	Approx 12,100km of powerline replacement in extreme and very high fire loss consequence areas
6	10,000	Approximately 1,300 in extreme and very high fire loss consequence areas	108 in extreme, very high and high fire loss consequence areas	Approx 40,000km of powerline replacement in extreme, very high and high fire loss consequence areas

Table 13: Recommended packages of measures

The powerlines to be replaced have been identified by maximising the incremental risk reduction per incremental cost associated with each powerline replacement option. The optimisation also considers the greater likelihood of multi-wire powerlines starting fires than SWER powerlines.

⁷¹ The installation of SWER ACRs is accompanied with a change in network reclose function as discussed in section 5. Each package includes operating expenditure for a public awareness campaign on the potential impacts on supply reliability and the precautions that can be taken.

⁷² Actual number of REFCLs installed will depend on the final modelling.

4.8 Comparative analysis of packages of measures

In this section, the packages of measures are compared by considering the estimated reduction in lives and property lost by bushfires started by powerlines associated with each package of measures, the costs associated with each package of measures, and the impact of each package of measures on electricity bills.

The costs associated with the packages of measures do not include the costs that are already being paid for by:

- customers in Jemena’s area – for installing REFCLs and converting SWER powerlines to multi-wire lines
- customers in United Energy’s area – for installing REFCLs and converting SWER powerlines to multi-wire lines
- customers in SP AusNet’s area – for installing new generation SWER ACRs.

4.8.1 Reduction in risk

Table 14 sets out the estimated statewide reduction in risk of distribution lines starting bushfires resulting from the implementation of each package of measures.

The reduction in risk has been calculated based on forced Ash Wednesday conditions with fires starting at 1pm. The risk reductions may differ if different fire start conditions are assumed, however, the risk reductions are expected to be of a similar magnitude and the relative risk reduction associated with each package is expected to be similar.

The estimate of risk reduction does not take into consideration the risk associated with low voltage lines, sub-transmission lines or transmission lines starting bushfires.

Package	Estimated risk reduction associated with distribution lines	Risk reduction per \$ million of capital cost	Incremental risk reduction per additional \$ million of capital cost
1	48%	0.24%	-
2	60%	0.12%	0.040%
3	67%	0.07%	0.014%
4	77%	0.04%	0.010%
5	83%	0.03%	0.008%
6	91%	0.01%	0.001%

Table 14: Comparison of the risk reduction of distribution lines starting bushfires resulting from each package of measures

Figure 32 indicates the diminishing reduction in risk that occurs as more precautions are undertaken. There is a very significant reduction in risk by implementing package 1, but the incremental risk reduction by implementing the larger packages is small in comparison.

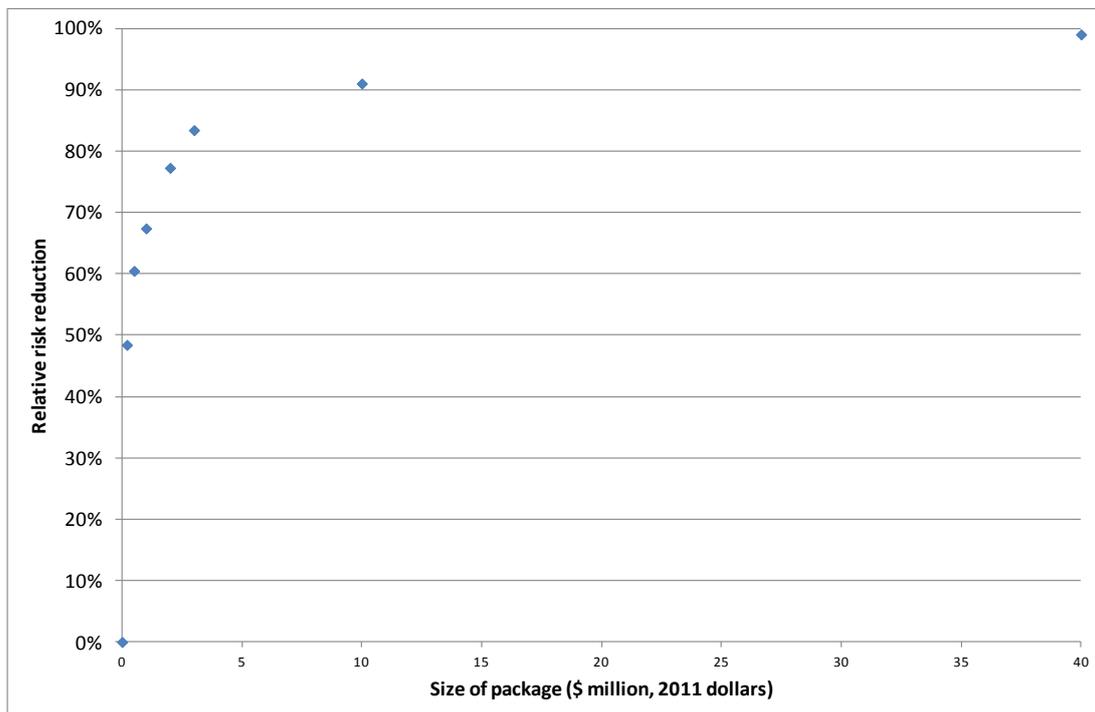


Figure 32: Risk reduction of distribution lines starting bushfires

4.8.2 Costs associated with packages of measures

The costs associated with each package of measures, expressed as the capital cost and the net present value (NPV) of the **incremental** cost, are summarised in Table 15 and Table 19, respectively.

The capital costs have been expressed in real 2011 dollars and have not been discounted. The capital costs include only direct project costs and do not include any allowance for indirect corporate costs, as these costs are already recovered by the electricity distributors through network tariffs, or financing costs. The capital costs have an error margin in the order of ± 20 per cent.

If the capital costs were to be expressed in nominal dollars (dollars of the day), they would be higher as they would take into account the escalation due to inflation.

Further details on the capital cost of each precaution are provided in sections 4.2.2, 4.3.1 and 4.4.

Package	Estimated total capital cost (\$ million, 2011 dollars, undiscounted)	Estimated capital costs associated with each precaution (\$ million, 2011 dollars, undiscounted)		
		New generation SWER ACRs ⁷³	REFCLs	Powerline replacement
1	\$200	43	156	0
2	\$500	43	432	25
3	\$1,000	43	432	525
4	\$2,000	43	432	1,525
5	\$3,000	43	432	2,525
6	\$10,000	43	432	9,525

Table 15: Comparison of the capital costs associated with each package of measures

The capital costs and cost per life saved associated with each package is illustrated in Figure 33.

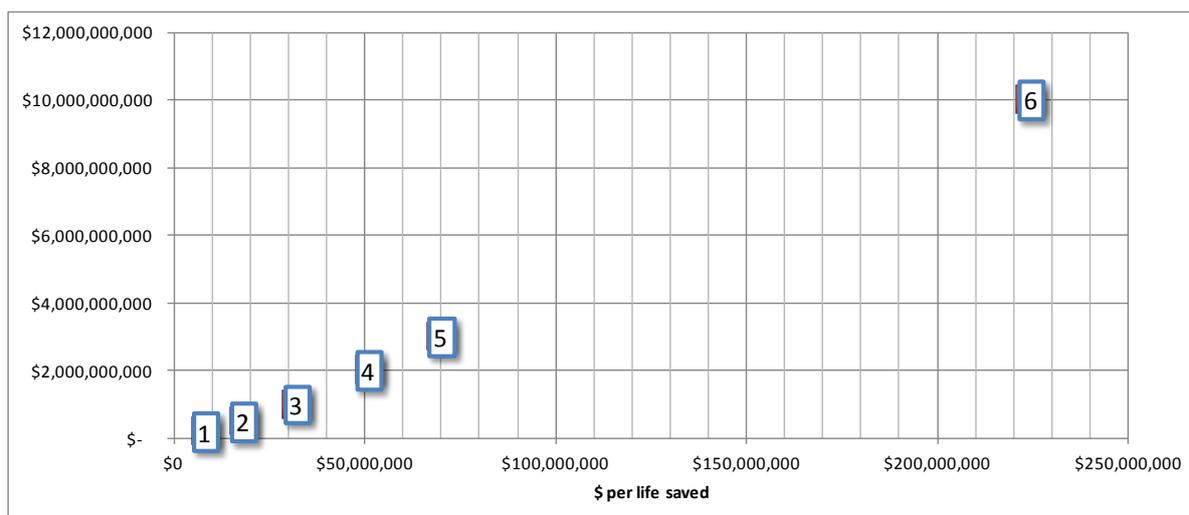


Figure 33: Comparison of effectiveness of packages of measures

The cost per life saved increases as the size of the package of measure increases.

By way of comparison, the cost per life saved associated with each package can be compared to the value that the Royal Commission placed on saving lives and the Royal Commission’s estimate of the total economic cost of the January – February 2009 bushfires.

The Royal Commission assumed that the value of lives lost was \$3.5 million in 2007 dollars⁷⁴, which is about \$3.9 million in 2011 dollars.

⁷³ Includes operating expenditure of \$4 million for a public awareness campaign

⁷⁴ In estimating the value of lives lost, the Royal Commission applied the value of statistical life consistent with the guidance provided by the Australian Government’s Office of Best Practice Regulation for preparing Regulatory Impact Statements (Best Practice Regulation Guideline Note: Value of statistical life, November 2008)

In estimating the total economic cost of the January – February 2009 bushfires, the Royal Commission noted measurement difficulties encountered and gaps in the available information. Nevertheless, it estimated the economic costs as set out in Table 16.

Item	Cost (\$ million, 2009 dollars)
RESPONSE COSTS	
Victorian Government – supplementary funding for fighting 2009 fires	593
Value of CFA and other volunteer time plus additional costs incurred by the MFB, ADF, Victoria Police, SES, State Coroner’s Office, NEO and DSE as a result of the fires	Not estimated
DAMAGE COSTS	
General insurance claims paid	1,200
Loss and damage to public infrastructure	77
Victorian Bushfire Recovery and Reconstruction Authority – establishment costs, expenditure to date and projected future expenditure	1,081
Valuation of lives lost	645
Loss of livestock and agricultural output	Not estimated
Timber – value of destroyed timber, replanting costs for private plantations and salvage costs	658
Asset damage and other cost incurred by Telstra and Melbourne Water (Long-term impact on water supply was not estimated)	25
Cost of 2009 Victorian Bushfires Royal Commission including costs incurred by state agencies in responding to the Commission	90
Total	4,369

Source: Victorian Bushfires Royal Commission, *Volume I: The Fires and the Fire Related Deaths*, July 2010, page 345

Table 16: Estimated major economic costs of Victoria’s January – February 2009 bushfires, by cost item

These costs are predominantly incurred as a result of the major bushfires, of which between a third and a half are typically started by powerlines. If up to half of these costs could be avoided if powerlines did not start any bushfires, then \$2,185 million in 2009 dollars would be avoided or around \$13.5 million per life in 2011 dollars.

The resultant payback period for the cost of risk for each package of measures is as set out in Table 17.

Package	Estimated capital cost (\$ million, 2011 dollars, undiscounted)	Payback period for the cost of risk (years)
1	\$200	2.4
2	\$500	4.7
3	\$1,000	8.2
4	\$2,000	12.6
5	\$3,000	19.4
6	\$10,000	58.9

Table 17: Payback period for the cost of risk

The payback period increases as the estimated capital cost increases. The payback period for packages 1, 2, 3, 4 and 5 is less than the period between catastrophic fire events (assumed to be once every 20 years in this analysis). However, the payback period for package 5 will be longer than the period between catastrophic fire events if the actual costs are at the upper end of the error margin (+20 per cent). The payback for package 6 is longer than the period between catastrophic fire events.

The Net Present Value or NPV is the sum of the costs and benefits over a 30 year period⁷⁵, discounted to 2011 dollars. It is a standard approach for calculating the net benefit (or cost) of long-term projects.

In determining the NPV for each package of measures, the capital costs associated with the precaution and the costs that are avoided by implementing the precaution (deferral in asset replacement that would otherwise occur⁷⁶ and changes in operating and maintenance cost⁷⁷) have been considered. Further details on the costs avoided with the replacement of powerlines are provided in sections 4.2.2 and 4.3.1.

The estimate of costs avoided assumes that the age profile of existing powerlines is consistent across the state. In reality this may not be the case. The highest priority powerlines to be replaced may be all relatively new, in which case the estimate of incremental cost will be too low. Alternatively, the highest priority powerlines to be replaced may be all relatively old, in which case the estimate of incremental cost will be too high.

The choice of discount rate is a key variable and can be contentious. For this reason, the NPV has been calculated using a low (6 per cent per annum), medium (8 per cent per annum) and high discount rate (10 per cent per annum).

It is assumed that new generation SWER ACRs will be installed over a five-year period commencing in year 1, REFCLs will be installed over a 10-year period commencing in year 2, and powerlines will be replaced over a 10-year period commencing in year 3.

⁷⁵ A period of 30 years has been used as the costs are significantly discounted after 30 years.

⁷⁶ Approximately 1% of the total capital cost per annum, in real 2011 dollars.

⁷⁷ Approximately 0.05% of the total capital cost per annum (in real 2011 dollars) after the 10 year implementation period, with a proportion of the costs avoided during the implementation period.

The NPV of the avoided costs associated with each package of measures is provided in Table 18 and the NPV of the incremental costs associated with each package of measures is provided in Table 19.

Package	NPV of the avoided costs (\$ million)		
	Low discount rate (6% per annum)	Medium discount rate (8% per annum)	High discount rate (10% per annum)
1	17	14	11
2	51	40	33
3	138	106	84
4	292	221	172
5	489	370	288
6	1,717	1,254	1,000

Table 18: Comparison of the net present value of the avoided costs associated with each package of measures

Package	NPV of the incremental costs (\$ million)		
	Low discount rate (6% per annum)	Medium discount rate (8% per annum)	High discount rate (10% per annum)
1	131	122	113
2	311	287	264
3	569	529	489
4	1,106	1,030	952
5	1,599	1,497	1,388
6	5,207	4,884	4,534

Table 19: Comparison of the net present value of the incremental costs associated with each package of measures

Table 18 and Table 19 indicate that, on an NPV basis over 30 years, the avoided costs are between approximately 10 and 20 per cent of the capital costs.

The impact of each of the packages of measures on electricity bills has been estimated by considering the incremental operating and maintenance costs, the return of the capital cost (depreciation⁷⁸) and the return on the capital cost^{79,80}. It has been assumed that the costs will be paid for only by those customers in the relevant electricity distribution area,

⁷⁸ Assumes that assets are depreciated over a 45 year period.

⁷⁹ A real pre-tax WACC, as determined by the AER as part of the revenue determination for 2011-15 has been used.

⁸⁰ This is the standard "building block" approach used by the AER to determine the electricity distributors' revenue requirement.

consistent with the current regulatory regime, and by assuming the costs are paid for by all Victorians.

The impact on electricity bills of the Royal Commission's recommendations that have not been considered by the Taskforce have not been included.

With the installation of REFCLs and replacement of powerlines occurring over a 10-year period⁸¹, the electricity bills will progressively increase over an 11-year period and will then decline over the life of the assets (assumed to be 45 years). The maximum impact of each package of measures (which occurs in year 11), expressed in 2011 dollars, is summarised in Table 20. The impact is expressed as a percentage and as the increase in quarterly bill for an average household, assuming the average household consumes 5,700 kWh of electricity per annum and has a quarterly retail electricity bill of \$315.

The electricity bill impact includes some avoided costs. However, while the capital costs are incurred over a 10-year period, the offsetting impact of the avoided costs occurs over a longer period, with some assets replaced having a nominal life of 70 years. As a result, the inclusion of the avoided costs does not materially reduce the maximum electricity bill impacts that are experienced within the 11-year period, but may have a more material impact on the electricity bill increase in later years when the electricity bill increases are lower.

Package	Maximum impact of package of measures on the average household electricity bill (\$ per quarter, 2011 dollars)		Maximum impact of package of measures on electricity bills (%)	
	Costs paid by electricity customers in respective area	Costs paid by all electricity customers	Costs paid by electricity customers in respective area	Costs paid by all electricity customers
1	1.14	0.57	0.4%	0.2%
2	3.33	1.44	1.1%	0.5%
3	7.66	2.89	2.4%	0.9%
4	13.63	5.81	4.3%	1.8%
5	18.62	8.64	5.9%	2.7%
6	61.94	28.79	19.7%	9.1%

Table 20: Impact of packages of measures on electricity bills

Table 20 indicates that:

- the impact of the package of measures on customers' electricity bills increases as the size of the package increases
- the impact on customers' electricity bills is less when the costs are paid for by all Victorians as compared to when the costs are paid for by the customers in the respective electricity distribution area

⁸¹ It is assumed that the installation of the REFCLs will commence in year 2 and replacement of powerlines will commence in year 3 of the 10 year program.

- Victorians are willing to pay for packages 1 and 2, assuming that the costs are paid for by the customers in the respective electricity distribution area assuming that there is an adverse impact on supply reliability
- Victorians are willing to pay for packages 1, 2, 3 and 4, assuming that the costs are paid for by all electricity customers assuming that there is an adverse impact on supply reliability
- Victorians may be willing to pay for package 5 as there will be less impact on supply reliability in the longer term with more powerlines replaced – however, they may not be willing to pay during the transitional period when the costs of replacing powerlines are being incurred but those customers whose powerlines have not yet been replaced are experiencing an adverse impact on supply reliability
- the impact of the packages of measures on electricity bills is small relative to the forecast increase in electricity bills due to the carbon price (approximately 10 per cent over the first five years)⁸² and the forecast increase associated with an increase in network tariffs (between approximately 0.4 and 2.4 per cent per annum from 2011 to 2015)⁸³.

The impact of each of the packages of measures on low income consumers and concession-card holders is summarised in Table 21. The impact of each of the packages of measures on electricity bills has been estimated by assuming the costs are paid for only by those customers in the relevant electricity distribution area, consistent with the current regulatory regime.

It is assumed that low income consumers and concession-card holders consume 4,000 kWh of electricity per annum, that concession card holders receive a discount of 17.5 per cent per annum, that concession card holders have an annual income of \$20,000 and low income households have an annual income of \$48,000.

Package	Low income consumers		Concession card holders	
	Maximum increase in electricity bill (\$ per quarter, 2011 dollars)	As a proportion of income	Maximum increase in electricity bill (\$ per quarter, 2011 dollars)	As a proportion of income
1	0.80	0.01%	0.66	0.01%
2	2.34	0.02%	1.93	0.04%
3	5.38	0.04%	4.43	0.09%
4	9.56	0.08%	7.89	0.16%
5	13.07	0.11%	10.78	0.22%
6	43.47	0.36%	35.86	0.72%

Table 21: Impact of packages of measures on electricity bills of low income consumers and concession card holders

Table 21 indicates that:

⁸² Commonwealth of Australia, *Strong Growth, Low Pollution: Modelling a Carbon Price*, 2011, page 10

⁸³ Derived from Australian Energy Regulator, *Victorian electricity distribution network service providers, Distribution determination 2011–2015: Final Decision*, October 2010, page 833

- the maximum quarterly increase in electricity bill for low income consumers and concession card holders is less than for the average household as the annual consumption of electricity is assumed to be lower
- the maximum quarterly increase in electricity bill is less for concession card holders than for low income consumers as the increase in the cost of electricity for concession card holders is offset by an increase in the concession paid (equivalent to 17.5 per cent of the increase that would otherwise be paid)
- the increase in electricity bill is less than 0.4 per cent of the annual income for low income consumers and less than 0.8 per cent of the annual income for concession cardholders under all packages.

Table 20 and Table 21 do not include the costs that may be imposed on individual customers with the replacement of powerlines. These costs are discussed further in section 7.1.3

4.8.3 Impact of packages of measures on the economy

The Taskforce undertook preliminary indicative economic modelling to determine whether the Taskforce's recommendations would have a significant impact on the Victorian economy. The modelling provides an indication only of the magnitude of the impact associated with implementing the Taskforce's recommendations. The modelling does not take into consideration the benefit to the economy from a reduction in bushfires, noting that a reduction in bushfires started by powerlines may have a negligible impact on total bushfires.

The modelling was undertaken based on two packages of measures:

- Package A – a \$1 billion capital expenditure program (similar to package 3)
- Package B – a \$10 billion capital expenditure program (similar to package 6)

Two options for cost recovery were modelled:

- Option 1 – costs recovered across all Victorians
- Option 2 – costs recovered from electricity customers in the relevant electricity distribution area, consistent with the current regulatory regime.

The outputs from the modelling were:

- economic output – a measure of the aggregate output generated by an economy, in this case the state, over a period of time (typically a year)
- change in real income – provides an indication of the change in economic welfare of the residents of a region. The change in real income is equivalent to the change in real economic output, plus the change in net foreign income transfers, plus the change in terms of trade (which measures changes in the purchasing power of a region's exports relative to its imports).

The initial effect of a capital expenditure program is to draw scarce labour and capital resources away from other parts of the Victorian economy. The expenditure programs are anticipated to be particularly labour intensive, which has a significant crowding out effect on other local industries. Simultaneously, the competitiveness of the Victorian economy is reduced as a result of the increase in electricity bills. These effects result in a reduction in the future earning potential of the economy. The capital expenditure programs also cause a

near term rise in the demand for imports (but, unlike most other investments, do not result in an operation phase that increases exports in the longer term).

Some offsetting benefits arise from the fact that the capital expenditure causes an increased demand for Victorian factors of production (notably labour and capital), which results in increased real prices in the near term. In addition, the ability for exporters to pass on at least some of their additional production costs means that there is a small increase in Victoria's terms of trade. Hence, the impact on real income is less than the impact on real economic output.

The adverse impact on the Victorian economy is unlikely to be noticeable for a \$1 billion capital expenditure program, but would be noticeable for a \$10 billion capital expenditure program. The adverse impacts of a \$200 million or \$500 million capital expenditure program would be expected to be less noticeable than a \$1 billion capital expenditure program and the adverse impact of a \$2 billion or \$3 billion capital expenditure program would be expected to be more noticeable than a \$1 billion capital expenditure program but less noticeable than a \$10 billion capital expenditure program.

Further details on the economic modelling are provided in Appendix J.

4.9 Recommended package of measures

The Taskforce's Terms of Reference required it to balance the likelihood that powerlines will start bushfires with:

- the cost of electricity
- the reliability of the electricity supply
- impact on landowners
- impact on the environment.

The Taskforce observes that:

- The risk associated with powerlines starting catastrophic bushfires decreases as the size of the package of measures increases, with a declining rate in the reduction of risk as the size of the package of measures increases. The relative risk of powerlines starting bushfires is estimated to reduce by 48 per cent with the \$200 million package, by 60 per cent with the \$500 million package and by 67 per cent with the \$1 billion package.
- No powerlines will be replaced with a \$200 million package and an immaterial length will be replaced with a \$500 million package. Nearly all powerlines in the extreme fire loss consequence areas will be replaced with a \$2 billion package and all powerlines in extreme fire loss consequence areas and approximately half the powerlines in the very high fire loss consequence areas will be replaced with a \$3 billion package.
- The impact on the cost of electricity increases as the size of the package of measures increases. The customer research has indicated that Victorians are willing to pay for the \$200 million and \$500 million packages, on the basis that there would be an adverse impact on supply reliability, if the costs are paid for by customers in the respective distribution area.
- As discussed in detail in section 5, the Taskforce's recommendations on the change in the network reclose function will have an adverse impact on supply reliability on Total Fire Ban days. This impact will be mitigated by replacing powerlines, however, this is

offset by an increased risk that insulated overhead cable could be damaged by fire, which would take some time to repair. The larger the package of measures, the more powerlines will be replaced.

- Replacing powerlines will have an impact on landowners and the environment, as discussed in section 8.1. The larger the package of measures, the greater the impact on landowners and the environment.

By considering each of these factors, the Taskforce observes that:

- The rate of risk reduction does not exceed the point of diminishing returns with package 1.
- The customer research has indicated that the cost of a package of measures beyond package 5 is not affordable.
- The customer research indicates that packages 2, 3, 4 and 5 provide the most appropriate balance between the likelihood that powerlines start bushfires, the cost of electricity, the reliability of the electricity supply, the impact on landowners and impact on the environment.
- The most appropriate package will be determined by the Victorian Government balancing funding between precautions to prevent the ignition of bushfires from powerlines, precautions to prevent the ignition of bushfires from other causes, measures to mitigate the development of bushfires and measures to mitigate the consequence of bushfires.

The Taskforce therefore recommends that:

Recommendation 1

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

- (c) 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 powerlines⁸⁴ in the next 10 years (Rapid Earth Fault Current Limiters)
- (d) targeted replacement of SWER and 22kV powerlines⁸⁵ 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.

⁸⁴ Includes high voltage multi-wire powerlines operating at different voltage levels

⁸⁵ Includes high voltage multi-wire powerlines operating at different voltage levels

4.10 Distribution companies will act locally to meet regulatory obligations

The analysis that has been undertaken by the Taskforce has necessarily been undertaken at a macro level. The outcomes of the modelling provide guidance only as to the actions that will be undertaken by the electricity distributors to most effectively reduce the bushfire risk. The modelling does not take into account more detailed local knowledge that will necessarily be considered by the electricity distributors in assessing the most effective actions.

The regulatory obligation that is placed on the electricity distributors to facilitate the implementation of the Taskforce's recommendation, which was discussed in section 3.7, needs to ensure that the electricity distributors have the flexibility to consider the local knowledge in their decision-making.

The Taskforce expects that the electricity distributors will meet the outcomes required by the recommendations by considering a range of technologies, which may include:

- underground cables
- insulated overhead wires
- offering to support stand-alone power supplies rather than connecting customers to the electricity distribution system, where it is more efficient than replacing powerlines

and, for each location, using the technology that is most cost-effective for the local conditions.

For example the Taskforce's modelling may indicate the most cost-effective option to reduce bushfire risk is to replace a 5km section of bare wire 22kV powerline with ABC. However, the electricity distributor's detailed knowledge of the local conditions may indicate that the most cost-effective option is to replace a 1km section with underground cable, to replace a 3km section with covered wire and to replace the final 1km section with ABC.

Additionally, as discussed in section 3.3, the electricity distributors need to have the flexibility to be able to consider the best information available on fire loss consequence modelling in their decision-making.

For example the Taskforce's modelling may indicate that the most cost-effective option is to replace powerlines in areas A, B, C and D. However, the electricity distributor's detailed knowledge of the local conditions and more up-to-date fire loss consequence modelling may indicate that the most cost-effective option is to replace powerlines in areas A, C and E and in part of area B.

To ensure that the most cost-effective solution is delivered for Victorians, and consistent with the regulatory framework described in section 3.7, the electricity distributors should submit revised Bushfire Mitigation Plans to ESV that demonstrate how the recommendations will be implemented.

4.11 Case studies

The Taskforce's recommendations can be illustrated by considering the impact in three different areas:

- extreme fire loss consequence area, for example in the Dandenongs or Otway Ranges
- very high fire loss consequence area, for example to the north or west of Ballarat

- high fire loss consequence area, for example in the Wimmera.

In each of these areas, there are broadly three different types of faults that may occur:

- wire-to-earth faults on a multi-wire line, for example when a tree falls on one wire, which are estimated to start 49 per cent of electricity-related fires
- wire-to-wire faults on a multi-wire line, for example when wires clash, which are estimated to start 18 per cent of electricity-related fires
- faults on a SWER line, for example a wire breaks, which are estimated to start 7 per cent of electricity-related fires.

The effect of each package of measures under these circumstances is summarised in Table 22. Table 22 does not consider fires started by low voltage lines or service lines.

Location	Type of fault	Package 1	Package 2	Package 3	Package 4	Package 5	Package 6
Dandenongs and Otway Ranges	Multi-wire line – wire-to-earth fault	REFCL installed – probability of ignition negligible	As for package 1 with some powerlines replaced for which probability of wire-to-earth fault substantially reduced	As for package 2 with more powerlines in area replaced	As for package 3 with most powerlines in area replaced	As for package 4 with all powerlines in area replaced	As for package 5
Dandenongs and Otway Ranges	Multi-wire line – wire-to-wire fault	ESV direction on wire separation to reduce probability of a wire-to-wire fault, and change in network reclose function to reduce probability of ignition	As for package 1 with some powerlines replaced for which probability of wire-to-wire fault substantially reduced	As for package 2 with more powerlines in area replaced	As for package 3 with most powerlines in area replaced	As for package 4 with all powerlines in area replaced	As for package 5
Dandenongs and Otway Ranges	SWER line	New generation SWER ACR installed with change in operation to reduce probability of ignition	As for package 1 with some powerlines for which probability of fault substantially reduced	As for package 2 with more powerlines in area replaced	As for package 3 with most powerlines in area replaced	As for package 4 with all powerlines in area replaced	As for package 5
North and west of Ballarat	Multi-wire line – wire-to-earth fault	Change in operation of network – probability of ignition reduced	REFCL installed – probability of ignition negligible	As for package 2	As for package 3	As for package 4 with most powerlines replaced for which probability of wire-to-earth fault substantially reduced	As for package 5 with all powerlines in area replaced
North and west of Ballarat	Multi-wire line – wire-to-wire fault	ESV direction on wire separation to reduce probability of a wire-to-wire fault, and change in network reclose function to reduce probability of ignition	As for package 1	As for package 2	As for package 3	As for package 4 with most powerlines replaced for which probability of wire-to-wire fault substantially reduced	As for package 5 with all powerlines in area replaced

Location	Type of fault	Package 1	Package 2	Package 3	Package 4	Package 5	Package 6
North and west of Ballarat	SWER line	New generation SWER ACR installed with change in operation to reduce probability of ignition	As for package 1	As for package 2 with some SWER powerlines replaced for which probability of fault substantially reduced	As for package 3 with most SWER powerlines replaced	As for package 4 with all SWER powerlines replaced	As for package 5
Wimmera	Multi-wire line – wire-to-earth fault	Change in network reclose function – probability of ignition reduced	REFCL installed – probability of ignition negligible	As for package 2	As for package 3	As for package 4	As for package 5
Wimmera	Multi-wire line – wire-to-wire fault	ESV direction on wire separation to reduce probability of a wire-to-wire fault, and change in network reclose function to reduce probability of ignition	As for package 1	As for package 2	As for package 3	As for package 4	As for package 5
Wimmera	SWER line	Change network reclose function – probability of ignition reduced	New generation SWER ACR installed with change in network reclose function to reduce probability of ignition	As for package 2	As for package 3	As for package 4	As for package 5 with some SWER powerlines replaced

Table 22: Likely effect of the packages of measures on different parts of the state

5 Addressing Royal Commission's recommendation 32 (change network reclose function)

Protection systems are currently set to automatically turn off the power when a fault occurs in a way that minimises effects on supply reliability. The Taskforce has recognised that changes to protection system settings are required to minimise bushfire risk and that the two objectives – low bushfire risk and reliability of supply to customers – can be in conflict.

For maximum supply reliability, protection system operating times are set long enough so that protection systems are able to automatically coordinate to interrupt supply to the minimal number of customers.

Additionally, automatic circuit reclosers (ACRs) are installed that can turn powerlines on and off multiple times when a fault occurs. By doing so, supply is interrupted for a sustained period only for the approximately 30 per cent of faults that are permanent (for example a vehicle has run into a power pole and a wire is down) and supply is interrupted only momentarily for the approximately 70 per cent of faults that are transient (for example bark has blown across a wire or a lightning strike has caused a flashover from a wire to a steel cross-arm).

The Taskforce's arc ignition research has indicated that the bushfire risk can be reduced if the protection systems are able to operate almost instantaneously (which could be as fast as two hundredths of a second) under worst-case conditions. This can be achieved in some cases by setting the protection to be more sensitive, as discussed in section 5.1, and/or by eliminating the delays before the powerline is turned off when a fault occurs, as discussed in section 5.2.

If the protection is set more sensitively or the delay before the powerline is automatically turned off is reduced, it is likely there will be an adverse effect on the reliability of supply. There are means to mitigate this side-effect, as discussed in section 5.3; these demand careful consideration before specific action can be recommended.

The Taskforce has sought to strike the most appropriate balance between reduced bushfire risk through changes to the operation of the network reclose function and the consequential effects on supply reliability.

5.1 Sensitive protection settings

There are different types of protection systems that automatically turn off powerlines when a fault occurs. The most common types of protection systems are set to measure high currents in the powerline or a high current to earth (indicating a wire-to-earth fault). Protection systems that detect the existence of a current to earth theoretically can be set very sensitively. However, this can only be done in practice if their operation is delayed. Otherwise momentary disturbances on the powerline can result in a whole powerline being turned off.

SWER powerlines do not have a separate earth wire – the earth is part of the circuit. SWER protection systems therefore cannot use the existence of a current to earth as evidence of a fault – they must rely on detection of abnormally high currents in the powerline. The normal load current in many SWER powerlines is relatively low and can be similar to the current that can flow to earth when the powerline comes into contact with a tree. As a result,

protection systems for SWER powerlines are sometimes not able to detect faults. This was the case with the Coleraine fire – the protection system did not detect a fault when the coach bolt came loose and the pole top attachment fell off the pole.

The new generation SWER ACRs, which were described in sections 3.4.2 and 4.4.2, can be set to detect much smaller currents, that is the margin between normal load current and a current that results in the powerline being turned off, can be reduced. If the SWER ACRs are able to automatically turn off the power for smaller currents, then the bushfire risk will be reduced. However, if the SWER ACR is set too sensitively, it may turn off the power when a fault has not occurred. Over-sensitive settings are likely to have an adverse impact on supply reliability.

To balance the lower risk of bushfires with the higher risk of supply interruptions, the new generation SWER ACRs can be remotely set to more sensitive protection settings on high fire risk days only – typically less than 10 days per year. The electricity distributors would be able to monitor the load current remotely and set the SWER ACR to turn off the powerline if the current rises only a little above the forecast load current.

5.2 Speed of protection operation

Typically, when a fault occurs on a powerline, the current ACRs will turn the power off and on several times to determine whether the fault is a permanent fault or a transient fault. This sequence of events is as follows:

- the protection system automatically turns the power off in approximately half a second (this is termed a fast protection operation though it is slow compared to the speeds the Taskforce is contemplating)
- the ACR automatically turns the power back on again after approximately five seconds
- if the problem still exists, the protection system automatically turns the power off again after approximately half a second (second fast protection operation). If the problem no longer exists, the power is of course, not turned off
- the ACR automatically turns the power back on again after approximately five seconds
- if the problem still exists, the protection system automatically turns the power off again after approximately two seconds (slow protection operation). If the problem no longer exists, the power is of course, not turned off
- the ACR automatically turns the power back on again after approximately five seconds
- if the problem still exists, the protection system automatically turns the power off again after approximately two seconds (second slow protection operation). If the problem no longer exists, the power is of course, not turned off
- the electricity distributor takes action to patrol the line⁸⁶ and remove the permanent fault before the powerline is turned on again.

The Taskforce has found that this practice does not offer adequate protection against the risk that bushfires will be started by powerlines.

Specifically, the Taskforce's arc ignition research indicates that:

⁸⁶ In some cases the line is not patrolled before the powerline is turned on again.

- Under worst-case conditions, probability of ignition will be close to 100 per cent if the fault remains energised for two seconds. To achieve low probability of ignition, most faults must be disconnected within one or two tenths of a second.
- A short delay between operations to turn the power back on again (five seconds) can increase the probability of ignition even when the time to turn off is very fast, but the probability of ignition when the power is turned back on again is not increased if the delay between operations is around 30 seconds.

Operation to preserve supply reliability

Under normal circumstances, the sequence of events outlined above minimises the impact of faults on customers' supply reliability. It ensures that power is turned back on quickly when a transient fault occurs. It also ensures that the number of customers that lose their power when a permanent fault occurs is minimised.

Referring to Figure 34, if a permanent fault occurs between ACRs B and C, then the objective of the protection system is to interrupt supply only to those customers that are supplied by the powerline beyond ACR B.

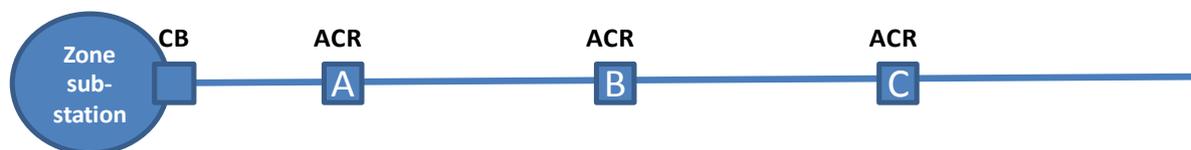


Figure 34: Illustrative example of ACRs on a rural radial powerline

If the protection system operates using the sequence outlined above, with two slow operating times, the protection system will be able to locate the fault resulting in the least number of customers losing their power supply. However, there will be more fault energy released into the environment to start a bushfire.

If the protection system is set to operate more quickly on high fire risk days, the protection system may not be able to locate the fault, so more customers may lose their power supply. For example the circuit breaker (CB) in the zone substation may operate first resulting in the supply being interrupted to all customers on the powerline. There will, however, be less fault energy to start a bushfire.

Operation to reduce fire risk

The ACRs can be operated in several different modes, each mode representing a different balance between the likelihood of powerlines starting bushfires and the impact on supply reliability:

- One fast protection operation only – this mode has the minimum bushfire risk but also the most adverse impact on supply reliability – the supply to customers will be interrupted for all faults, whether they are permanent or transient and the protection system will not be able to locate the fault and so more customers will be interrupted than those supplied by the section of the powerline with the fault.
- Two fast protection operations – this mode has a higher likelihood of powerlines starting bushfires than one fast protection operation only, however, the arc ignition research has demonstrated that if the time that elapses before the power is turned back on is increased to 30 seconds, the likelihood of bushfire ignition is substantially less than if it is turned back on after five seconds. By operating twice, there is a reduced risk that the supply to customers will be interrupted for a sustained period if there is a transient fault,

however, if there is a permanent fault, the protection system will not be able to locate the fault and so more customers will be interrupted than those supplied by the section of the powerline with the fault.

- One slow protection operation only – some ACRs on multi-wire powerlines and some circuit breakers (CBs) in zone substations operate in this mode currently on days of Total Fire Ban. The slow protection operation will be able to locate the fault to minimise the number of customers whose power supply will be interrupted, but the likelihood of a bushfire starting is very high under worst-case conditions as the operating time is too long.
- One fast and one slow protection operation – this mode was considered to be the most appropriate balance by the Royal Commission between the risk of bushfires starting and the risk associated with losing the power supply on a high fire risk day. The two operations minimise the risk of a sustained interruption when a transient fault occurs and the slow protection operation allows the protection system to locate the fault. However, the arc ignition research indicates that the likelihood of bushfires starting is significantly higher than if there were fast protection operations. This would not be appropriate for extreme and very high fire loss consequence areas on Total Fire Ban days.
- Two fast and two slow protection operations – this is currently the normal operating mode for most ACRs and for many ACRs on high fire risk days. It ensures that the minimum number of customers lose their power supply when a fault occurs. However, the arc ignition research indicates that the likelihood of bushfires starting is significantly higher than if there were fast protection operations. This would not be appropriate for extreme and very high fire loss consequence areas on Total Fire Ban days.

As discussed previously, the arc ignition research has indicated that if the power is turned back on five seconds after the first protection operation and the fault is still present, the events are dependent and the likelihood of ignition when the power is turned back on is higher than when the fault initially occurred. However, if the power is turned back on 30 seconds after the first protection operation and the fault is still present, the events are independent and the likelihood of ignition when the power is turned back on is no higher than when the fault initially occurred. There has been insufficient research to determine the point at which the second protection operation can be considered to be independent of the first.

The longer it takes to turn the power back on after a protection operation, the higher the risk of electrocution. While the risk is low in less populated areas, the risk is higher in more populated areas. The risks therefore need to be carefully balanced when extending the time to turn the power back on after a protection operation.

The maximum sequence of reclose operations in Victoria is currently 24 seconds.

The Taskforce has therefore concluded that, subject to further research and analysis, the time to turn the power back on after a fault on Total Fire Ban days should be increased to 24 seconds, except where the risk of doing so outweighs the improvement in bushfire safety.

Operation to suit conditions of the day

If the ACRs can be controlled remotely, then the operating mode can be changed on bushfire risk days. The operating mode of most ACRs on multi-wire lines can be changed remotely or, for those electricity distributors with a small number of ACRs in high bushfire

risk areas, can be changed manually on a high fire risk day. With the installation of the new generation SWER ACRs, which are remotely controllable, the operation of all ACRs in high bushfire risk areas will be able to be changed on high fire risk days.

The Taskforce has carefully considered the balance that is required between bushfire risk and the risk of a loss of power supply on high fire risk days in assessing the most appropriate operation of ACRs. The Taskforce conducted a series of trials over summer 2010/11 to test different operating modes. Participation in the trials was not voluntary and there was considerable concern expressed by some about being included on the trial. However, it was a benign summer and as a result there was no adverse impact on the participants' reliability of supply during the trial period. Further details on the trial are provided in Appendix I.3.

The trial reinforced the need for any change in network operations to be accompanied by an awareness campaign so that the community clearly understands the changes that are to occur, how these may impact them, and the precautions that could be taken.

The Taskforce has reviewed a selection of published material on the trade-off between bushfire risk and supply reliability:

- the Royal Commission's report discussion leading to recommendation 32 on the change of the network reclose function
- guideline used by NSW electricity distributors on the change in network reclose function on high fire risk days⁸⁷
- report of a national workshop on rural distribution networks and bushfire risk held in Melbourne in April 2010, including a national survey on the change in the network reclose function⁸⁸
- research by VENCORP into the economic value of customer supply reliability⁸⁹.

The Taskforce noted the scarcity of objective evidence and analysis on the value of supply reliability on high fire risk days. As discussed in section 4.5, the VENCORP report quantifies the economic value of customer supply reliability by customer type for outages ranging from 20 minutes to 24 hours. However, it does not distinguish the value based on the time of day of the interruption and the type of day, that is whether it is a high fire risk day or a benign day in spring.

In the short term, a degree of judgement must be used until more precise analysis is available to support evidence-based decisions.

In NSW, it was found that⁹⁰:

... the risks introduced by disabling reclosers generally outweighed the risks mitigated by disabling reclosers. Thus a strategy of mandatory disabling reclosers to mitigate the risk of bush fire initiation could not be supported.

⁸⁷ Available at http://www.dtiis.nsw.gov.au/energy/electricity/networks/safety/electricity_network_safety_issc33_network_configuration_during_high_bushfire_risk.pdf

⁸⁸ Available at http://new.dpi.vic.gov.au/_data/assets/pdf_file/0006/42369/SWER-Workshop-21-April-2010-Final-Report-June-2010.pdf

⁸⁹ CRA International, *Assessment of the Value of Customer Reliability (VCR)*, 12 August 2008

⁹⁰ ISSC 33, *Guideline for Network Configuration During High Bush Fire Risk Days*, Issued December 2007, Revised December 2010, page 7

However network operators should undertake their own risk analysis to determine whether any changes to network configuration should be used during high bush fire risk days. In determining whether reclose devices should be disabled during high bush fire risk days, the following should be considered:

- Pre bush fire season inspections and defect rectification programs.
- Feeder performance – i.e. do the feeders in question have particularly poor reliability performance and hence high likelihood that faults will not be transient.
- Historical data of bush fire initiation from electrical network assets.
- Other bush fire risk mitigation strategies.

In considering the guideline on the network reclose function that applies to electricity distributors in NSW, the Taskforce notes that:

- in Victoria, a much higher proportion of bushfires are started by high voltage powerlines than in NSW where they are predominantly started by low voltage powerlines⁹¹
- the environmental conditions in Victoria are such that Victoria is more vulnerable to catastrophic bushfires than NSW
- there is a greater reliance on gravity fed water in Victoria than NSW, which has a greater reliance on pumped water
- there was a high level of concern in NSW regarding the lack of back-up supplies for communication facilities.

For these reasons, the Taskforce is of the view that the appropriate balance between bushfire risk and an adverse impact on supply reliability may be different in Victoria than in NSW.

The Taskforce recognises that changing the operation of the network to cut bushfire risk will affect supply reliability on high fire risk days. For the other 96 per cent of the year, the precautions considered by the Taskforce can be expected to improve supply reliability.

However, it is in the extreme heat conditions of high fire risk days that supply interruptions may have the greatest effect on customer health and welfare. The Taskforce has noted the DHS report that estimates 374 excess deaths occurred in Victoria during the heatwave of the last week of January 2009, though it also recognises it is not known how many (if any) of these deaths can be associated with supply interruptions at the time.

The Taskforce has also noted the range of strongly held views expressed in its public consultation process on the potential impact of supply interruptions on fire preparedness. These extend from concern that fire preparedness will be materially reduced to statements that electricity supply must never be assumed in fire plans, so supply reliability should not matter.

The Taskforce has also noted the concerns of electricity distributors that resources may be quickly absorbed resolving an increased number of protracted supply interruptions on high fire risk days, materially reducing their ability to respond to new interruptions. Typically, it takes three skilled staff plus one vehicle to investigate and restore a powerline that has automatically turned off. On high fire risk days, the increased number of supply interruptions created by the change in the network reclose function could quickly use up all available resources.

⁹¹ Noting that the likelihood of low voltage powerlines starting bushfires will not be reduced with the changing of the reclose function.

Further, the normal pattern of extreme fire risk days is that a wind change occurs late in the day, reducing temperatures but exacerbating existing fires by turning the north-east flank into a new fire front. When this happens the fire risk from new fires may be small relative to the existing fires. However, the likelihood of a fault occurring increases with the wind change. There may be good reason to allow the network reclose function to return to its normal operating mode once the wind change has reached a powerline.

Taking into account the complexity of the issue and the current scarcity of reliable information, the Taskforce has concluded that research and analysis should be undertaken into the value (economic, health and safety) of supply reliability on extreme fire risk days to support sound decisions on changing the operation of the network in the longer term.

In the meantime, the Taskforce has concluded that the most appropriate balance between the risks of bushfire safety and a loss of power supply on high fire risk days is achieved by changing the network reclose function so that the protection system operates, at most, with two fast protection operations on Total Fire Ban days and one fast protection operation only on Code Red days, for powerlines in extreme and very high fire loss consequence areas, and with one fast and one slow protection operation on Total Fire Ban days in high fire loss consequence areas.

5.3 The impacts on supply reliability can be mitigated

The impact of a change in the network reclose function on supply reliability can be mitigated in a number of ways:

- replacing powerlines
- minimising the area in which the operation of the network is changed
- minimising the time during which the operation of the network is changed
- using fault location devices or fault data from existing devices to determine the approximate location of the fault
- reconfiguring the network with more ACR devices or more feeders to reduce the maximum number of customers that may be impacted by any interruption
- turning the powerline back on after a period of time without patrolling the line
- installing REFCLs
- reducing the energy levels when a reclose operation occurs
- ensuring that the appropriate resourcing levels, processes and systems are in place to expedite restoring the power supply.

Replacing powerlines

The likelihood of faults occurring on powerlines that are underground or insulated is less than on bare wire powerlines. The more powerlines are replaced, the fewer customers that are impacted by the change in the network reclose function. If the powerline replacement is strategically targeted to powerlines with the highest density of customers and to powerlines that have a higher likelihood of faults occurring (for example in vegetated areas) within the highest fire loss consequence areas, the mitigation of the adverse impact of supply reliability is maximised.

Minimising the area in which the network operation is changed

The number of customers that will be exposed to a change in the operation of the network reclose function will increase as the area in which the change in network reclose function increases, as illustrated in Figure 35 based on Black Saturday conditions. As the number of devices that are changed is increased, the number of customers exposed to a change in operation increases and the incremental reduction in bushfire risk decreases.

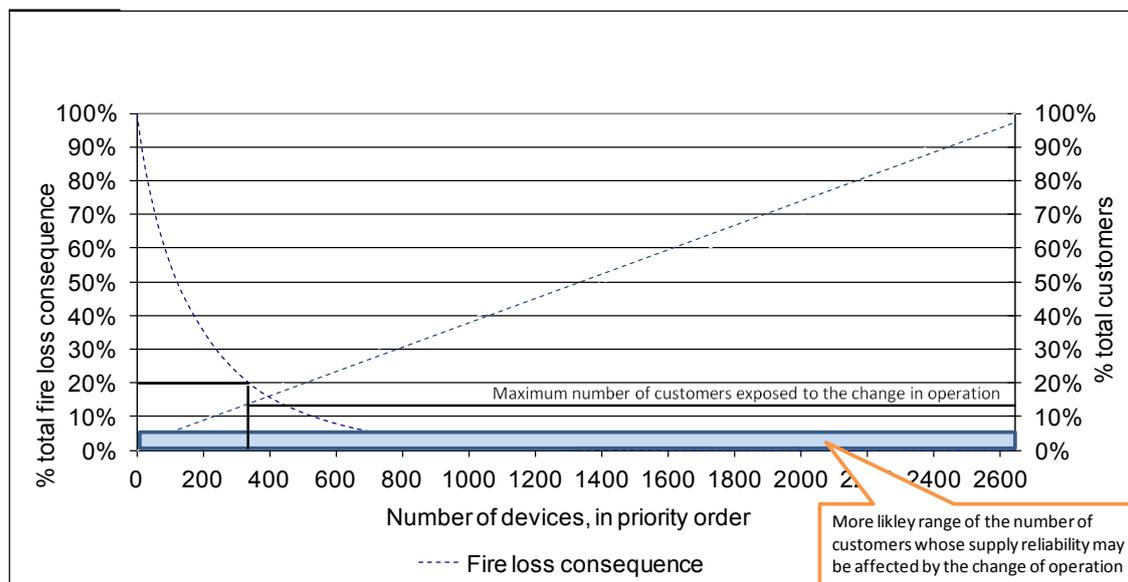


Figure 35: Link between improvement in bushfire safety and number of customers that are exposed to a change in network operations – Powercor’s and SP AusNet’s areas, based on Black Saturday conditions

As illustrated in Figure 35, if the network reclose devices that represent 80 per cent of the State’s fire loss consequence (based on Black Saturday conditions) are changed on a Code Red day, around one in eight rural customers may be exposed to a change in the network reclose function.

The Taskforce considers that the best balance between the risks of bushfires and loss of power supply is to define a different operation of the network depending on the fire loss consequence and the conditions on the day. Rather than specify, for example that the operation of the network be the same across all areas that have an extreme fire loss consequence (based on worst-case conditions), the operation of the network should take into consideration whether the conditions are more benign than worst-case, for example where there has been a reduction in the fuel load. In more benign years, fewer customers will be exposed to a change in operation of the network reclose function than in years that reflect worst-case conditions.

The Taskforce is of the view that, for each year, the different areas should be determined as follows:

- a body, to be nominated by the Victorian Government, will determine the most up-to-date inputs and assumptions to be used to model the worst-case statewide fire loss consequence
- the electricity distributors, in collaboration with ESV and fire agencies, will run the fire loss consequence modelling based on the inputs and assumptions provided to determine the threshold that applies for the powerlines that represent the highest 80 per

cent fire loss consequence, that is determine the **threshold (X)** used to define the extreme and very high fire loss consequence areas based on worst-case conditions **(model run A)**

- on an annual basis, the fire loss consequence modelling will be re-run, based on the current conditions provided by the body referred to above, to determine the powerlines that will have a fire loss consequence that exceeds the threshold determined from the worst-case fire loss consequence modelling (X) **(model run B)**
- the ACR devices on the powerlines that exceed the threshold X, identified from the annual fire loss consequence modelling **(model run B)**, will have their operation changed to one fast or two fast protection operations in areas that exceed the Code Red day or Total Fire Ban day criteria, respectively
- the ACR devices on all other powerlines in areas that exceed the Total Fire Ban day criteria will operate with one fast and one slow protection operation, consistent with the Royal Commission’s recommendation.

This process is illustrated in Figure 36.

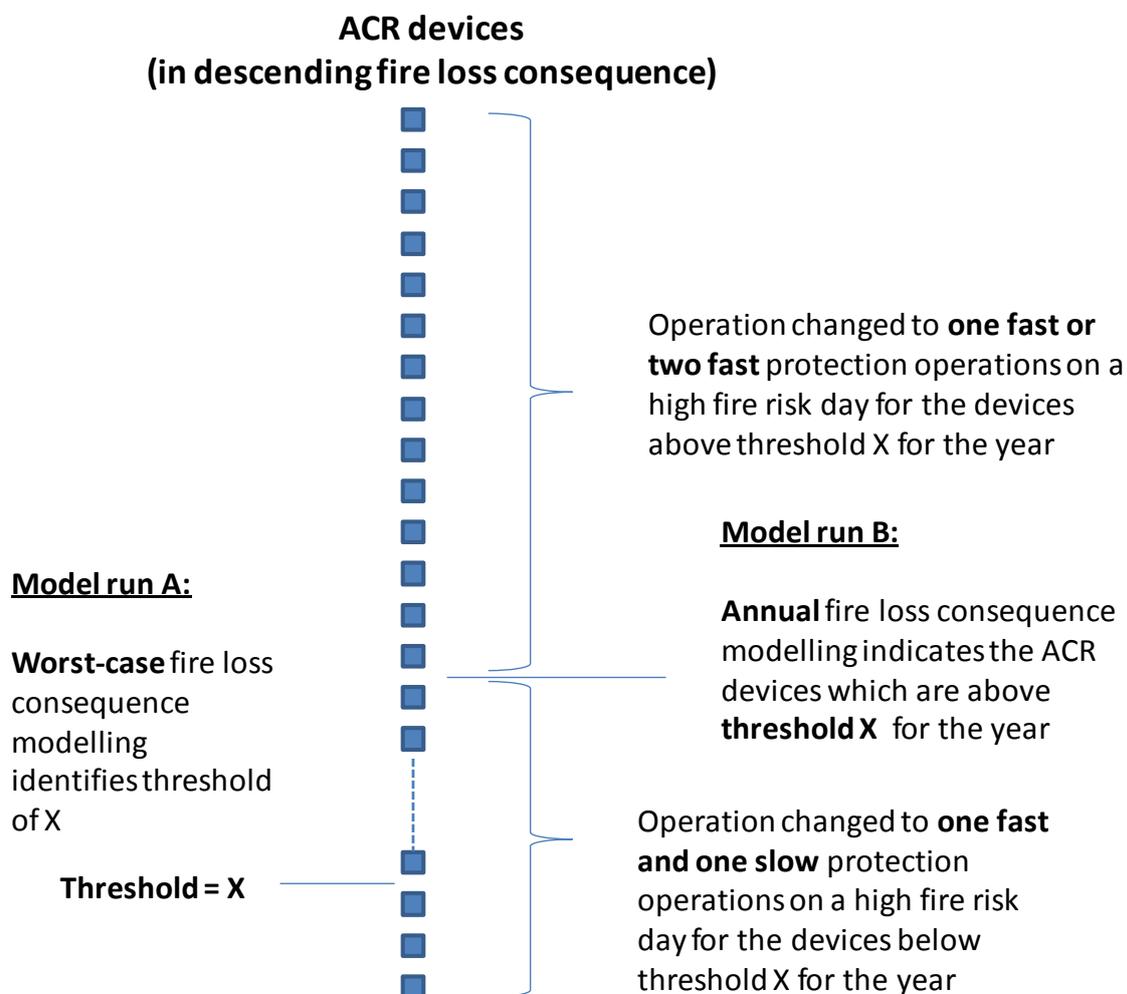


Figure 36: Annual mode of operation for ACR devices on high fire risk days

The Taskforce has developed the terms of reference for research and analysis to identify the criteria for the area in which the network operation should be changed to take into consideration the specific local conditions on a high fire risk day. Once completed, this research and analysis will ensure the optimum balance between bushfire risk and supply reliability.

In the meantime, the network reclose function should be changed on those devices which exceed threshold X in that year, only in those fire district areas in which a Total Fire Ban has been declared. If the fire agencies advise that a smaller area within the fire ban district has the conditions to meet the criteria for a Total Fire Ban, the network reclose functions can be changed in that smaller area.

Decisions on the areas in which the network reclose function should be changed will need to be made based on the most up-to-date data on weather conditions, fire conditions and firefighting resources. This data is monitored in the lead up to and on high fire risk days in the State Control Centre. To get access to the most up-to-date data, the electricity distributors need to have a liaison officer in the State Control Centre to be able to liaise between the fire agencies and the electricity distributors.

The Taskforce has been in discussions with the Fire Services Commissioner and expects that, commencing with the 2011/12 fire season, an electricity distribution liaison officer will be located in the State Control Centre on the days leading up to, and on, high fire risk days.

Minimising the time during which the network operation is changed

Where the operation of ACR devices is currently changed on Total Fire Ban days, it is changed at 10am in the morning and returned to normal operation when the Fire Danger Index⁹² in the local area falls below 30.

Recognising that these criteria are relatively coarse, the research and analysis to identify the area in which the network operation should be changed will also consider the time at which the network operation should be changed and the time at which it should be returned to normal operation by taking into consideration the specific local conditions on a high fire risk day.

Locating the fault

The more information that is provided to the electricity distributors on the location of a fault, the more quickly the fault can be repaired and the powerlines turned back on.

The location of a fault may be deduced if sufficient information is captured in the brief instant of fault current flow before the powerline is automatically turned off. The information can be sent to a Distribution Feeder Automation (DFA) system in a network operations centre, which can drive automated responses to achieve a degree of “network self-healing” and maximise customer supply restoration without increased risk of bushfire.

The data is currently not available to drive these automated responses, but if it were, there could be two variants of this approach:

- **Restoration using zone substation data** – if the fault is relatively close to the zone substation, the fault current can be relatively high. If the zone substation protection systems could indicate the level of fault current with a degree of accuracy sufficient to partially locate it, for example the DFA could conclude “the fault cannot be more than X

⁹² A composite of the grass fire danger index and forest fire danger index that is published on the Weather zone website.

kilometres from the zone substation because if it were, the observed fault current could not be achieved". This conclusion could be used in two ways:

- **Automatic partial restoration:** the powerline beyond the zone indicated by the DFA could be assumed to be sound and supply could be restored immediately to this if a suitable tie is available to supply it from another powerline. This "out of zone" section of the powerline could comprise more than 90 per cent of total feeder length and could include a number of rural towns that would otherwise remain off supply because of a fault close to the zone substation. In this case, use of remotely controlled feeder switching could see automated supply restoration within one to two minutes to these towns.
- **Restoration following partial patrol:** the extent of the patrol required prior to restoration could be limited to the zone indicated by the DFA (extending out from the zone substation for at most a few kilometres). If no permanent fault is found by this quick patrol, it could be assumed the remainder of the feeder is sound and it could be safely restored without further delay. Many faults are transient and this approach could potentially shorten supply outages by tens of minutes or even hours.
- **Restoration using zone substation and powerline data** – if, following a protection operation (whether at the zone substation or along the powerline), every device on the powerline could send its recent current data to a central DFA system for analysis, then the DFA system could deduce the approximate fault location. If this deduction is sufficiently reliable, it could allow automatic reconfiguration of the network and restoration of power to un-faulted sections within one to two minutes. This could greatly reduce the impact on customers from nearly all faults, by:
 - reducing the requirement for patrol to a single (specifically identified) section of the powerline
 - quick restoration of power to all sections of the powerline that are un-faulted and have access to a suitable power source – generally either the zone substation (for sections "upstream" of the fault) or another "healthy" feeder via ties.

However, it may take some time to implement these types of approaches.

Reconfiguring the network

Currently one ACR device automatically turns the power on and off for up to several thousand customers on a powerline. The one powerline can supply customers in low fire loss consequence areas, high fire loss consequence areas, very high fire loss consequence areas and extreme fire loss consequence areas.

If the operation of an ACR device is changed because of the customers that are supplied in the very high and extreme fire loss consequence areas, the customers in the low and high fire loss consequence areas will also be exposed to the change in operation.

On Code Red days, under worst-case conditions, up to one in eight rural electricity customers may be exposed to the change in operation of an ACR device, although a smaller number of customers will actually experience any effect. Initially it is possible, but unlikely, that the reliability of supply for up to one in 20 rural electricity customers may be adversely affected on Total Fire Ban days by the change in operation.

As an example, during the Taskforce's trial of ACR devices during summer 2010/11, 1600 customers were exposed to the change in operation of an ACR device but customers did not actually experience a negative impact on supply reliability.

The number of customers exposed to a change in operation of an ACR device could be reduced if additional ACR devices were installed at the point where a powerline moved from being high fire loss consequence to very high fire loss consequence.

As an alternative to installing more ACR devices, the powerlines could be reconfigured so that those customers in the very high and extreme fire loss consequence areas were supplied by a separate powerline to those in the low and high fire loss consequence areas.

The Taskforce considers that the electricity distributors should prioritise the installation of additional ACR devices to minimise the adverse impact on supply reliability of a change to the operation of the network.

The Taskforce also notes that the electricity distributors will have an incentive to do this through the operation of the Service Target Performance Incentive Scheme, assuming that the electricity distributors' reliability targets are not inappropriately adjusted to take into consideration the change in the network reclose function. If an electricity distributor's reliability improves by installing additional ACR devices, it will be rewarded (customers will pay more) through the Service Target Performance Incentive Scheme.

Turning the power back on without patrolling the line

When a supply interruption occurs, the powerline is normally patrolled to identify the cause of the fault and ensure that the situation is safe before restoring the power supply. If there are more protection devices operating, and more powerlines that need patrolling, there will be a greater demand for resources to patrol the powerlines. It may take longer to patrol the powerline and under some circumstances the line may not be able to be patrolled due to an inability to access an area or the high risk associated with entering the area. As a result, some electricity customers may be off supply for extended periods of more than 24 hours.

In some circumstances, some electricity distributors will turn the powerline back on without patrolling the line after an hour or so if there are no reports of fires or safety incidents in the area affected. However, if the protection operates again when the powerline is turned back on, the line will need to be patrolled. Turning powerlines back on without patrolling is generally done on long powerlines in rural areas that will take a long time to patrol.

Recognising that some electricity distributors will not turn a powerline back on until it has been patrolled, the Taskforce is of the view that the electricity distributors should systematically develop a rationale for the circumstances under which a powerline should or should not be patrolled (and to the extent) before turning it back on after a period of time. The Taskforce understands that the electricity distributors have commenced developing such a rationale.

Installing REFCLs

The network reclose function may not need to be changed for those multi-wire powerlines that are supplied by a zone substation with a REFCL installed, particularly in high fire loss consequence areas. However, further investigation is required to better understand how the REFCL operates when a wire-to-earth fault evolves into a wire-to-wire fault.

Subject to further analysis, a REFCL may be more likely to mitigate the impact on supply reliability where the powerlines have been replaced with a technology that does not enable wire-to-wire faults.

Reducing the energy levels when a reclose operation occurs

The operation of the network reclose devices could also be varied if the energy levels are reduced when a reclose operation occurs. A number of electricity distributors have been

investigating the use of an “Interruption” that can reclose on a fault at a time when the fault energy is minimal. If testing demonstrates that the likelihood of ignition is minimal through the use of this device, then reclose operations could be permitted.

Resourcing levels, processes and systems

Recognising the trade-off between the risks of turning powerlines back on and the risks of a loss of supply, the electricity distributors must ensure that they have the appropriate resourcing levels, processes and systems to restore the power supply on a timely basis to minimise the consequences of a loss of supply. However, it is recognised that in some circumstances, the powerline may not be able to be turned on until the day following an interruption to enable the powerline to be patrolled to identify the source of the fault, particularly if resources are stretched or access to areas is limited by the emergency services.

5.4 Action to be taken for the 2011/12 fire season

The most effective action that can be taken in the short term is to change the network reclose function for the 2011/12 fire season.

As most of the ACRs on multi-wire powerlines are remotely controllable and most ACRs on SWER powerlines are not, the Royal Commission recommended that the reclose function in ACRs on 22kV powerlines be suppressed only on days of Total Fire Ban and the reclose function in ACRs on SWER powerlines be suppressed for the six most crucial weeks of the fire season.

The Taskforce recognises the difficulty in being able to forecast the six most crucial weeks of the fire season to suppress the reclose function in ACRs on SWER powerlines. While it may generally be assumed to be from mid January to the end of February, there can be severe fire conditions prior to mid January and after the end of February. For example the six most crucial weeks of the 2010/11 fire season was in December and early January.

The Taskforce has consulted with the fire agencies as to the most appropriate period over which to change the reclose function on the older style SWER ACRs. The fire agencies have advised that the worst bushfire period, which is the most appropriate nominal period for changing the reclose function, is from early January to mid March. However, as the conditions vary from year to year, the Fire Services Commissioner will provide two weeks notice of the date by which the reclose function should be changed and will advise when the reclose function should be restored when the bushfire conditions ease.

Within five years new generation SWER ACRs will be installed that will enable the reclose function to be suppressed remotely on Total Fire Ban days and Code Red days. In the meantime, the electricity distributors can choose to either manually change the operation of SWER ACRs on Total Fire Ban days or to change the operation for an extended period.

Jemena and United Energy have a small number of SWER ACRs that will be removed as the SWER powerlines are converted to 22kV powerlines by 2015. In the interim, they have indicated that they will manually change the operation of the SWER ACRs on Total Fire Ban days, as they are located close to their depots.

Conversely, Powercor and SP AusNet have a much larger number of SWER ACRs that are located over a large area. They have indicated that the function of the majority will be changed for an extended period. They will have an incentive to replace the SWER ACRs as quickly as possible to mitigate the potential for adverse impacts on customers' reliability of supply.

As discussed previously, research and analysis is required to determine the criteria for selecting the area in which the network reclose function should be changed on high fire risk days and the time at which the network operation should be changed and returned to normal, and to develop the framework to be used in the lead up to and on high fire risk days to make decisions on the operation of the network.

Prior to the completion of this research and analysis, to appropriately balance the bushfire risk and the risk associated with a loss of electricity supply, it is recommended that, to the extent possible and practicable⁹³ the change in operation of the network reclose function occur at 10.00 am or when the fire danger exceeds 30, whichever occurs earlier, and the network reclose function is restored to normal operation when the fire danger index is less than 30. The timing for changing the network reclose function is consistent with current practice.

In preparing devices for this change in operation, priority should be given to the areas of highest fire loss consequence.

In some electricity distribution areas the reclose function is currently not suppressed where a Neutral Earthing Resistor (NER) is installed. The NER reduces the fault current, particularly close to zone substations, by increasing the resistance. However, the arc ignition research indicates that the NER does not reduce the fault energy to a sufficient level to reduce the likelihood of bushfires starting.

For these reasons, the Taskforce expects that, effective immediately, the electricity distributors will not use the presence of a NER as the basis for not suppressing the reclose function of the network on high fire risk days.

5.5 Taskforce’s recommendation

The Taskforce recommends that:

Recommendation 2

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

⁹³ Having regard to the available resourcing levels and the devices that can be changed.

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 index⁹⁴ 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 Commissioner⁹⁵.

The electricity distributors may choose to operate in a safer regime than these minimum requirements specify.

Recommendation 3

To ensure the greatest benefits are achieved from the Taskforce's recommendations 1 and 2:

- (a) The electricity distributors act to minimise the potential for recommendation 2 to adversely affect customers' reliability of supply⁹⁶.
- (b) Victorians should continue to be advised, as part of the state's regular fire-preparedness communication program, that they may experience reduced levels of supply reliability on high fire risk days and should take appropriate precautions, including consideration of a back-up power supply if they are highly reliant on a reliable electricity supply.
- (c) The Victorian Government nominate the body responsible for the inputs to, and assumptions for, statewide fire loss consequence mapping.
- (d) By 31 October 2011, the Fire Services Commissioner ensure there is effective liaison between the electricity distributors and the State Control Centre (including through an industry liaison officer) in the lead up to, and on, high fire risk days, to inform the operation of protection systems.
- (e) Energy Safe Victoria (ESV) seek funding to commission research and analysis on the detailed operation of protection systems on high fire risk days, and issue the framework to be used to make decisions, in the lead up to and on high fire risk days, on the operation of the protection systems.
- (f) The electricity distributors systematically develop a rationale for the circumstances under which a powerline should or should not be patrolled (and to what extent) before it is turned back on after a period of time. The rationale must include consultation with the emergency services to ensure no evidence has been detected of a fire or other dangerous situation.
- (g) Subject to a Victorian Government decision on the Powerline Bushfire Safety Taskforce's recommendations by the end of November 2011, the electricity distributors submit a revised Bushfire Mitigation Plan, which demonstrates how the required outcomes will be achieved, to ESV by the end of March 2012.
- (h) By 30 June 2012, the electricity distributors submit a plan to ESV to reduce the fire risk associated with low voltage lines and service lines where it is cost-effective to do so.

⁹⁴ The fire danger index is a composite of the grass fire danger index and the forest fire danger index that is published on the Weatherzone website.

⁹⁵ The worst bushfire period is nominally from 1 January to mid March, but may be longer or shorter depending on the circumstances.

⁹⁶ The actions that can be taken to minimise the effect on reliability of supply are discussed in section 5.3.

6 Additional precautions to reduce bushfire risk

As discussed in section 2.5, a number of changes are currently being implemented to improve the inspection and maintenance of powerlines and improve vegetation management in response to Black Saturday and the Royal Commission's recommendations.

The Taskforce, and parties making submissions in response to the Consultation Paper, have recognised that there is a number of other precautions that are relevant to reducing bushfire risk from powerlines. These include:

- **Changes to the way in which bare wire powerlines are constructed**, including longer cross arms, longer insulators, use of steel rather than wooden cross arms, different orientation of wires on a pole (vertical separation or a horizontal and vertical separation rather than a horizontal separation), increased separation of wires and replacement of expulsion drop out fuses
- **Changes to the way in which powerlines are maintained** including inspection of SWER powerlines every three years, annual powerline inspection particularly in the most dangerous areas, encouraging local monitoring of powerlines, risk based maintenance regime, investigation of the cause of all protection operations, and replacement of tie wires proactively rather than on failure
- **Improved vegetation management and fuel controls** by striking a more appropriate balance between visual amenity and the environment, and bushfire safety
- **Installing fire detection devices.**

These precautions are discussed in further detail in the following sections.

6.1 Change bare wire powerline construction and improve powerline maintenance

The objective of changes to bare wire powerline construction and improvements to powerline maintenance would be to reduce the likelihood of faults and to reduce the likelihood of electric arcs and of molten metal particles being emitted.

The electricity distributors have a responsibility under the *Electricity Safety Act 1998* to investigate alternative powerline construction methods and to improve their maintenance regime on an ongoing basis. As a result they are already replacing wooden cross arms with steel cross arms on poles carrying high voltage lines, have recently contributed to a change in the Australian Standard to increase the separation between wires for all new and replaced powerlines, and made changes to the inspection and maintenance regime following Black Saturday, as discussed in section 2.5.

The Taskforce is of the view that ESV should investigate alternative powerline construction to determine whether the likelihood of faults (and thereby the likelihood of bushfires) reduces by changing the powerline construction. If ESV determines that the likelihood of faults (and thereby the likelihood of bushfires) can be reduced in a cost-effective manner, consistent with the precautionary-based risk management framework, the electricity distributors should consider whether a change to the way in which new and replacement bare wire powerlines are constructed, consistent with ESV's findings, is required.

The Taskforce also recognises that the electricity distributors have adopted different approaches to asset management, inspection and maintenance, with more conservative approaches generally adopted in higher fire loss consequence areas.

The Taskforce is of the view that the electricity distributors should differentiate their asset replacement regime in a way that is consistent with the Taskforce's precautionary-based risk management approach, that is by extreme, very high, high, and low fire loss consequence areas. By doing so, assets will be replaced on a more conservative basis and assets will be inspected and maintained on a more frequent basis in extreme and very high fire loss consequence areas than they are in high and low fire loss consequence areas.

The Taskforce has estimated that there are currently tens of millions of points of potential failure in the rural powerlines. The average number of powerline faults in rural areas on a Total Fire Ban day due to the external environment and equipment is currently around 50. The probability that any item of plant fails on a Total Fire Ban day is thus less than 0.0001 per cent. No improvement in maintenance will be able to reduce this probability to zero.

The Taskforce was of the view that any change to bare wire powerlines construction or improvements to powerline maintenance is part of ongoing continuous improvement driven through the enhanced regulatory arrangements now in place in response to the Royal Commission's recommendation 34, rather than a strategic step change to be considered by the Taskforce.

6.2 Improve vegetation management and fuel control

The Taskforce's objective in improving vegetation management is to reduce the likelihood that vegetation could make contact with powerlines thus causing faults, noting that 24 per cent of bushfires started by powerlines are caused by vegetation. The objective of improved fuel control is to reduce the likelihood that bushfires are started, if there are electric arcs or if molten metal particles are emitted, by reducing the amount of vegetation underneath powerlines and around power poles.

Many of the participants in the consultation meetings were strongly of the view that an inappropriate balance had been struck with the current vegetation management regime – the regime was effectively captured by minority interest groups to the detriment of safety. They were of the view that safety should always be prioritised higher than visual amenity and the environment.

In addition, Ken Stuart on behalf of the Mount Taylor Fire Brigade submitted that:

Powerlines as they transect the country should act as a fire break with fuel management being managed jointly by the CFA, DSE, Shires and Power Companies.

This view was not universal. For example Val Stepnell, in a submission to the Taskforce, raised concerns about the destruction of native flora.

There is a relatively prescriptive electric line clearance regulatory regime that the electricity distributors (and others) must comply with. Changes to the electric line clearance regime have been made following Black Saturday, as discussed in section 2.5, and further changes will be considered by ESV and the Electric Line Clearance Consultative Committee (Committee). These changes include an increase in the number of zones from the current two (Low Bushfire Risk Areas or LBRA and High Bushfire Risk Areas or HBRA) and a more appropriate classification of areas into the new zones.

The Taskforce supports the changes that have been made to the electric line clearance regime since Black Saturday and the changes that are being considered by ESV and the

Committee. In assessing the new zones for electric line clearance, the Taskforce recommends that the precautionary-based risk management approach, already adopted by the ESV, should be applied, that is by extreme, very high, high and low fire loss consequence areas. By doing so, more stringent requirements will apply to vegetation management in extreme and very high fire loss consequence areas than in high and low fire loss consequence areas.

The electric line clearance regime is currently focused only on the clearance of vegetation around powerlines, as illustrated in Figure 37. It does not include vegetation underneath the powerlines or vegetation around power poles.

R.S. Jemmeson submitted that there should be:

...a bare earth area around, beneath, and above all power supply equipment. I suggest an area, as least two to three meters (sic) out from the equipment.

The Taskforce is of the view that the Victorian Government should amend the *Electricity Safety Act 1998* and the *Electricity Safety (Electric Line Clearance) Regulations 2010* to broaden the requirements for electric line clearance to include the management of vegetation underneath powerlines and around power poles.



Figure 37: Clearance space around vegetation in HBRA, as governed by the existing regulations

6.3 Install fire detection devices

The early detection of bushfires is a key element for the successful delivery of any fire management program. Bushfire detection methods can be generally grouped into two distinct categories:

- volunteer reporting: public reporting of fires (000), public aircraft, ground based field staff (agency and industry field staff)
- operational detection systems: fire towers, aerial patrols, electronic lightning detectors, automatic detection systems.

As the non-urban mobile phone network coverage has become more widespread, observations of fire outbreaks by the general public are becoming more prevalent, particularly in well settled areas.

In areas with few people or poor communications, there is greater reliance on more traditional detection and reporting systems. Victoria has an extensive network of fire spotting towers as shown in Figure 38.

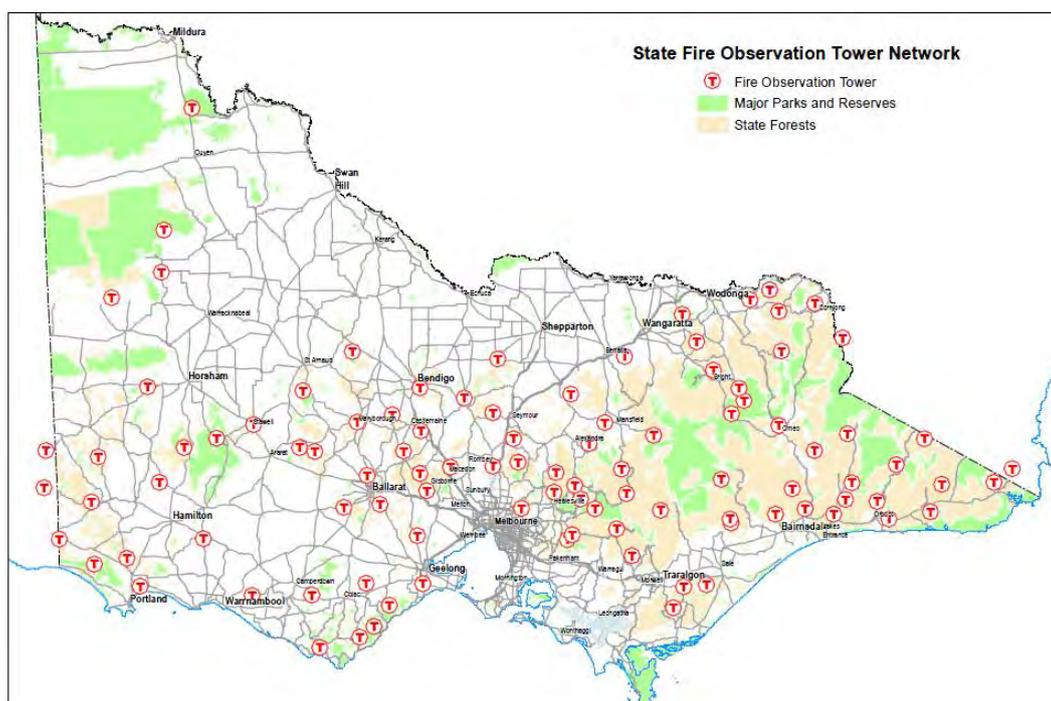


Figure 38: Victoria's network of fire observation towers

These towers are well placed to quickly spot fires and the human observers in them can apply their expertise to deliver very high quality data to fire authorities. The fire agencies have recently trialled some new techniques, under a national initiative⁹⁷, which did not provide these same benefits.

Two fire detection options have been considered by the Taskforce – the installation of smoke/fire detectors and the direct real time reporting of faults to fire authorities. In assessing these options, the Taskforce noted that the five major electricity-related fires examined by the Royal Commission were all detected within a few minutes and it was unlikely the options it has considered would materially improve on this performance.

⁹⁷ Attorney-General's Department, *Remote Fire Detection Trials – Evaluation of Three Fire Detection Systems* http://www.ag.gov.au/www/agd/agd.nsf/Page/Publications_Evaluationofthreefiredetectionsystems-8October2010#LinkTarget_10831 accessed on 30 November 2010

Install smoke/fire detectors

Two manufacturers of smoke or fire detectors have provided information to the Taskforce for its consideration. The devices could be mounted on powerline poles and have a range of around 1 kilometre. The cost of supply, installation and communications is estimated to be about \$2,500 each. The Taskforce has decided not to pursue this option for three reasons:

- impact on likelihood of bushfires: the devices make no improvement to the existing likelihood that powerlines start bushfires
- burden on fire authorities: the devices produce huge volumes of data that requires analysis before responses can be identified
- ability to detect fires more quickly: a material reduction in the time in which powerline-related bushfires are detected by using these devices is unlikely.

Direct real time reporting of faults to fire authorities

When a fault occurs in the electricity network, there is always a possibility of a fire start. It has been suggested that electricity distributors could report all protection operations to fire authorities as they occur. The Taskforce has assessed this idea but on balance has decided not to pursue it. Although the cost was lower than the fire detector option outlined above, the data processing burden remained a major drawback and it would have no impact on the likelihood that powerlines start bushfires.

On 7 February 2009, there were about 600 protection operations, of which approximately 20 resulted in a fire. If all protection operations were reported to fire authorities, it would take some time to analyse this data to identify those that required attention. Many protection operations are currently not remotely monitored, for example fuse operations. These are reported by customers to the electricity distributor who would then report it to the fire authority. Given the fire authorities are generally advised of a fire start within minutes, this process is unlikely to reduce the time to detect a fire.

With enhanced protection systems and the installation of smart meters, most if not all protection operations will be remotely detected. This will lead to far more protection operations than currently reported, thus further increasing the risk of overloading fire authorities with data, only a minute portion of which is relevant to them.

6.4 Taskforce's observations

In summary, the Taskforce observes that:

- The Victorian Government should amend the *Electricity Safety Act 1998* and the *Electricity Safety (Electric Line Clearance) Regulations 2010* to broaden the requirements for electric line clearance to include the management of vegetation underneath powerlines and around power poles.
- The electricity distributors should differentiate their asset replacement, asset inspection and maintenance, and vegetation management in a way that is consistent with the Taskforce's precautionary-based risk management approach, that is by extreme, very high, high and low fire loss consequence areas.
- The Electric Line Clearance Consultative Committee should differentiate the vegetation management requirements in a way that is consistent with the Taskforce's precautionary-based risk management approach, that is by extreme, very high, high and low fire loss consequence areas.

- ESV should investigate alternative powerline construction, including the length of insulators, length of cross arms and the orientation of powerlines, to determine whether the likelihood of faults (and thereby bushfire starts) reduces by changing the powerline construction.
- If ESV determines that the likelihood of faults occurring can be reduced in a cost-effective manner by changing the powerline construction, the electricity distributors should change the way in which new and replacement powerlines are constructed, consistent with ESV's findings.

6.5 Further research and development is required

The research and analysis undertaken by the Taskforce has increased the knowledge and understanding of the ignition of bushfires by powerlines, particularly the time within which ignition occurs, and new technologies that can reduce the likelihood of powerlines starting bushfires.

However, it has also revealed that further research and development is required, particularly in relation to:

- improved fire loss consequence modelling
- the optimum operation of ACRs on high fire risk days
- new protection technologies to reduce bushfire risk and minimise impacts on supply reliability
- ignition
- the construction of bare powerlines
- vegetation management
- the value to Victorians of supply reliability on high fire risk days
- why powerlines start a disproportionate number of catastrophic bushfires.

The Taskforce believes that there is a need for ongoing funding for a long-term research and development program to improve knowledge and understanding in this area.

Research and development is primarily concerned with the novel application of established facts and principles to yield new products and services. As the stock of publicly available knowledge increases, so do the returns to society from the basic research and development that produces these facts and principles. However, if the new facts and principles become widely known, the commercial incentives for basic research and development diminish as the opportunities for individual gain are reduced.

A firm that undertakes the research and development incurs all of the costs, however, the benefits from that learning are available to all firms that follow. The result is the undersupply of learning and discovery. As a result, governments have recognised that there is a market failure and have provided funding for research and development, for example the Victorian Government's Energy Technology Innovation Strategy, or provided an allowance for regulated businesses to invest in research and development, for example the UK's Innovation Fund.

To ensure that the required research and development is undertaken, the Taskforce recommends that the Victorian Government provide funding for further research and development.

Recommendation 4

The Victorian Government should improve the capacity for ongoing research and development to further reduce the likelihood that powerlines start bushfires and assist Energy Safe Victoria (ESV) to effectively and appropriately regulate the electricity distributors.

- (a) Funding of not less than \$2 million per annum for five years should be provided for research and development.
- (b) Appropriate independent governance arrangements should be established to oversee the allocation of the funding.
- (c) ESV, electricity distributors and other parties should be able to apply for the funding.
- (d) The funding should be provided contingent on the results of the research and development being made publicly available.
- (e) Priority should be given to improved fire loss consequence modelling, research and analysis to optimise the operation of network reclose devices, and developing new protection technologies to reduce bushfire risk and minimise impacts on supply reliability.

As the benefits of the research and development will accrue to the electricity distributors (and customers) in other states, the Victorian Government is encouraged to seek funding from other states and the Commonwealth Government.

7 Paying for the reduction in bushfire risk

The Taskforce's Terms of Reference required it to advise the Victorian Government on the options for fairly and efficiently recovering the costs associated with implementing its recommendations and to provide advice on the efficient and prudent allocation of the \$50 million Safer Electricity Assets Fund.

The options for recovering the costs associated with the recommendations in this report are discussed in section 7.1 and recommendations for the allocation of the Safer Electricity Assets Fund are provided in section 7.2.

7.1 Options for recovering the costs

The Taskforce is required to identify options for the recovery of costs that are fair and efficient. It is assumed that "fair" refers to an equitable distribution of costs and that "efficient" refers to economic efficiency and administrative simplicity.

An equitable distribution of costs is defined as one that is fair and impartial towards all concerned, based on the principles of even-handed dealing. It implies giving as much advantage, consideration, or latitude to one party as is given to another. In the context of the Taskforce's recommendations, it is unclear whether an equitable distribution is one in which the costs are recovered equally over a defined region, one in which the contributors to bushfires (by having access to an electricity network) pay or one in which the beneficiaries of reduced bushfires pay. As the costs for the electricity supply system are generally based on a user pays basis, it is implied that equity refers to the beneficiaries paying.

Economic efficiency is defined as delivering the desired outcome at the least cost. In general, to ensure an efficient allocation of resources, costs are allocated to the beneficiaries. If the beneficiaries are subsidised, this will distort future decision making leading to inefficient resource allocation.

The simpler the cost recovery mechanism, the lower the administrative costs incurred.

The Taskforce has separately considered the costs associated with the electricity distribution network and the private costs that will be imposed on individuals as a result of changes to the electricity distribution network.

7.1.1 Current arrangements for recovering costs

The current arrangements for recovering costs associated with the electricity distribution network have struck a balance based on equity, economic efficiency and administrative simplicity, and are broadly based on a user pays principle.

Costs that are directly attributable to a specific customer, for example costs of connecting to the electricity distribution network, are paid for by that customer.

Costs that are not directly attributable to a specific customer, for example replacing part of the network, are paid for by all customers in the electricity distribution area. At the time of privatisation the decision was made on the number of electricity distribution areas. By balancing equity, economic efficiency and administrative simplicity considerations, the decision was made to have five electricity distribution areas – two in largely rural areas

(Powercor and SP AusNet), two largely in the suburbs of greater Melbourne (Jemena and United Energy) and one covering the Melbourne CBD and inner suburbs. Costs are generally recovered equally across all customers, which are broadly similar, in the one electricity distribution area.

However, there are a couple of notable exceptions whereby costs are recovered from a subset of customers. SP AusNet has:

- tariffs specifically designed for customers in alpine areas
- separate public lighting operating, maintenance and replacement charges that apply in its central area and in its north east area.

There are some costs that are partly recovered from individual customers and partly recovered from the rest of the customers in the electricity distribution area, for example the cost of augmenting the network to connect a new customer. The economic logic is to ensure that the customer requiring the augmentation does not impose a greater cost on other customers than the costs that would be recovered from that customer over time. If the costs to be recovered from the customer requiring the augmentation over time are estimated to be less than the cost of the augmentation, then that customer pays the difference. This ensures that the customer is not being subsidised by other customers and thereby potentially connecting to the network inefficiently.

Generally all costs associated with the supply of electricity are recovered through electricity bills. However, there is one exception – the former Powerline Relocation Scheme, which supported the undergrounding of distribution powerlines in areas that are of importance because of environmental, historic or scenic significance; or high pedestrian or vehicular use⁹⁸.

Under the former Powerline Relocation Scheme, the costs for undergrounding powerlines were paid jointly by the Victorian Government, electricity distributor and proponent (usually the local council). The basis for the allocation of costs was that the beneficiaries of the improvement in visual amenity were the local community (which justified the local council contribution) and potentially the wider community (which justified the Victorian Government's contribution).

7.1.2 Options for the recovery of network costs

The options for the recovery of costs associated with the electricity supply system in general and with the Taskforce's recommendations in particular are along a continuum from an arrangement under which the costs are specific to each person to one in which the same costs apply across the state.

For administrative simplicity, the options for recovering the network costs associated with implementing the Taskforce's recommendations that are considered are limited to the following, noting that more than one of these could be combined to form an additional option:

- state – costs are recovered from all Victorians
- regional – costs are recovered from those in a defined geographical area

⁹⁸ For further details on the Powerline Relocation Scheme, please refer to <http://new.dpi.vic.gov.au/energy/consumer-info/powerline-relocation/brochure>

- local – costs are recovered from those in a more localised area
- individual customer – costs are recovered from customers at individual premises.

The mechanisms for recovering the costs at each level are as follows:

- state – through increased taxes on all Victorians or through reduced services in other areas. Alternatively there could be a levy on all electricity customers (similar to a former levy for Alcoa) with the funds redistributed to pay for the works
- regional – through electricity bills in which case the costs are recovered from customers in the respective electricity distribution area, consistent with the current economic regulatory framework. Alternatively through rates levied by a group of local councils within the defined geographical area
- local – either through electricity bills where the electricity tariffs differ by area (similar to the current tariff on electricity customers in the Melbourne CBD area for a higher security of supply) or through local council rates
- individual customer – the direct beneficiaries would be individually levied.

The Taskforce notes that municipalities strongly oppose recovering the costs through local council rates⁹⁹:

Municipalities are not collection agencies for distribution companies and would not cooperate with such a proposal. If a local payment option was proposed and supported, then the collection process should be through electricity subscriber individual accounts and not through a third party.

7.1.2.1 Assessment of cost recovery options

In assessing each cost recovery option, it is necessary to consider the “service” that is provided by each precaution and who is the beneficiary of that “service”.

The precautions are:

- targeted replacement of powerlines – for customers in targeted areas (those in the highest fire loss consequence areas)
- new protection technologies – for all customers in extreme, very high and high fire loss consequence areas
- changed network reclose function – for all customers in extreme, very high and high fire loss consequence areas.

The “services” provided by these precautions include the reduced likelihood of bushfires, improved public safety, improved reliability of supply (or in some cases, reduction in reliability of supply), improved visual amenity and avoided costs. The location of these “services” for each of the precautions and operational options is set out in Table 23.

⁹⁹ Submission from the Municipal Association of Victoria to the Taskforce, page 6

“Service”	Targeted replacement of powerlines	New protection technologies	Changed reclose function network
Bushfire safety	Localised	Non-urban	Non-urban
Public safety	Localised	Non-urban	Non-urban
Reliability of supply	Localised	Non-urban	Non-urban
Visual amenity	Localised	N/A	N/A
Avoided costs	Electricity distribution area	Electricity distribution area	Electricity distribution area

Table 23: Location of “services” delivered by each of the precautions

The beneficiaries will generally be in the same area as the location of the “service” for reliability of supply and avoided costs. However, the beneficiaries may not be in the same area as the location of the “service” for bushfire safety and visual amenity.

Where the “service” provided is a reduction in the likelihood of bushfires, the identification of the beneficiaries is more complex because the beneficiaries may not be in the same area as where there is a reduction in the number of bushfires. For example an action may be taken to reduce bushfires in area A to reduce catastrophic fires in area B that has an impact on area C.

In the case of visual amenity, the beneficiaries may be broader than the local area in areas that are of importance because of environmental, historic or scenic significance; or high pedestrian or vehicular use.

The majority of attendees at the Taskforce’s consultation meetings supported the recovery of costs across all Victorians. For example in a submission to the Taskforce, A. Noel stated that¹⁰⁰:

I do support the costs of improving powerline safety being imposed across the Victorian community, and not just in fire prone areas. Tax payers living in fire prone areas pay for many infrastructure improvements enjoyed by inner city residents which they do not directly benefit from, so it is quite equitable that sometimes the reverse should apply.

Conversely, John Cochrane was of the view that¹⁰¹:

Uniform tariffs have no relevance in today’s era when the emphasis is on optimisation of asset use. ... Optimisation is never achieved by dilution of costs centres, which is the effect of a uniform pricing policy. Across society the user should pay the cost of service and seek to optimise if the cost is excessive. If the government must subsidise certain consumers to achieve a social outcome – like occupation of the bush – governments should give a “social grant” but they should not make that grant through a reduction of power supply price. Maintaining the true cost of service as the basis for price will continue to give appropriate pricing signals.

The position of the Consumer Utilities Advocacy Centre (CUAC) was that the cost distribution should depend largely on the scale of the package¹⁰²:

¹⁰⁰ Submission from A. Noel to the Taskforce, page 2

¹⁰¹ Submission from John Cochrane to the Taskforce, page 2

¹⁰² Submission from the Consumer Utilities Advocacy Centre, page 4

If the package is at the 2 per cent end of the cost range ... CUAC is of the view that the most efficient way to recover the costs of such a package would be through distribution charges regulated by the Australian Energy Regulator. However, as the costs of any determined package rise, there is an increasing case to smear any costs across the State to ensure that consumers in particular distribution areas are not disadvantaged. ... CUAC would consider it appropriate for the State Government to contribute a portion of the costs of the mitigation package from the consolidated revenue if the package was likely to lead to bill increases of over \$40 a year for an average consumer in a particular distribution area.

The Victorian Government will need to decide how the network-related costs of improving bushfire safety are paid.

7.1.3 Private costs imposed on individuals

Under the existing cost recovery arrangements, when customers choose to contribute to pay to underground an existing powerline (for example through the former Powerline Relocation Scheme) then they pay the cost to reconnect to the network. Presumably they will choose to pay this cost when the value to them of the underground network exceeds the cost.

However, if there is a targeted program to replace powerlines, customers may not necessarily make this decision. The decision has been made based on the benefits that accrue on a broader scale, that is the public good associated with replacing the powerlines. Customers located in the area where powerlines are to be replaced may not have the capacity to pay to replace their service line or POEL.

The options available for recovering the private costs associated with service lines and POELS that are imposed on individuals by the replacement of powerlines are:

- be paid for by the individual customers or the electricity distributor (consistent with the ownership of the asset), consistent with the current regulatory framework, with assistance to those in financial hardship
- be paid for, in part by the individual customer (through a standard contribution), with the balance (if any) paid for by the electricity distributor (and thereby all electricity customers)
- be paid for by the electricity distributor as part of the project, with the costs associated with customers' assets recovered as operating expenditure
- be paid for by the Victorian Government.

The Victorian Government will need to decide how the private costs imposed on individuals to improve bushfire safety are paid.

7.2 Options for allocating the Safer Electricity Assets Fund

The Victorian Government has committed \$50 million in direct funding, through the Safer Electricity Assets Fund (SEAF) to commence the 10-year process of reducing the likelihood that powerlines start bushfires. The Taskforce's Terms of Reference required it to provide advice on the efficient and prudent allocation of the \$50 million funding.

The Taskforce has identified the following criteria for considering how the SEAF funding should be directed.

- **Efficiency** – the successful project(s) should deliver the desired outcomes at least cost. The desired outcomes are a reduction in the likelihood that powerlines start catastrophic bushfires with acceptable impact on supply reliability.
- **Effectiveness** – the successful project(s) are, or are likely to be, effective in reducing the likelihood that powerlines start catastrophic bushfires with acceptable impact on supply reliability.
- **Equity** – impacts are equitably distributed across the community, noting that customers in Jemena and United Energy’s areas will be paying for the installation of REFCLs in all zone substations that feed non-urban areas and for the conversion of all SWER lines to multi-wire lines, and customers in SP AusNet’s area will be paying for new generation SWER ACRs.
- **Additionality** – any projects funded should be additional to those that will be delivered in the absence of funding.
- **Maximum leverage of knowledge** – provides information on technology performance and community understanding to inform how best to apply later funding.

As previously discussed, the most effective precautions to reduce the bushfire risk associated with powerlines on a statewide basis are to install new generation SWER ACRs and REFCLs and to change the network reclose function on high fire risk days. While the replacement of powerlines is a more effective precaution for a given location; for a given cost, the area in which powerlines can be replaced is much smaller than the area that can be covered by the new generation SWER ACRs and REFCLs and to change the network reclose function.

The Taskforce’s analysis indicates that an effective package of measures can be at a cost that customers are willing to pay for. However, the Taskforce notes that the package of measures may impose costs on individuals – particularly in relation to the costs associated with service lines and POELs, as discussed in section 7.1.3, and in the installation of back-up generators where they are necessary to mitigate the adverse impacts of the package of measures on supply reliability.

While some Victorians will have the financial capacity to pay to replace service lines and POELs or to pay to install back-up generators, there are others that do not have the financial capacity.

As an example, there are currently 43,000 customers with approximately 6,200km of POELs. There is an existing requirement to underground POELs, as discussed in section 2.3. The cost to underground all POELs is approximately \$690 million, and is paid for by the customer that owns the POEL. As the requirement to underground POELs has been in place for a couple of decades, some of these POELs have already been placed underground. The proportion is unknown, but is only likely to be around 20 per cent, leaving a cost remaining of around \$550 million.

If it is assumed that around 1 per cent of POELs are put underground per year, then over four years, 4 per cent or 248km of POELs would be undergrounded at a cost of around \$27.6 million.

As discussed in section 6.5, the role of government in funding research and development is well accepted. The Taskforce’s research and analysis has revealed that further research and development is required and has recommended that ongoing funding of \$2 million per annum is required. The research and development could initially be funded through SEAF.

The Taskforce therefore recommends that:

Recommendation 5

The Safer Electricity Assets Fund should be used to fund, in priority order:

1. Research, development and demonstration (\$2 million per annum over five years) – fund research and development projects that will further reduce the likelihood that powerlines start bushfires.
2. Private costs that are imposed on individuals by the Taskforce's recommendations to address equity and financial hardship concerns (\$40 million) – contribute to the cost of service lines and private overhead lines, or alternative supply options.

8 Full benefits can be delivered in 10 years

It has been recommended that new protection technologies are deployed within five to ten years and targeted powerlines are replaced in the highest fire loss consequence areas within 10 years.

The full benefits associated with the Taskforce's recommendations can be delivered within the required 10-year implementation timeframe, however, whether this will actually occur will be determined by many factors including resource and financing constraints, regulatory controls applicable to powerline replacement and access to easements for replacement powerlines, which are discussed in section 8.1.

A reporting and compliance framework is required to monitor and report on the implementation of the recommendations, as discussed in section 8.2.

8.1 Implementation speed will be determined by many factors

The speed with which the bushfire risk benefits will be able to be delivered is largely dependent on the package of measures that is selected by the Victorian Government. It will be far more difficult to deliver a \$3 billion or \$10 billion capital works program over a 10-year period than a \$500 million or a \$1 billion capital works program.

The electricity distributors' forecast capital works program for the 2011–15 period is in the order of \$5.4 billion, which is a significant increase relative to the capital works program for the 2006–10 period. This increase in capital works is in the context of significant increases in capital works programs by the electricity network businesses in other states and significant work programs driven by climate change policy.

Depending on which package of measures is accepted by the Victorian Government, the additional capital works that are required over the next 10 years to reduce bushfire risk may be very significant relative to the existing capacity within the industry. There may be resourcing constraints and financial constraints that limit the ability of the electricity distributors to deliver the works required to reduce bushfire risk, noting that the electricity distributors effectively finance the capital works programs with the costs recovered over the life of the assets (45 years).

The REFCLs are located in the electricity distributors' zone substations so there are few additional constraints to being able to install them within a 10-year period.

The REFCL has been trialled at Frankston South zone substation since late 2009 and so there is local experience with installing the REFCL in an area with relatively short powerlines. However, there is little experience installing an REFCL in an area with long rural powerlines that are not balanced with respect to load and capacitive current. Long rural powerlines are generally not in the areas with the highest fire loss consequence. The impact on the state's overall bushfire risk would be minimal if a small number of more complex installations in the high fire loss consequence areas were delayed beyond the 10-year timeframe.

The new generation SWER ACRs are located on existing power poles. As the new generation SWER ACRs have been trialled by SP AusNet, overseen by the Taskforce's independent technical expert, it is expected that these can all be installed within the required five-year timeframe.

The regulatory controls applicable to powerline replacement works, which are discussed in section 8.1.1 and the access to easements, which is discussed in section 8.1.2, may materially impact the ability to replace powerlines within a 10-year timeframe.

8.1.1 Regulatory controls applicable to powerline replacement

Under current arrangements, any action to replace network assets with different assets requires approval of many different planning bodies, local governments and other agencies. Legislative controls on roadside reserves, native vegetation and other matters must all be satisfied. These requirements are summarised in Table 24.

Regulatory/planning regime	Obligation on proposer of capital works
Local government	Negotiation of aspects not covered by planning exemptions
Roads Management Act 2004	Negotiate approvals and easements required
Land Acquisition and Compensation Act 1986	Negotiate compensation for any increase of assets on private land
Aboriginal Heritage Act 2006	Engage archaeologist to prepare Cultural Heritage Management Plan
Native Vegetation Framework ¹⁰³	Engage botanists to prepare Net Gain Assessment

Table 24: Legislative controls that must be considered when replacing powerlines

Almost every location within the state is affected by at least one of these controls and most are subject to multiple controls, as illustrated in Figure 39.

¹⁰³ Available at <http://www.dse.vic.gov.au/land-management/victorias-native-vegetation-management-a-framework-for-action>

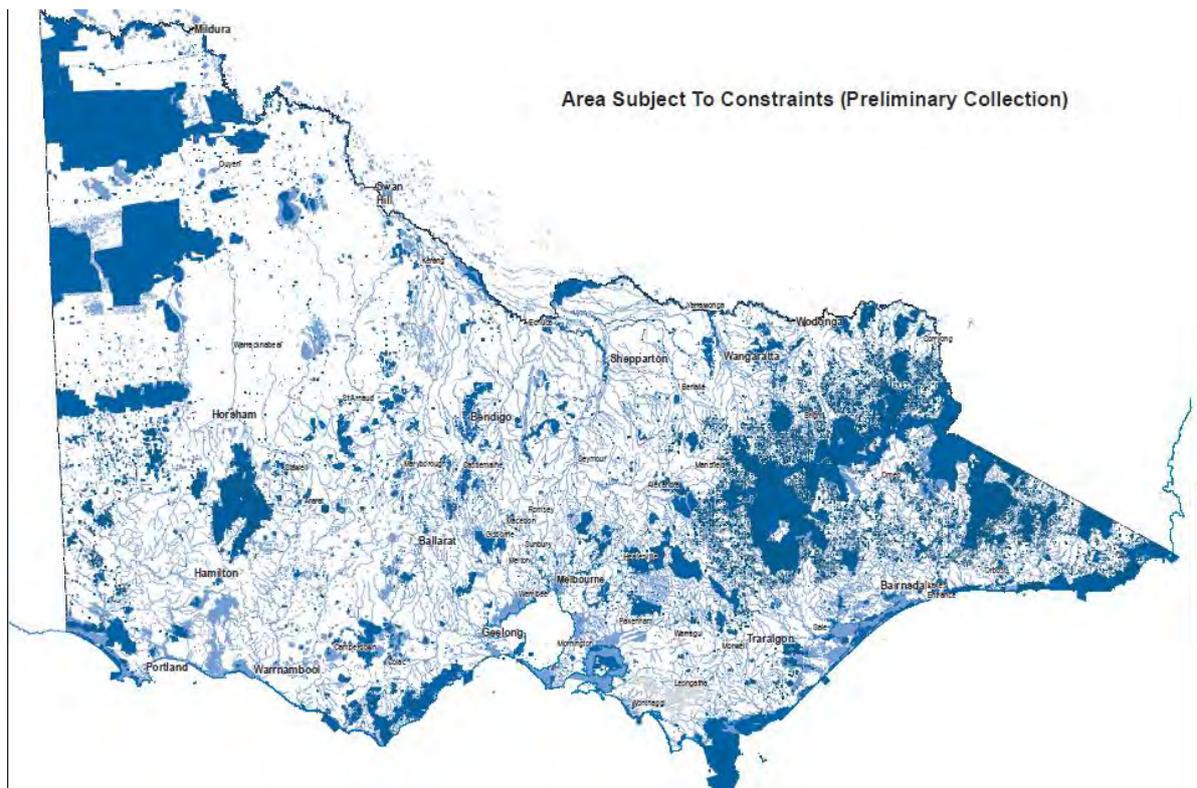


Figure 39: Presence of special regulatory controls on powerlines

The major change in the last few decades is that powerlines constructed on roadside reserves are subject to the requirements of the *Road Management Act 2004*, which gives road authorities a degree of control over powerline construction to manage road safety aspects.

Roadside vegetation must also be considered, as in some areas of the state the only remnant native vegetation is on roadside reserves. In such cases, the Native Vegetation Framework applies.

Experience has demonstrated that activity required to satisfy regulatory requirements greatly extends project timeframes and increases costs.

8.1.2 Access to easements

Non-urban powerlines are located on roadside reserves, on private land and on public land. Many of these powerlines were built more than 50 years ago under agreements with landowners and other public authorities that were much less formal than will be required for powerline replacement.

The introduction over the last 50 years of multiple controls on the use of road reserves for powerlines will increase pressure on electricity distributors to use adjoining private land for new powerlines if those on road reserves are replaced.

Electricity distributors have a right to maintain powerlines located on private land, including replacement of powerline components such as poles, insulators and even wires. However, they must renegotiate landowner agreement for any replacement works other than like-for-like replacement – either above ground or underground.

As most powerline replacement is likely to involve major disruption during construction or greater long-term alienation of land area, private landowners are unlikely to accept these effects without compensation. In some cases they may resist regardless of compensation given that there is no incentive for them to agree. It is relevant that the major fire risk reduction benefits of powerline replacement will often be realised tens of kilometres away rather than at the site of the works where the impact on land use will occur.

Powers of compulsory acquisition of powerline easements have been used by the State for major transmission line projects, generally only as a last resort. There is little if any precedent for their use to build local distribution powerlines especially for the powerline replacement technologies being considered by the Taskforce.

The Taskforce recognises that a requirement for distributors to negotiate with many tens of thousands of local landowners is likely to delay implementation beyond the target 10-year timeframe. The burden of negotiations for replacement of powerlines already located on private land will be increased where regulatory controls generate a requirement to move powerlines from road reserves to private land to implement the Taskforce's recommendations.

These difficulties were identified by the Municipal Association of Victoria¹⁰⁴:

Given the issues related to laying underground cables on private land, it is likely that the use of road reserves for new easements would be considered as an alternative. Municipalities already deal with a plethora of legislation relating to roadside management, and the provision of an underground powerline easement would further complicate this already complex management space. It is fully understood that existing easements for overhead lines may not translate into suitable underground easements. As such, substantial on-ground assessment and consultation will be required to determine the best fit option, and to balance the risk against all other competing utility demands on the road reserve.

The costs associated with negotiating easements for the replacement powerlines have been included in the estimated costs provided in section 4.3.1, however, there is no guarantee that the easements could be negotiated to meet the 10-year implementation timeframe.

The difficulties in gaining access to private land or roadside reserves may require a full redesign of the network or it may trigger removal of more isolated customers from the grid. Similarly complex issues arise in the case of VicTrak and crown land.

Support may be needed from the Victorian Government to assist with meeting the 10-year implementation timeframe for replacing powerlines. This may be in the form of legislation to facilitate the replacement of powerlines, the relaxation of roadside controls, or the use of powers to compulsorily acquire easements.

8.2 A reporting and compliance framework is required to ensure outcomes are delivered

With the additional investment that is likely to be made in the electricity distribution networks to reduce bushfire risk, there is an obligation to ensure that the required outcomes are delivered. ESV, as the safety regulator, is best placed to ensure that an appropriate reporting and compliance framework is in place.

¹⁰⁴ Submission from the Municipal Association of Victoria to the Taskforce, page 5

In response to the Royal Commission's recommendation 34 to strengthen the role of ESV, the introduction of the Electricity Safety Management Schemes (ESMS) and the incorporation of the Bushfire Mitigation Plan into the ESMS, ESV commenced reporting publicly on an annual basis on the safety performance of the electricity distributors. The first Comparative Safety Performance Report was published in 2011 to report on 2010 safety performance.

It is appropriate that future Comparative Safety Performance Reports also report on the implementation of the Taskforce's recommendations.

The Taskforce has made its recommendations by considering the best information available at the time. Further research and development has been recommended that may provide new information. It is prudent that the Taskforce's recommendations, and the implementation of those recommendations, be reviewed in five years time to ensure that they continue to be the most cost-effective means to reduce bushfire risk from powerlines.

The Taskforce therefore recommends that:

Recommendation 6

- a) Energy Safe Victoria (ESV) implement a reporting and compliance framework to ensure that the recommendations that are accepted by the Victorian Government are implemented by the electricity distributors.
- b) ESV publish the outcomes of the reporting and compliance function and report on the status of the implementation of each recommendation accepted by the Victorian Government in its annual Comparative Safety Performance report.
- c) A review be undertaken by ESV or an independent body at the end of five years to assess whether the Taskforce's recommendations continue to be the most cost-effective means to reduce the likelihood of powerlines starting bushfires, and to assess the effectiveness of the implementation of the Taskforce's recommendations.

Appendix A The Taskforce

The Powerline Bushfire Safety Taskforce was established following the release of the Royal Commission’s Final Report to review the full range of options to reduce the risk of catastrophic bushfires from electricity infrastructure and to quantify the benefits and costs, taking into account all measures taken by Government to reduce those risks.

A.1 Objective of the Taskforce

The objective of the Taskforce was to:

Recommend the technological and operational options that could be implemented within 10 years to substantially reduce the frequency of bushfire starts from electricity system assets, with reference to likely consequence, particularly on days of extreme weather conditions, while meeting the requirements of Victorian communities with regard to cost, supply reliability, landowners and the environment.

For the purposes of this review, a bushfire start was defined as a fire reported to the Melbourne Fire and Emergency Services Board, Country Fire Authority or Department of Sustainability and Environment except where the fire is restricted to a building or buildings.

When considering the consequences of a bushfire, the Taskforce had particular regard to the potential for loss of life and homes.

A.2 Governance arrangements for the Taskforce

The governance arrangements that were established for the Taskforce are illustrated in Figure 40.

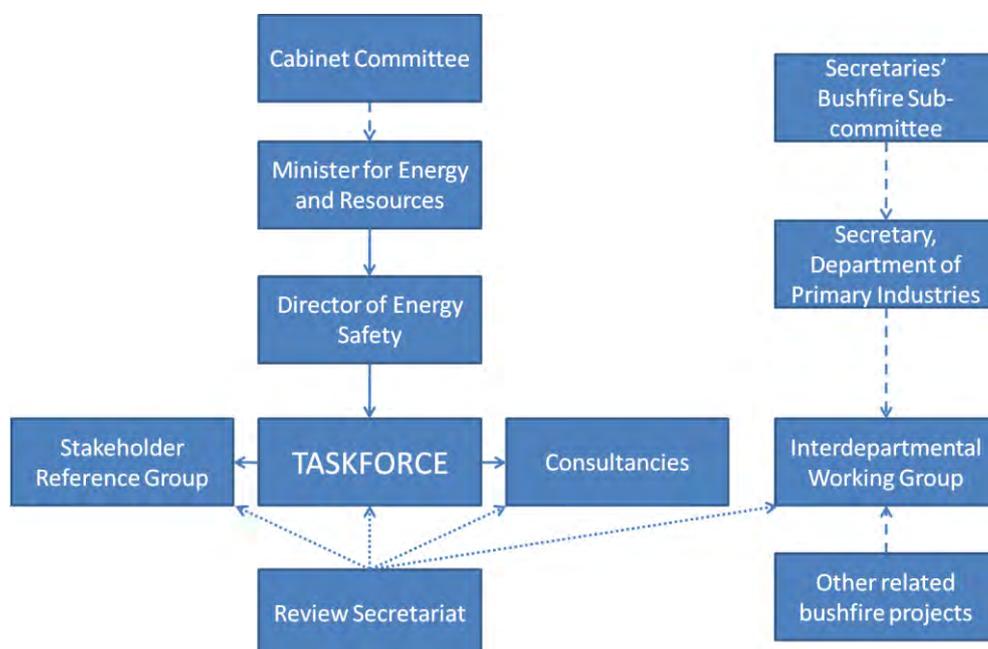


Figure 40: Taskforce governance arrangements

ESV provided a Taskforce Secretariat, headed by the Deputy Director of Energy Safety, to support the work of the Taskforce.

A.3 Taskforce membership

The Taskforce was required to have an independent Chair and include a representative of an affected fire community, the Country Fire Authority, and the relevant electricity distributors. The Taskforce was to also include members with relevant skills and experience as determined by the Director of Energy Safety in consultation with the Taskforce Chair.

The members of the Taskforce are listed in Table 25.

Member	Affiliation and/or expertise
Tim Orton	Independent Chair
Craig Savage	Jemena
Vince Power	Powercor
Gary Towns	SP AusNet
Mike Fajdiga	United Energy Distribution
Adam Jenkins	CFA
Professor Grahame Holmes	RMIT, technical expert
Richard Robinson	R2A, risk management expert
Brent Taylor	Value Bank Research Centre, stakeholder engagement expert
Ian Porter	Alternative Technologies Association, alternative technologies expert
Graeme Brown	Marysville and Triangle Development Group, community representative

Table 25: Taskforce membership

A.4 Stakeholder Reference Group

The Taskforce was required to establish a Stakeholder Reference Group representative of the broad range of affected stakeholders including community, business, farming, and employee representatives.

The purpose of the Stakeholder Reference Group was to:

- review work that was being undertaken as part of the review, and provide feedback that reflected the views of their constituency
- provide advice on the timing and content of any elements of work relating to consumer research or community consultation.

The members of the Stakeholder Reference Group are listed in Table 26.

Member	Affiliation/role
Mike Ebdon	Deputy Director of Energy Safety - Chair
Jo Benvenuti	Consumer Utilities Advocacy Centre
Graeme Watson	Electrical Trades Union
Russell Rees	Municipal Association of Victoria

Member	Affiliation/role
Susan Finger	Victorian Farmers Federation
Kerri Easton	Rural communities, East Gippsland
Lyn Gunter	Rural communities, Murrindindi
Christine May	Agricultural community
Len McKeown	Small business (non agricultural) community
Brent Taylor	Stakeholder representative on Taskforce

Table 26: Stakeholder Reference Group membership

A.5 Consultants engaged by the Taskforce

In addition to the expertise contributed by members of the Taskforce and Stakeholder Reference Group, the Taskforce relied on specialised expertise provided by a range of consultants. These are listed in Table 27.

Consultant	Specialised area of expertise
ACIL Tasman	Economic modelling
Australian Technical Services	Management of trials
Chant Link and Associates	Market research
GHD	Fault tree analysis
HRL Technology Pty Ltd	Arc ignition research
The Nous Group / Marxsen Consulting	Technical support
Parsons Brinckerhoff	Detailed cost-benefit analysis
R2A	Threat-barrier analysis
Sinclair Knight Merz	Preliminary indicative costs
Spatial Vision	Spatial data

Table 27: Expert consultants engaged by the Taskforce

Appendix B Community consultation

The Taskforce released a consultation paper on 2 May 2011 to seek input from the community on the optimum package of measures to reduce the likelihood of powerlines starting bushfires, while ensuring that the impact on cost, on reliability of supply, on landowners and the environment is acceptable. The Taskforce also conducted a series of community meetings to discuss the Consultation Paper. Meetings were held in the following locations:

Date and time	Location
Monday 23 May 2011	Colac
Tuesday 24 May 2011	Ararat
Wednesday 25 May 2011	Macedon
Thursday 26 May 2011	Whittlesea
Wednesday 1 June 2011	Healesville
Thursday 2 June 2011	Bairnsdale
Thursday 9 June 2011	Benalla

Non-confidential submissions on the Consultation Paper were received from the following parties:

- Robert and Denise Bird
- John Cochrane
- Consumer Utilities Advocacy Centre
- Michael Delahunty
- Electrical Trades Union
- William Greenland
- Lyn Gunter
- Michael Gunter
- R. S. Jemmeson
- Jemena Electricity Networks (Vic) Ltd
- Thomas Jones
- Len McKeown
- Municipal Association of Victoria
- Nillumbik Shire Council
- Angela Noel
- Rocla

- Stepnell Farms P/L
- Ken Stuart, on behalf of the Mount Taylor Fire Brigade
- Upper Goulburn Community Radio Inc.
- Victorian Farmers Federation
- Yarra Ranges Council
- Glenelg Shire Council.

In addition, three confidential submissions were received.

The non-confidential submissions have been published on ESV's website at <http://www.esv.vic.gov.au/For-Consumers/Bushfire-Taskforce>.

Appendix C Background information on the electricity supply system

As discussed in section 2.1, the privatised Victorian electricity supply system consists of four elements:

- **Generation** – electricity is predominantly generated in Victoria from brown coal, but also natural gas, hydro, and wind. There are a number of generators that sell the electricity generated in a competitive market.
- **Transmission** – electricity is transmitted at high voltages on tall steel lattice towers from the major points of generation to major load centres. There is a single transmission network provider in Victoria.
- **Distribution** – electricity is transformed to lower voltages for distribution, generally through the “poles and wires” network, to business and residential customers. Five electricity distributors distribute electricity in Victoria – each one has a defined area.
- **Retail** – electricity is sold to customers by the retailer.

The distribution rather than transmission system was the subject of the Royal Commission’s recommendations.

There are five electricity distributors in Victoria that own and operate the electricity distribution system:

- **CitiPower** – CitiPower supplies just over 300,000 customers in Melbourne’s CBD, docklands and inner city.
- **Jemena** – Jemena supplies electricity to 302,000 customers in Melbourne’s north-western suburbs, with Tullamarine airport at its approximate centre.
- **Powercor** – Powercor supplies nearly 680,000 customers in an area that extends from Williamstown, north to the Murray River, west to the South Australian border and south to the coast. It has common ownership and a common management structure with CitiPower.
- **SP AusNet** – SP AusNet supplies 602,000 customers in an area that extends from the outer eastern suburbs of Melbourne, north and east to the New South Wales border (encompassing Seymour, Benalla, Wangaratta and Wodonga), south and east to the coast including many of the heavily treed areas of Victoria.
- **United Energy Distribution** – United Energy Distribution supplies 617,000 customers in an area that extends southwards from the south eastern suburbs of Melbourne, down the Mornington Peninsula.

As illustrated in Figure 41, the electricity distribution networks of CitiPower, Jemena and United Energy Distribution are predominantly urban while those of Powercor and SP AusNet are predominantly in rural areas, with Powercor having responsibility for the western part of the state and SP AusNet the eastern part of the state. The electricity distribution areas of Powercor and SP AusNet are primarily the focus of this report, though both Jemena and United Energy Distribution have some assets in non-urban areas.

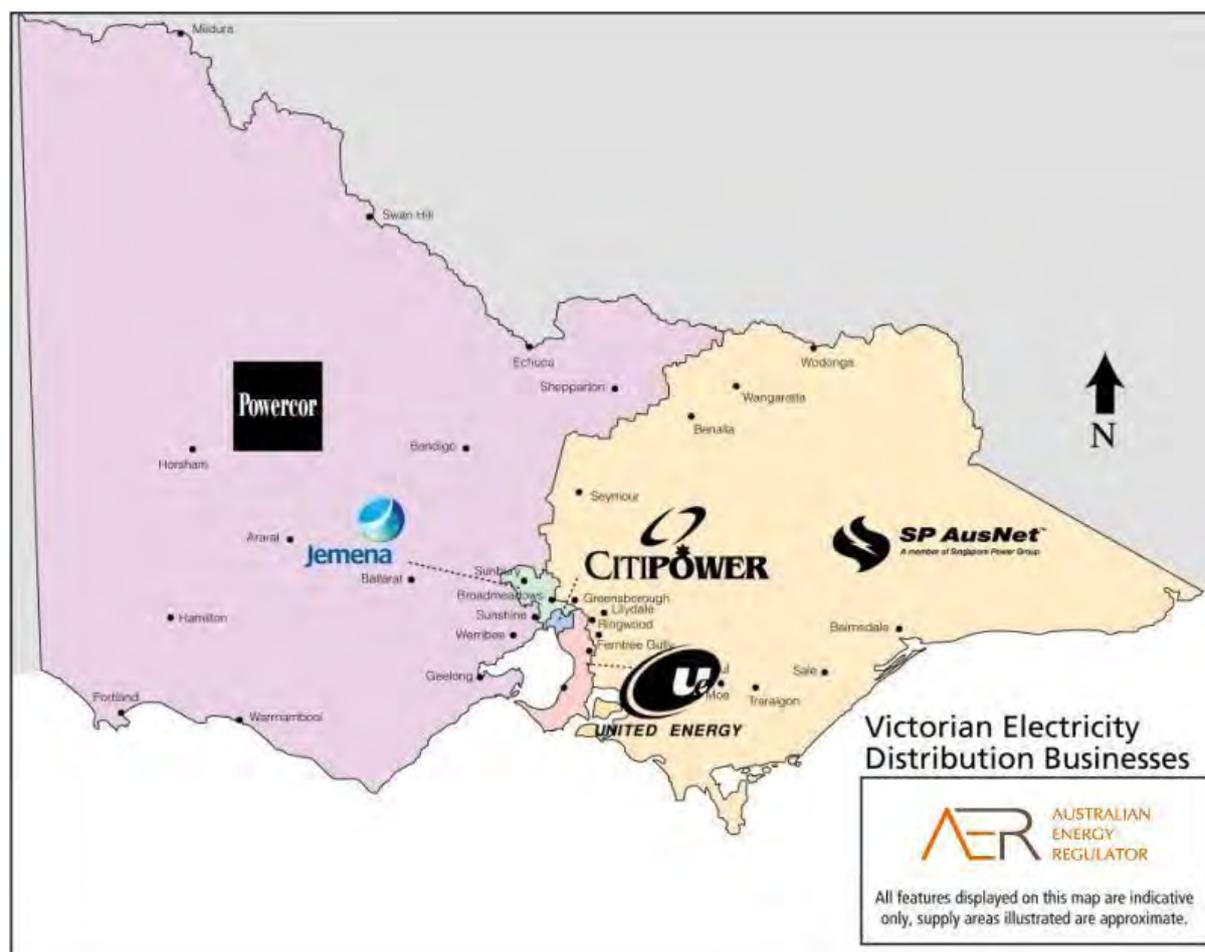


Figure 41: Victoria's electricity distribution areas¹⁰⁵

The electricity distribution system consists of powerlines and the following elements:

- **transformers** – which reduce the voltage progressively as the electricity is transported from the transmission network (at 220kV, 330kV or 500kV) to electricity customers (240V or 415V)
- **circuit breakers, sectionalisers and isolators** – which are large switches that open and close the powerlines
- **protection devices** – which protect the electricity supply system when a fault occurs. They are designed and operated to minimise the number of customers that lose supply when a fault occurs. The devices may send signals to the large switches to turn the power on and off, or may act as a switch, for example a fuse.

¹⁰⁵ Source: Australian Energy Regulator, *Victorian Electricity Distribution Businesses Comparative Performance Report 2008*. November 2009, page II

Appendix D The ignition process

Ignition is defined as the initiation of a self-sustained high temperature oxidation reaction.

Ignition of solids is a complex process. When a potential bushfire fuel is sufficiently heated, a process of pyrolysis begins that leads to the emission of flammable gases. If the emitted gases are above a critical minimum concentration, ignition is then possible. If the flow of gas is adequate, the flame is established some distance above the solid surface. If the flow of gas is inadequate to sustain burning, there is just a flash of flame.

The pyrolysis process is a chemical reaction; it is a thermal decomposition or “cracking” process. It occurs as a result of heating to the required temperature to activate cracking; but does not require the transfer of any external chemical reactants. Hence the controlling step in pyrolysis is heat transfer into the fuel. The first regions to pyrolyse will be at the surface of the fuel and volatisation (emission of gases) will occur immediately the surface is exposed to high levels of radiant heat.

The rate at which a potential forest fuel is heated will have a significant impact on its flammability. If it is heated slowly or exposed to temperature for a long time, the moisture can gradually evaporate and the dried material will be more likely to ignite than if heated quickly, when there is less opportunity for the material to dry out. However, countering this effect, if the heating rate is too slow, but the temperature is sufficiently high for pyrolysis products to be emitted, the emitted gases will never reach a sufficiently high concentration to ignite.

Dried grasses are one of the most flammable fuels – they act as a thermally thin solid and will heat through instantaneously. Stokes¹⁰⁶ found that smouldering of dried grasses occurs at fuel temperatures of up to around 600°C. With some air movement, the combustion products are displaced by oxygen that can increase the smouldering intensity to glowing embers. It may be necessary to get to fuel temperatures of around 800°C to be sufficient to cause ignition. The actual ignition of the emitted gases only requires a low energy spark, but initial heat is needed to first liberate the gases.

Research by Shuangning et al¹⁰⁷ on the pyrolysis of wheat straw indicated that volatisation increases continuously from the time the material is exposed to heat.

There can be smoke without fire; smouldering and smoking can occur with exposure to critical power levels for more than half the time to ignition – but if the heat source is removed, the smoking will stop and ignition will not occur¹⁰⁸.

D.1 Fuel factors affecting ignition

The ignition of a bushfire will depend on characteristics of the fuel, particularly the moisture content and density as well as the size – thin materials will tend to rapidly heat through, with little internal thermal gradient. Meteorological factors, including air temperature, humidity and wind speed, are also important, as are the available input heat flux energy and background temperature.

¹⁰⁶ Stokes, A., “The ignition of electrically produced incandescent particles”, *Journal of Electrical and Electronics Engineering Australia* 10(3), 1990, pages 175-187

¹⁰⁷ Shuangning, X., Weiming, Y., Baoming, L., “Flash pyrolysis of agricultural residues using a plasma heated laminar entrained flow reactor”, *Biomass and Bioenergy* 29, 2005, pages 135-141

¹⁰⁸ Stokes, A, *ibid*

The moisture content of a fuel is the most critical parameter in determining the probability of ignition. Given a specific set of circumstances, the literature review indicated that for a range of fuels, ignition probability is 50 per cent for a moisture content of around 20 per cent, then at low moisture content (less than 5 per cent), ignition is almost certain.

The equilibrium moisture content of fuel is determined by ambient temperature and humidity and on a hot day moisture levels of less than 5 per cent are realistic.

The ignition temperature of grasses and some wood materials is in the range of 250–350°C. When heated to these temperatures the material may self-ignite.

D.2 Arc ignition testing

An 18-day program of tests was undertaken at Testing and Certification Australia's (TCA's) high power laboratory in Sydney over the April to August 2011 period to get a better understanding of the ignition of fires by electric arcs.

Ignition testing was carried out at 12,700V (the wire-to-earth voltage of Victoria's 22kV and SWER networks) at realistic fault currents ranging from 4.2 to 1000 amps. Based on the literature review and preliminary exploratory tests, arc-ignition test conditions were selected to encompass likely worst-case situations on extreme fire risk days. These included dry straw/hay fuel at less than 5 per cent moisture content, 45°C air at less than 20 per cent relative humidity, zero arc-fuel distance and 110mm arc gap length chosen so the whole of the arc length was in contact with the fuel.

Ignition probability was assessed against the arc duration, the arc power and the energy released by the arc to the immediate environment and the effects of wind speed, fuel moisture and ambient temperature were determined. The action of auto-reclose devices and rapid earth fault current limiters (REFCLs) was simulated so that the effect of these on the risk of ignition could be assessed.

The limited program of ignition testing provided valuable insights into the behaviour of arcs and conditions for ignition of dried grass and other fuels. Reliable conclusions can be drawn from consideration of the results as a whole. More precise information applicable to specific conditions will require further tests.

The key findings from the tests on the probability of ignition from electric arcs include:

- ignition can occur almost instantaneously (in less than one hundredth of a second or 10ms) when the arc/plasma contacts the fuel, even at low currents
- with a wind speed of 10 km/h¹⁰⁹ at 45°C, sustained ignition is 50 per cent probable for arc durations of around 60ms for a 200 amp arc, 75ms for a 50 amp arc and 155ms for a 4.2 amp arc¹¹⁰, as illustrated in Figure 42

¹⁰⁹ Wind speed increases exponentially with height – the wind speed at a height of 0.5m is considerably less than the wind speed at a height of 10m. For example while the wind speed at Kilmore Gap at a height of 10m on 7 February 2009 varied between approximately 30 and 80 km/h, the wind speed at a height of 0.5m varied between 10 and 20 km/h. The wind speed at ground level, where bushfires may be ignited, may be considerably lower again.

¹¹⁰ Results for the 4.2 amp test are less certain than for higher currents.

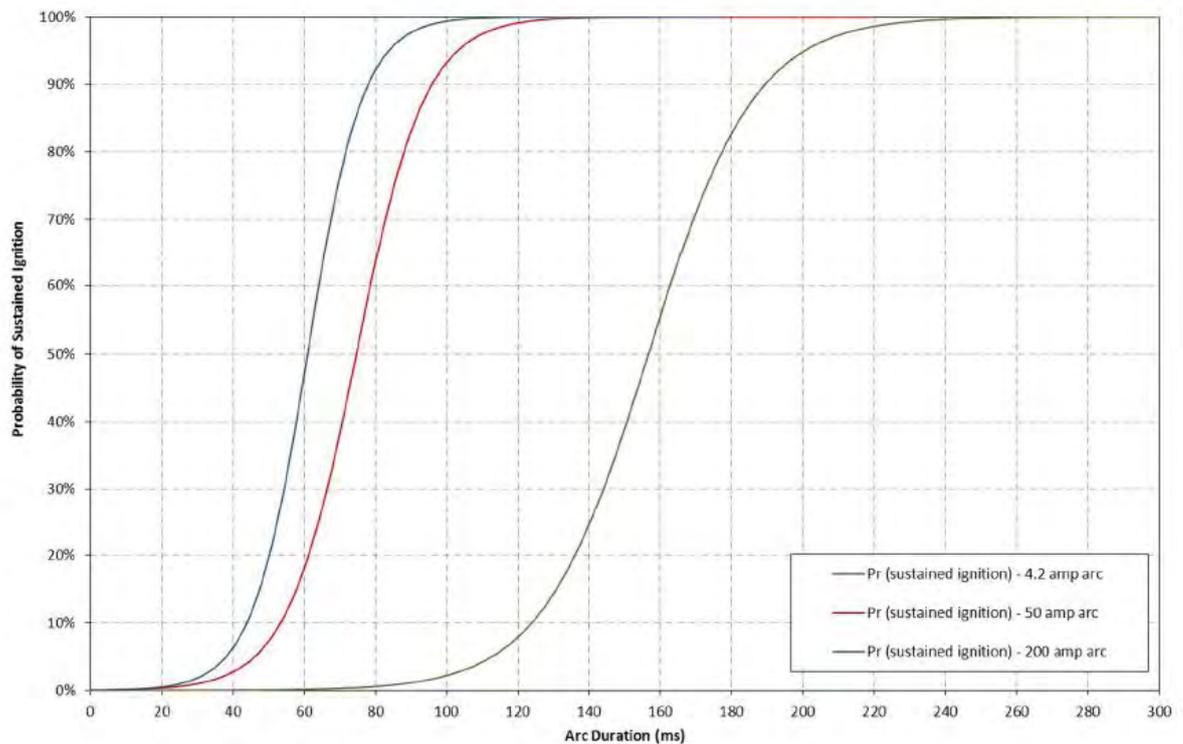


Figure 42: Ignition probability against arc duration for 4.2, 50 and 200 amp arcs at 45°C and 10 km/h wind speed for hay/straw at 5 per cent moisture

- no instances of ignition from radiation heat flux were observed. Tests indicate that radiation transfers less than 20 per cent of total arc energy to the environment
- probability of sustained ignition depends on the following:
 - arc current and duration (can be represented as arc energy and average power)
 - airflow speed – even a light to moderate breeze can extinguish initial ignition. As illustrated in Figure 43, the arc duration increases significantly when the wind speed increases from 10km/h to 20km/h
 - fuel type, fuel moisture content, air temperature and relative humidity. As illustrated in Figure 44, the arc duration increases when the fuel moisture content increases from 5 per cent to 8 per cent.

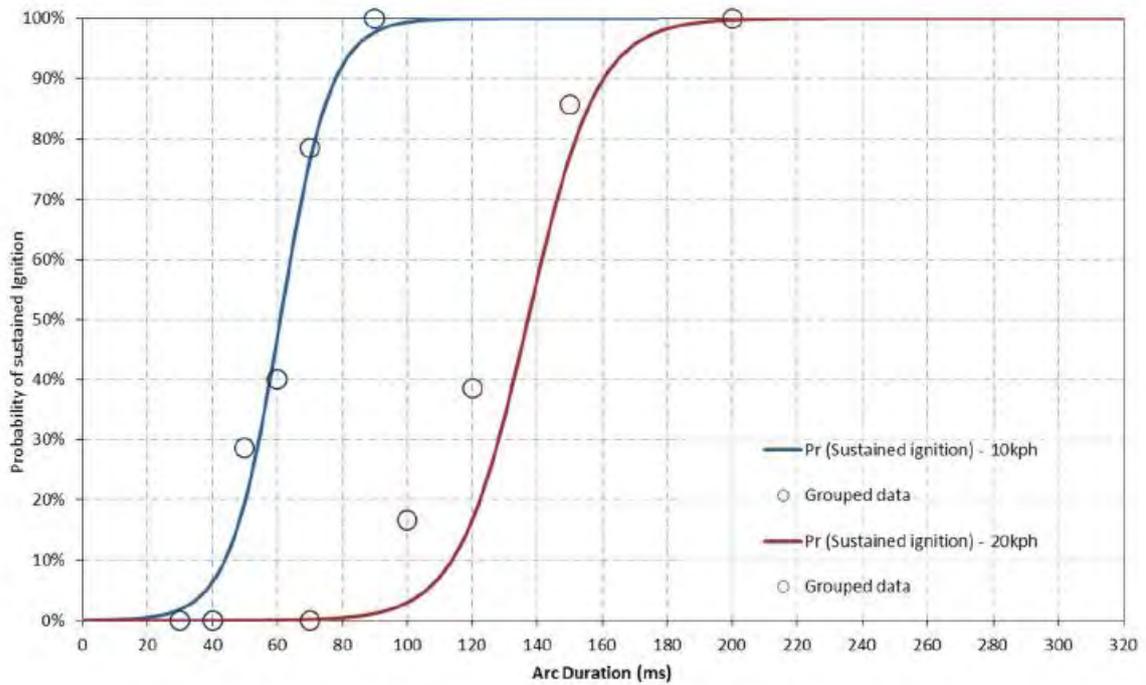


Figure 43: Effect of wind speed on Ignition probability (200 amps, 45°C, 5 per cent moisture)

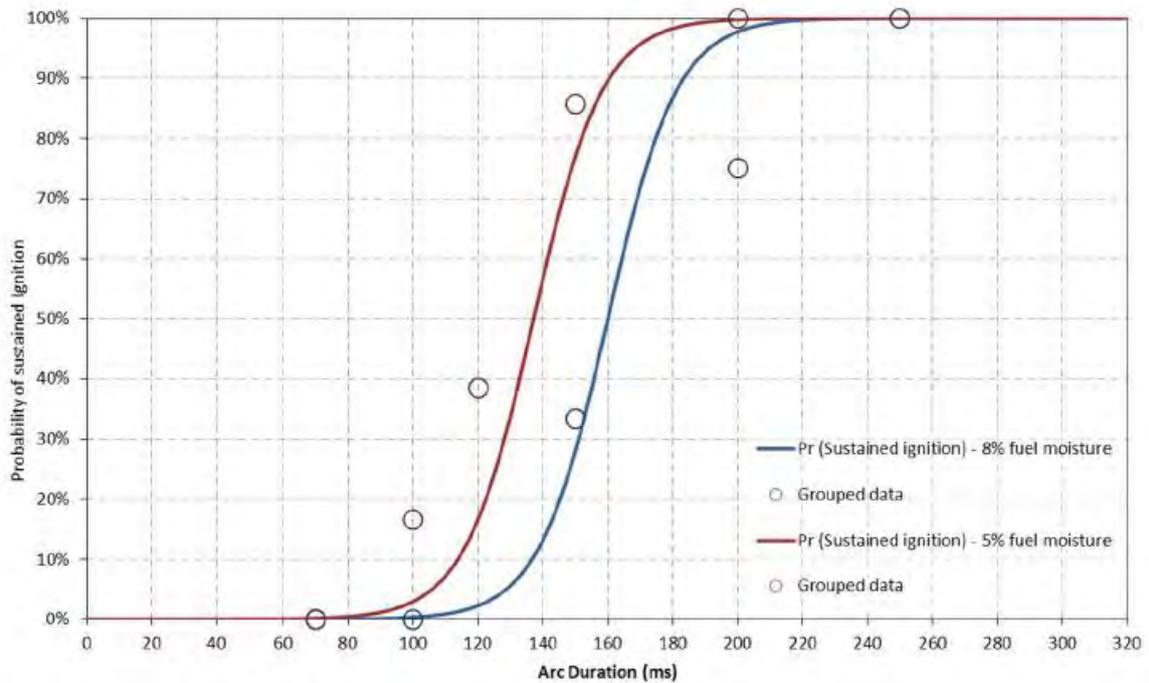


Figure 44: Effect of fuel moisture on Ignition probability (200 amps, 20 km/h airflow)

After arc current and duration, airflow is an important determinant of ignition probability:

- early extinguishment of low current arcs with even moderate airflow speeds indicates that low current arcs may not present a major ignition risk in realistic wind speeds

- airflow often extinguishes initial ignition, making the probability of sustained ignition much less than the probability of initial ignition. The final outcome of some tests took 30–60 seconds to fully resolve. On occasion, strong airflow can extinguish surface flame while sustained ignition continues in the fuel bed shielded from airflow. Post-arc extinction of initial ignition by airflow is a major cause of uncertainty in outcomes.

Testing was also conducted to determine the effect of a reclose operation on the probability of ignition. A single reclose after five seconds was found to have significantly higher probability of sustained ignition than the initial fault, as shown in Figure 45. That is the reclose attempt appears to be predisposed towards ignition by the initial fault five seconds earlier.

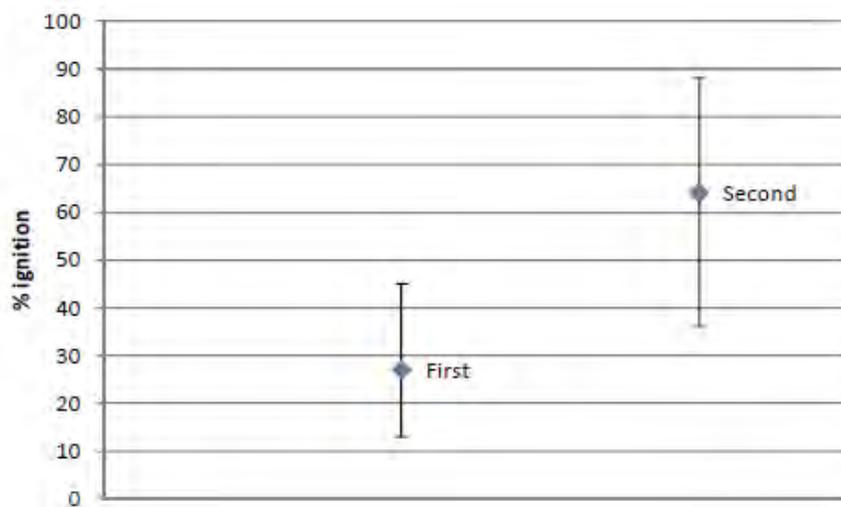


Figure 45: Difference in ignition probability with a 5 second delay

Tests with an increased reclose delay of 30 seconds showed the probability of ignition with the reclose attempt was no higher than in the initial fault, as shown in Figure 46. That is any residual effects from the initial fault had diminished to a level that did not predispose the reclose attempt towards ignition, so the fault and reclose attempt can be considered independent events.

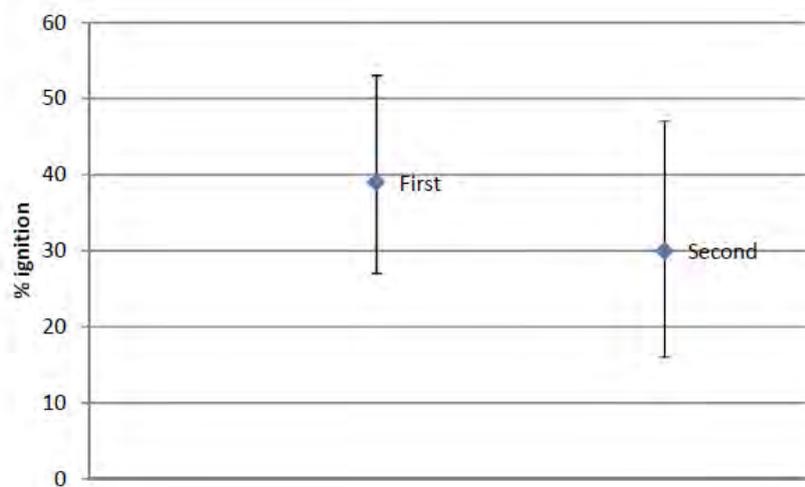


Figure 46: Difference in ignition probability with a 30 second delay

In summary, the ignition research indicates that electric arcs can ignite fires almost instantaneously (which could be as low as two hundredths of a second) under worst-case conditions. The probability of bushfires being ignited can be reduced if powerlines are turned off, or the fault current substantially reduced, faster than this timeframe when a fault occurs.

The ignition research also indicates that if reclose devices are used on the network, the probability of bushfires being ignited can be reduced if the time between turning off powerlines and then turning them on again is increased from five seconds to 30 seconds.

D.3 Molten metal particles

Testing of the fire risk of wires clashing after the 1977 and 1983 bushfires covered copper, aluminium and steel wires.

Copper powerlines

Copper particles were found to continuously cool in flight, that is heat loss by air cooling exceeds heat generated by oxidation as the hot particle flies through the air. However, particle temperatures were still calculated to be high when the particles reached the ground. The particle size had the most significant effect on the temperature of the particles when they reached the ground, but wind velocity, ejection velocity and emissivity also had a significant effect. The temperatures of particles when they reached the ground were calculated to be generally in the range 1100 to 1500°C.

There were no definitive conclusions about the critical conditions under which copper particles emitted from clashing wires could cause ignition of grasses, but it was indicated that the largest observed particles (1.3mm diameter) could potentially lead to ignition.¹¹¹

Steel and aluminium powerlines

Clashing steel and aluminium powerlines provide a more spectacular arc display than copper – the steel and aluminium molten metal oxidises in flight with an exothermic reaction, that is the temperature of the particle can increase in flight. The initial particle temperature is the most significant factor influencing the temperature of the particles when they reach the ground.

In a recent study, Mangaya¹¹² concluded that:

The probability of a fire being initiated by hot particles ejected into a high velocity wind as a result of short circuiting of high voltage overhead transmission lines is high.

Implicit in this conclusion is the assumption that if a particle is at a temperature greater than the measured ignition temperature of the surrounding grasses, then the grass fuel will probably ignite. In this study, ignition was considered to have occurred when the grass started smouldering¹¹³.

¹¹¹ Joynt, R., "The possibility of fires being caused by copper conductor clashing", *SECV R&D Report No. LS/83/342*, June 1983

¹¹² Mangaya, B., "Ignition of veld grass by hot aluminium particles ejected by clashing overhead transmission lines", *Fire Technology*, 38(1), 2002, pages 81-91

¹¹³ The Taskforce arc-ignition test program revealed that with significant wind speeds, many initial "smouldering" ignitions were extinguished by 45°C 15%RH airflow. The Taskforce test program assessed ignition probability based on sustained ignition.

Appendix E Threat-barrier analysis

This appendix outlines the threat-barrier modelling approach used by the Taskforce to assess the value of potential precautions that might be used to reduce the risk of electrically initiated bushfires in Victoria on Code Red days.

The Taskforce has adopted a precautionary approach to risk. This means that all practical precautions are considered and the task is to determine what cannot be justified on the balance of the significance of the risk as compared to the effort required to reduce it. That is practical precautions are identified by criticality (consequence), and, the desirability of implementing a precaution is assessed by weighing the risk against the costs (broadly defined) of implementation. Using threat-barrier modelling, the Taskforce has investigated available options to reduce the risk of powerlines starting bushfires, particularly on Code Red days and concludes that there is no –silver bullet” option on the table. It is noted that the precautionary options being explored only reduce the likelihood of electrically initiated fire starts and will not impact consequences.

The Taskforce has identified a good practice method to minimise powerlines starting bushfires in Victoria by representative bushfire consequence region. This will provide guidance to the distributors and the regulator as to how such an issue ought to be managed. The Victorian Government’s decision will really be about how fast these enhancements will be rolled out and in what priority order. That is all new electrical work will comply with this recognised good practice, as will any renewals in any event. Full replacement of distribution assets can take longer than 50 years on a life cycle basis but retro-fitting devices to distribution lines can take place in much shorter periods, for example five years.

E.1 The precautionary approach

The precautionary approach is the analysis method required by the judicial formulation of causation established by the courts. After a serious event, the courts look to see (with the advantage of 20:20 hindsight) what were the precaution/s that should have been in place but were not. Risk is not strictly relevant since, after the event, likelihood is not relevant. The fact of the occurrence of harm is at this point certain. As an Australian judge has been reported as noting to the engineers after a serious train incident: –What do you mean you did not think it could happen? There are seven dead.” That is the notion of risk is really only used to test the value of the precaution it is claimed ought to have been in place. How risky a situation is before the event is not germane except in so far as an aid to determining the reasonableness of possible precautions¹¹⁴.

E.2 Threat-barrier analysis

Threat-barrier analysis is a well developed analysis technique used in many industries to demonstrate the utility of precautionary effort in a transparent manner.

The model developed by the Taskforce is shown in Figure 47. The loss of control point is important legally. It is always better to prevent the problem, either by eliminating the threat or enhancing precautions than by trying to recover the situation after control is lost. This is

¹¹⁴ Robinson, Richard M, Gaye E Francis et al 2010. *Risk & Reliability – Engineering Due Diligence* (8th edition of the R2A Text). R2A Pty Ltd. Melbourne

entirely consistent with the hierarchy of controls described in occupational health and safety legislation and risk management literature generally. By correctly identifying the loss of control point, the laws of humanity and the laws of nature can be made congruent.

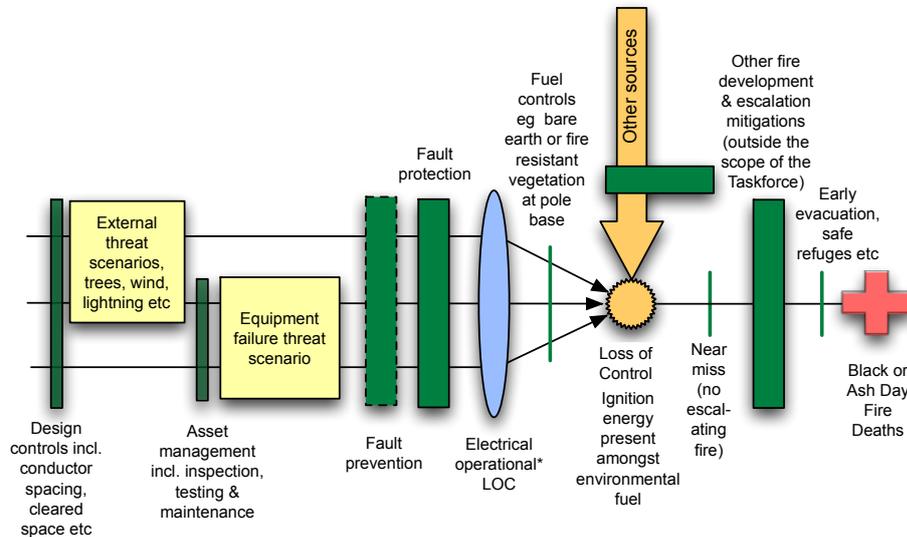


Figure 47: Fire season electrical fire start threat-barrier diagram

The loss of control point was defined by the Taskforce as the point at which sufficient ignition energy is present amongst environmental fuel to start a fire, that is a potential bushfire start. Ignition energy is a combination of fault energy and duration. Defining the loss of control point in this way had the added advantage of representing the scope of the Taskforce’s endeavours, that is to the left hand side of the diagram. Fire starts due to sources other than powerlines are shown by the vertical arrow. Mitigation barriers are after the loss of control point and are outside the Taskforce’s Terms of Reference.

Two diagrams were created to graphically show the difference between a fire start during the bushfire season (shown in Figure 47) and on a Code Red day (shown in Figure 48).

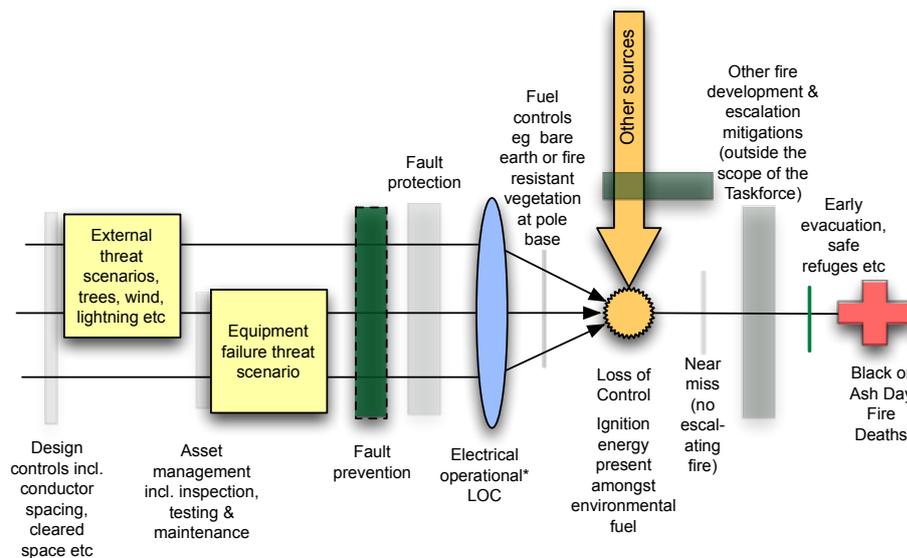


Figure 48: Code Red day electrical fire start threat-barrier diagram

The difference between the two diagrams is the fading of many barriers on a Code Red day. For example on a Code Red day the extreme conditions make the likelihood of a fire start if an electrical fault occurs, higher. That is the *fault protection* barrier is weaker. Further, on Black Saturday the CFA and DSE were overwhelmed with calls and were unable to respond to every request for assistance meaning the escalation control barrier was also weaker than usual.

E.3 Modelling

A model was created to test the value of potential, practical precautions based on the threat-barrier diagram described above. That is all practicable options are described and the model tests for precautions or combinations of precautions that provide the best investment. The judicial formulation for cost-effectiveness is used, namely, the balance of the significance of the risk as compared to the effort required to reduce it (after Sappideen and Stillman¹¹⁵), shown in Figure 49.

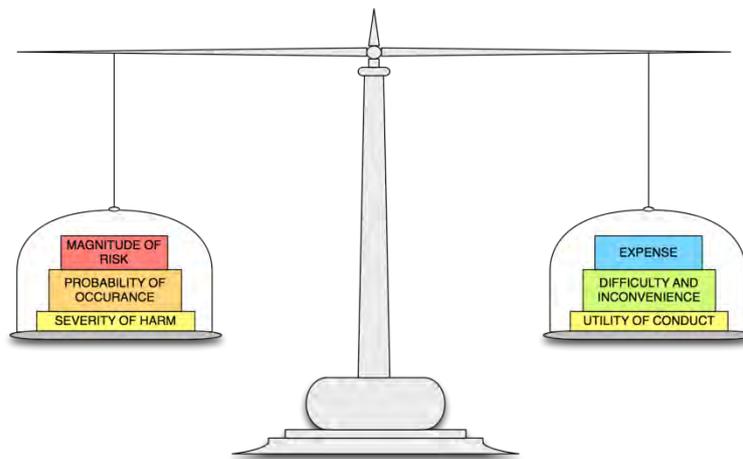


Figure 49: How would a reasonable defendant respond to the foreseeable risk?

Effort includes *expense*, which refers to money, *difficulty and inconvenience*, which is how difficult the precaution is to implement and monitor, and *utility of conduct* refers to what other disbenefits might occur due perhaps to conflicting responsibilities such as that of maintaining an essential service.

E.3.1 Black or Ash Day risk characterisation

Based on the Black Saturday (2009), Ash Wednesday (1983) and Black Friday (1939) fires the model characterises the risk associated with these days as: 100 Victorian deaths every 25 years. This return frequency has been reduced to one in 20 years to take into account predicted weather pattern changes. This is used to normalise the relative risk estimation of the rest of the model. The model is presently silent on other losses (estimated at over \$4 billion for Black Saturday by the Royal Commission).

¹¹⁵Sappideen, C & RH Stillman, (1995). *Liability for Electrical Accidents: Risk, Negligence and Tort*. Engineers Australia Pty Ltd. Sydney

E.3.2 Consequence (criticality) areas/regions

The model has three levels of criticality for rural areas: extreme, very high and high presently characterised in the ratio of 1:0.3: 0.1, with extreme consequence areas as the base (worst) case. These regions were defined based on the fire consequence modelling completed for the Taskforce by Dr Kevin Tolhurst and colleagues at the Bushfire CRC. The threat-barrier model is silent on the projected population and Victorian GSP increase over the return period.

E.3.3 Relative risk

Relative risk per unit length (km) is presently done for life safety only, for an Ash or Black day. SWER and multi-wire powerline options are identified. The precautions that are considered are shown in Table 28 with the values used for the extreme consequence region assessment.

Precaution	Δ fatality risk	Δ Effort (\$ per km)
A) New generation SWER ACRs	50%	\$1,114
B) REFCLs	70%	\$7,976
C) Convert SWER to multi-wire (REFCL)	63%	\$148,592
D) SWER – insulated wire	90%	\$257,709
E) SWER – underground	99%	\$332,727
F) Multi-wire – insulated wire	90%	\$309,961
G) Multi-wire – underground	99%	\$514,477

Table 28: Extreme consequence region precautions and values

E.3.4 Relative effort

Relative effort is estimated on an average unit length (km) basis per option as capital expenditure (dollars).

E.3.5 Application

Results are initially presented as a plot of *quantum of risk vs. quantum of effort* on a relative risk basis for a unit length of a powerline in the representative bushfire consequence areas.

The model presently applies to the three fire loss consequence regions and is then summarised statewide. A comparative analysis of the possible packages of measures is also made based on various capital cost measures.

Appendix F Assumptions in the costing of replacement options

In compiling estimates of the capital expenditure required to replace powerlines, necessary assumptions have been made with regard to both the technical and commercial aspects of each estimate.

The same commercial assumptions have been made across all technologies.

The technical assumptions generally reflect current industry practice and the most practicable application of the technology.

F.1 Commercial assumptions applied to each replacement option

The following assumptions have been made:

- All costs are in AU\$2011.
- No corporate overheads have been applied. All incremental costs associated with carrying out the defined works have been included as part of the estimate.
- Financing costs are not included.
- Each scenario estimate contains an element for project management equal to 10 per cent of the gross project cost. This cost also includes costs associated with putting the network into service, such as updating data bases.
- Each scenario estimate contains an element for construction (site) management equal to 10 per cent of the gross project cost.
- Contractors' risk and margin have not been included as estimated internal business rates or commercial quotations have been used.
- Project risk and contingency have been included at 3 per cent of gross project cost.
- Costs have been applied for the disposal of existing assets with an offset for recovered materials using current prices. The only significant recovered material benefit will be metals from distribution transformers. All other materials are assumed to be disposed of. All disposed materials and spoil are assumed to be free from contamination with PCBs, asbestos or other controlled pollutants.
- The net disposal cost of existing wires is assumed to be zero due to salvage cost offsetting the disposal cost.
- Labour costs have been built up from a blend of contractors' quotations and effort based estimates. Where the latter has been applied, in order to address the range of labour rates in existence we have assumed a mid-band labour rate of \$100 per hour for electrical skills (line workers and cable jointers).
- Travel and accommodation and Living Away From Home Allowance payments have been applied on the basis that labour will not be available within the areas under consideration.
- No overtime working has been assumed.
- No financial consequence from a variation in reliability has been assumed.

- The overhead topologies were assumed to reuse the existing easements to simplify negotiations for installing new assets and minimise the impact on any native vegetation and vegetation management costs.
- Underground cable was assumed to follow public roads. The cost of LV customer connections was included, but it is assumed that these assets will be owned by the customer from the property boundary, negating the need to establish easements.
- The cost of negotiating HV cable routes and locating assets along public roads or private property was included at a rate of \$200 per hour with an allowance of one person for six months per segment (defined network area).

F.2 Technical assumptions applied for each technology

F.2.1 General technical assumptions

These assumptions apply to each of the proposed replacement technologies.

All voltage levels have been converted to 22 kV.

Outage management

All cable will be installed without disruption to the power supply. Upon change over, it has been assumed that there were two isolations required for the section of cable being put into service, plus two isolations required for each distribution transformer to allow connection of the transformer and of the customer connections.

Any necessary additional poles and new pole tops for overhead line works will be installed without disruption to power supply. This is on the basis that live line works were allowed. We have also assumed that there will be one outage per spur line to put the new wires into service. There will also be two isolations for each distribution transformer to allow customer connection.

Traffic management

Traffic management has been costed based on three levels of management:

- low – requiring only two people with minimal signage and communication
- medium – requiring three people
- high – requiring four people and appreciable signage and communication.

Traffic management services have been assumed to be readily available locally and no allowance for travel, accommodation or other disbursements has been made.

Replacement of SWER distribution transformers

When replacing SWER, it is assumed that the existing SWER distribution transformer is removed from service and replaced with a new distribution transformer. The only case where the SWER transformer is retained is for rural areas where the SWER topology was retained using covered wire.

F.2.2 Replacing the existing powerlines with underground cable

It became apparent following the initial site visits that a plough-in approach for installing underground cable would not be generally achievable. Plough-in techniques are most suitable and cost-effective in locations where the ground conditions are unhindered by existing services, made surfaces or rocky inclusions. Upon initial inspection, it was evident

that the most suitable cable routes would be along existing roadways and the application of open-trench or directional drilling methods would be most appropriate.

Trenching and directional drilling costs and speeds were based on quotes from contractors and discussion with utilities personnel with experience in these techniques.

Consequently, it has been assumed that cables will be installed in existing roadways using a blend of these two techniques. The choice of method is based on the specific site conditions and impact on traffic management.

A trench depth of 1m has been assumed with conduits installed in open trenches and direct pulling of cables for the directional drilling method.

Joints are assumed to be direct buried with the number required based on drum lengths of 500m.

Using the direct drilling method, the maximum drill length is 100m at which point the drill must surface and the process restarted. The conduit will require a joint at each of these points, but the cable will only be jointed based on the drum length of 500m.

Substations are assumed to have underground connections on both HV and LV terminals and are of the kiosk/package type mounted on mass-poured concrete slab foundations.

LV service connections are assumed to be an average length of 200m in rural areas where supplied directly from a transformer. In urban fringe areas, a main LV "backbone" is assumed, with customer services connected as required. The LV backbone was measured based on existing route maps and 50m is assumed as the cable length for customer service connections.

Poles carrying existing telecoms services (urban fringe areas) will be left in place and gifted to the relevant telecoms entity. No cost impact for this has been considered.

Street lighting replacement has not been considered in these costs, however, the costs are expected to be immaterial relative to the error margin in the estimates.

F.2.3 Replacing the existing powerlines with aerial bundled conductor

In general, it is assumed that existing line routes can be over-built with the addition of inter-span poles to cater for increased wire weights.

HV and LV ABC technologies have been applied, in general utilising the current existing standards in use by the distributors.

In compiling the estimate, pole spacing is based on a conservative application of AS7000:2010 Appendix S: Wire Sag and Tension, Section S7: Tension Constraints. This used the pole strength, wire tension and sag to determine the maximum span lengths. For HV ABC lines a pole spacing of 85m has been applied.

All new poles are assumed to be concrete. We have included replacement of 20 per cent of the existing poles to allow conformance with the new design.

As the routes will follow existing line routes, no costs for removal of vegetation have been included. It is assumed that maintenance of existing easements provides sufficient clearance from vegetation for the installation of ABC.

Transformer replacement has been included for the replacement of SWER lines, but not for existing 22kV lines.

F.2.4 Replacing the existing powerlines with covered wire

As with ABC, overbuild has been assumed using the existing easements. It has been assumed that bare wire will be replaced with an equivalently rated unscreened insulated wire. Additional pole requirements are based on average 150 m spacing.

All new poles are assumed to be concrete. Replacement of 20 per cent of the existing poles has been included to allow conformance with the new design.

As the routes will follow existing line routes, no costs for removal of vegetation are included. It is assumed that maintenance of existing easements provides sufficient clearance from vegetation for the installation of covered wire.

Transformer replacement is assumed not to be required.

F.2.5 Replacing the existing powerlines with covered wire with support wire

The main difference, between stringing and tensioning bare overhead powerlines, and covered wire with support wire, is the method of installation.

Bare overhead wires are strung for a particular ruling span, at a certain initial tension and temperature depending on the physical properties of the conductor. Over time the wire elongates due to the strands settling in and wire creep, which will result in a final tension. This is catered for by applying temperature compensation and tensioning the wire higher initially to eventually result in the required final tension.

In contrast, when installing covered with a support wire, the messenger wire is installed first at an initial tension. The wires and spacers are then installed onto the messenger wire, thus effectively increasing the weight per unit length of the messenger wire as a final condition. Messenger wire is a steel conductor, thus wire creep is regarded as negligible.

Pole spacing has been set at the same as the existing system; that is the existing poles are re-used without the need for additional mid-span poles.

All new poles are assumed to be concrete. Replacement of 20 per cent of the existing poles is included to allow conformance with the new design.

As the routes will follow existing line routes, no costs for removal of vegetation are included. It is assumed that maintenance of existing easements provides sufficient clearance from vegetation for the installation of covered conductor.

Transformer replacement is assumed not to be required.

F.2.6 Replacing the SWER powerlines with bare 22kV wire (either single wire or multi-wire)

Overbuild has again been assumed. The choice as to whether the replacement is with a three wire or single wire system is based on the number of customers connected. In general, the main, backbone SWER lines are replaced with three wire construction, with spurs off these as single wire. The assumption is that the existing single wire can be retained and the additional wires installed alongside utilising the equivalent wire type.

All new poles are assumed to be concrete. We have included replacement of 20 per cent of the existing poles to allow conformance with the new design.

Replacement of the pole top to suit a single/three wire network is included.

Additional pole requirements are based on an average 150 m spacing.

As the routes will follow existing line routes, no costs for removal of vegetation are included. It is assumed that maintenance of existing easements provides sufficient clearance from vegetation.

Transformer replacement is included.

F.2.7 Replacing the existing powerlines with aerial bundled conductor and ground mounted switchgear

The assumptions for this technology are the same as for aerial bundled conductor as set out in Appendix F.2.3.

In addition, the ground mounted substations are assumed to be of the kiosk/package type mounted on mass-poured concrete slab foundations with underground connections on both the high voltage and low voltage terminals.

F.2.8 Replacing the existing powerlines with covered wire and ground mounted switchgear

The assumptions for this technology are the same as for aerial bundled conductor as set out in Appendix F.2.4.

In addition, the ground mounted substations are assumed to be of the kiosk/package type mounted on mass-poured concrete slab foundations with underground connections on both the high voltage and low voltage terminals.

F.3 Avoided cost assumptions

The assumptions for estimating the capital expenditure to replace a given set of assets are set out in Appendix F.1 and F.2. All assumptions to estimate the capital cost also apply to estimate the avoided costs.

The age profile of the existing assets is based on an existing model of Powercor's assets previously developed using Parson Brinckerhoff's Asset Replacement/Valuation model. The asset profile of the entire network has been assumed as an average and applied to the assets of each geographical sector. Consequently, the profile of capital expenditure to replace existing assets can be determined.

The ongoing annual maintenance costs of existing assets are based on data supplied by SP AusNet and applied to each sector.

The ongoing annual maintenance costs of replaced assets are based on data provided by SP AusNet for networks of an equivalent technical construction to the scenario under consideration.

To allow the data to be extrapolated to the statewide level, the duration required to replace the assets in a given geographical sector has been assumed to be ten years with the replacement commencing in 2012. The capital expenditure cash flow is assumed to be equal in each year with each being a tenth of the estimated total capital cost.

In discounting the cash flows three discount rates have been applied (low, medium and high). The three values have been set at 6 per cent, 8 per cent and 10 per cent, respectively. The cash flows have been continued through to 2065 with all assets replaced again at the end of their life.

The calculations have accounted for the improved performance of the alternative technologies considered. Improved network performance has been included in the cash flows via the inclusion of the Value of Customer Reliability (VCR).

The VCR has been added into the calculation of incremental costs by providing a benefit for the improved network reliability provided by replacement of the existing assets with the alternative technology. The calculation uses the most recent value for residential customers provided in AEMO's 'Value of Customer Reliability Background Paper', 3 December 2010. This value is \$16.33 per kWh per customer per annum. Customer numbers have been based on the average customer demand and the average minutes off supply from AER's 2009 Comparative Performance Report for the Victorian electricity distributors. The difference in the performance of the replaced technology is included via the difference in annual minutes off supply for the equivalent network technologies.

Appendix G Area-specific data relevant to the costing of replacement options

As discussed in sections 4.2.2 and 4.3.1, detailed cost estimates for each powerline replacement option were estimated for five representative areas. The location and routing of the replacement technologies were optimised to take into account the specific circumstances of the terrain, soil condition, vegetation, access to easements, and any other constraints.

The terrain, soil condition, vegetation, dwelling density, and other constraints across the state have been mapped. These maps are provided below.

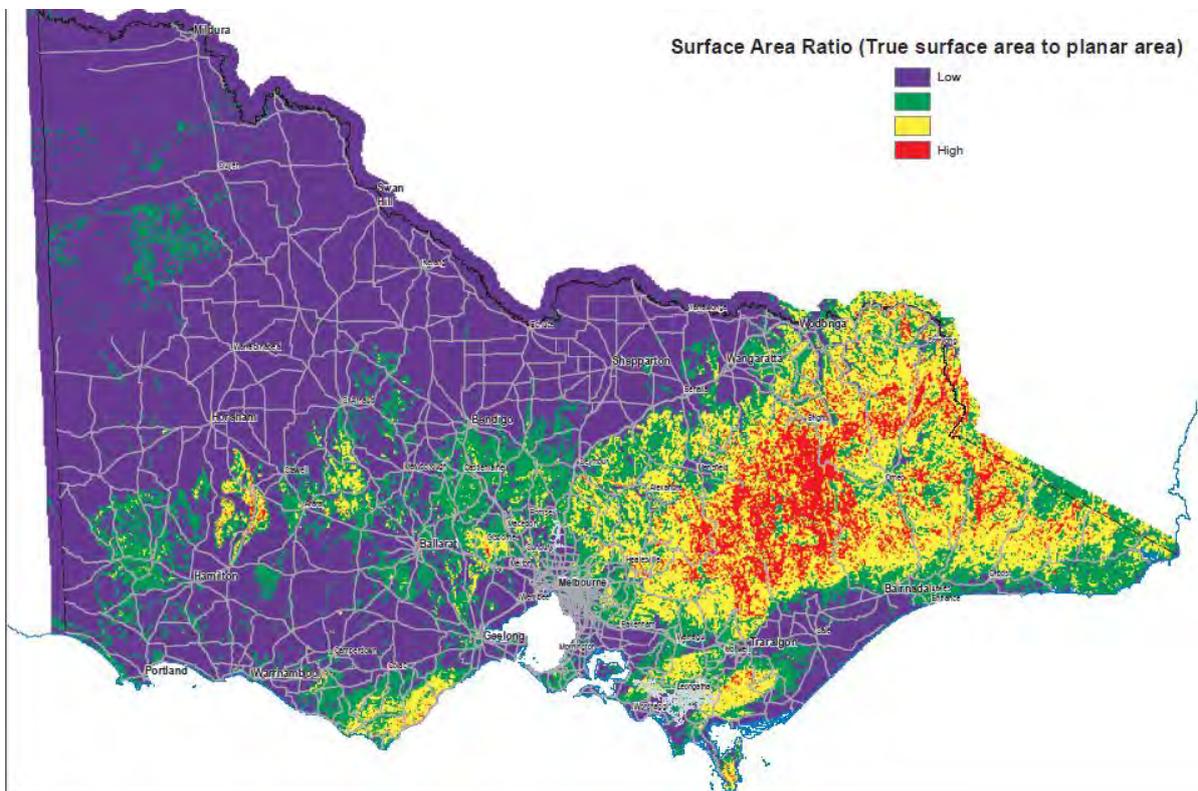


Figure 50: Presence of hilly terrain in powerline locations

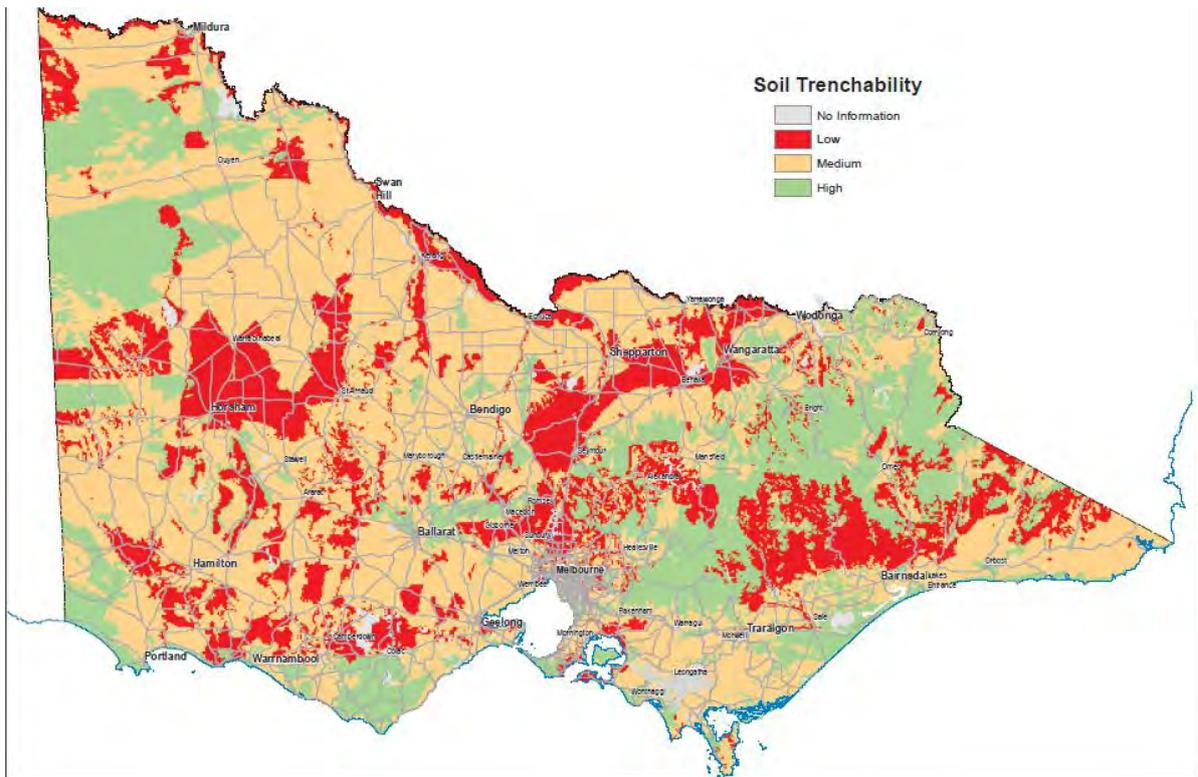


Figure 51: Soil trenchability (presence of subsurface rock) in powerline locations

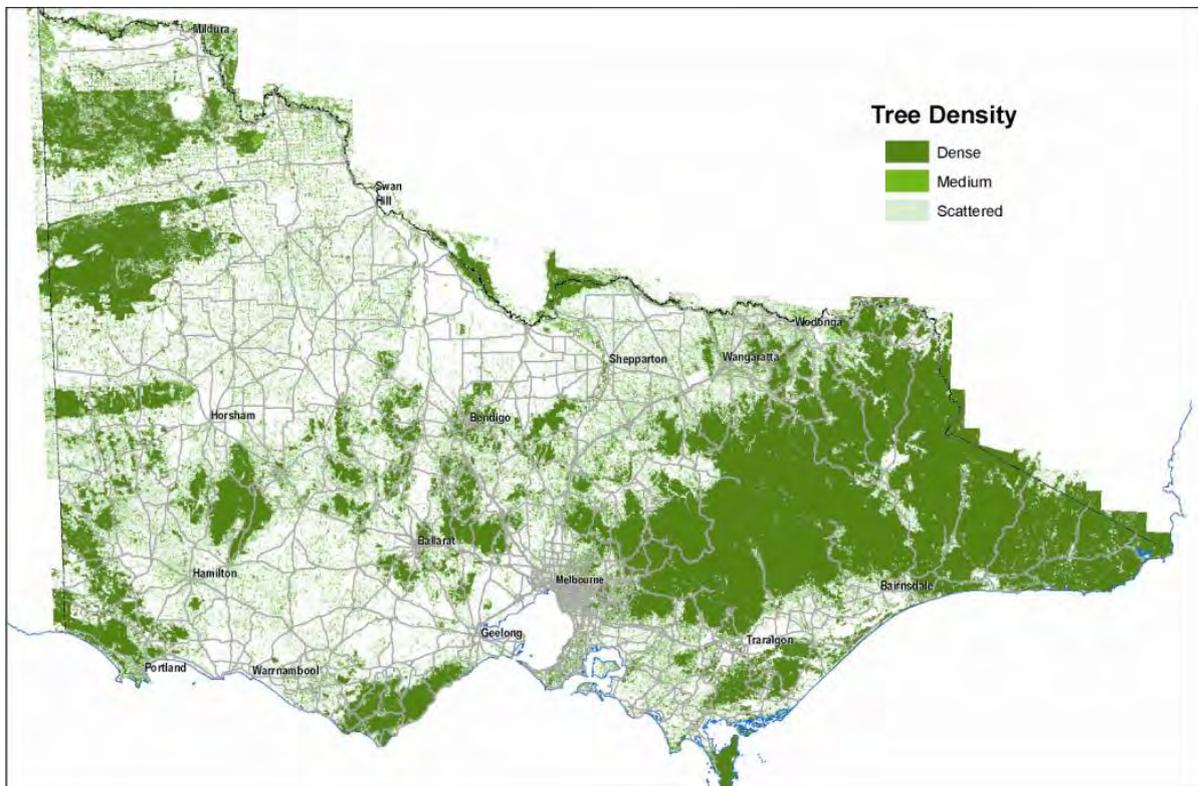


Figure 52: Vegetation intensity of powerline locations

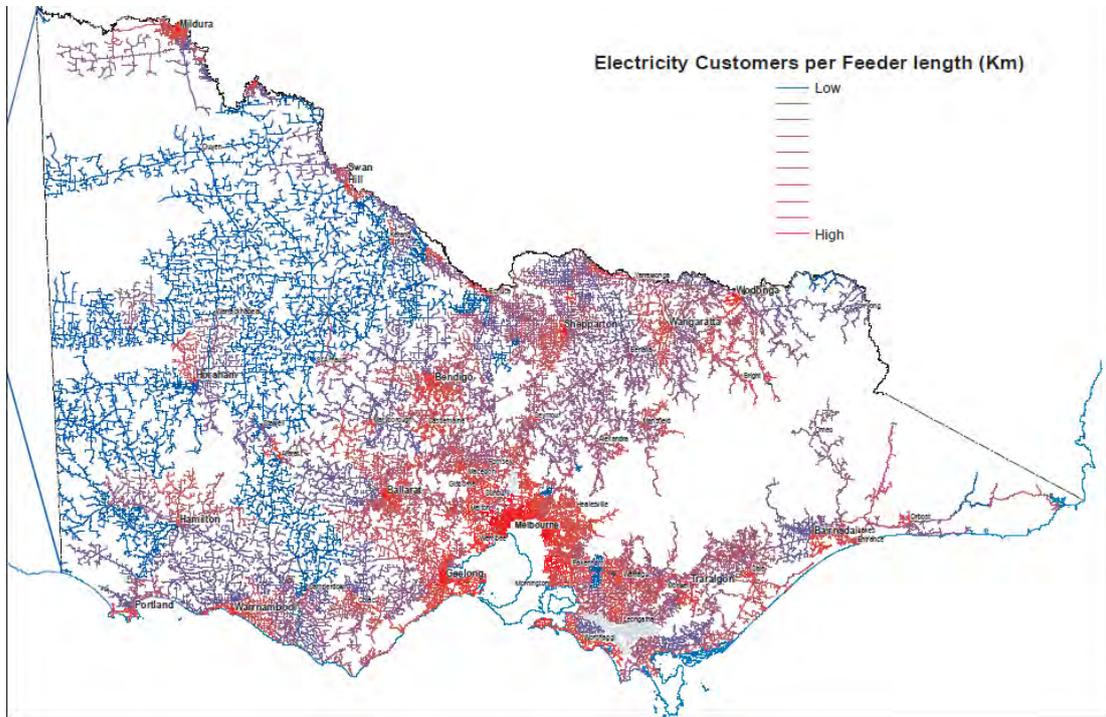


Figure 53: Electricity customers per kilometre of powerline

Appendix H Advice provided on power outages by the Department of Primary Industries



Your guide to power outages

How to prepare and be safe

Why we have power outages

Victoria has the most reliable power supply in Australia, but sometimes power outages do occur.

Power outages can be caused by severe weather, such as lightning, floods, heatwaves, bushfires or high winds, or by trees falling on powerlines. Animals, car accidents or digging near underground powerlines can also cause interruptions to power.

Restoring power is usually the responsibility of your local electricity distribution company, who owns and maintains the poles and wires bringing power to your home.

This guide outlines some simple things you can do at home to help prevent power outages – and to prepare for those rare occasions when power is lost for a long time.

Help prevent power outages

Trees interfering with powerlines are a cause of many easily preventable power outages.

You can help to reduce this risk by regularly checking the size and health of trees growing close to powerlines, and letting the appropriate people know if these trees need to be cut back or removed.

DO NOT attempt to remove or prune trees near powerlines yourself, even if they are on your property.

If the tree is on your property, contact your local electricity distributor. If the tree is in the street, call your local council. These groups can arrange for the trees to be pruned or removed according to safety regulations.

For more information on tree clearing, visit the Energy Safe Victoria website at www.esv.vic.gov.au or call 1800 800 158.

Preparing to manage a power outage

Power outages can occur at any time. To prepare, you should have an energy plan and kit, which includes:

1. **Important Contacts.** Complete the list provided in this brochure and keep these numbers somewhere safe and easy to find in case of a power outage.
2. **Access to a phone,** such as a charged mobile phone that doesn't rely on electricity to operate.
3. **Alternative lighting,** such as candles or torches. Remember to keep naked flames away from flammable material and gas sources.
4. **Alternative cooking facilities and heating.** Keep in mind that some gas appliances may still require electricity to operate them. Always ensure gas connections on portable appliances are maintained and in good working order.
5. **A battery-powered radio.** Stay tuned to news services to get updates on weather conditions and power outages.
6. **Access to fresh water.** If you use electricity to run a water pump, make sure you have an alternative source for fresh water.

What if you have special needs?

If you require an uninterrupted supply of power because you:

- are on life support equipment;
- have a medical condition that requires continuous power supply; or
- have any other special needs,

you should report your needs to your electricity retailer (the company you pay for your electricity) so they can contact you in the event of an outage. Make sure they have your up-to-date telephone numbers and contact details.

Victoria Department of Primary Industries

energysafe VICTORIA

YOUR GUIDE TO POWER OUTAGES

Power outages

Important Contacts

Record all the contact telephone numbers you need during a power outage in the list below and keep this somewhere safe and accessible.

Contact	When	Telephone number
Faults & Emergencies number on your electricity bill (your local electricity distributor)	To report a power outage	
Your local council	For information on emergency services available in your area, particularly if you are elderly, disabled or need special help	
Your electricity retail company	To report special needs if you require uninterrupted power. Make sure they have your up-to-date contact details.	
SES	For storm and flood emergency assistance	132 500
VICSES Flood & Storm Information Line	For general information on storms and floods	1300 VIC SES or 1300 842 737
Emergency Services	For life threatening emergencies	000
Department of Human Services	For information on food safety	1300 650 172

Department of
Primary Industries

What to do when you lose power

Be energy safe

- Keep clear of fallen powerlines and keep others away. The powerlines may still be live, so you should call your local electricity distributor (see the "Faults and Emergencies" number on your most recent electricity bill).
- Check your neighbour's house to see if they have also lost power. If your neighbour has power on, then check to see if your safety switch has been tripped.
- Be careful when using candles and other open flames - keep naked flames away from flammable material.
- Make sure appliances are turned off (because they could come back on when you are not there).
- Don't try to connect temporary generators to household wiring. Engage a licensed electrician to do all electrical work. 'Do It Yourself' electrical work is very dangerous and illegal.
- If the power has been cut due to storm damage to your house, the damage to your house may need to be repaired before a licensed electrician can safely restore power.

Be a good neighbour

- Check and offer support to neighbours and relatives particularly those with special needs, such as elderly people and people with disabilities.

Be safe with food

- Only open fridge and freezer doors when absolutely necessary. This will keep the food and air temperature colder for longer.
- If possible, use bagged ice to keep food cold or frozen.
- Once cold or frozen food is no longer cold to touch (5°C or above) make sure it is used within four hours or throw it away.
- If power is restored when frozen food is still cold to touch (less than 5°C) the food is safe to refreeze.
- If you have hot food, make sure it is consumed within four hours or throw it away.
- For more information on food safety visit www.dhs.vic.gov.au/health/foodsafety or call the Department of Human Services on 1300 650 172.

Who can help restore power

Your electricity distribution company

Your electricity distribution company is responsible for the poles and wires which carry electricity to your home and normally organises for the power to be restored. They can be contacted on the faults and emergencies number on your most recent electricity bill.

State Emergency Services (SES)

For storm and flood emergency assistance contact the SES on 132 500. They can note the details and send help if necessary.

General information on storms and floods can be obtained from the VICSES Flood & Storm Information Line on 1300 VIC SES or 1300 842 737

Life threatening emergencies should be reported to 000.

Your local council

Contact your local council if you need information on emergency services available in your area, particularly if you are elderly, disabled or need special help.

Restoring power supply

If the power outage is caused by a fault with the poles and wires, your electricity distribution company will work to restore power as quickly as possible. The time this takes can depend on factors such as how widespread the damage is, the severity of the damage, weather conditions and access to the area.

Customers who experience long or frequent power outages in a year may be eligible for Guaranteed Service Level Payments. To find out about your eligibility, contact your local electricity distribution company or visit www.aer.gov.au or call 1300 302 502.

You may also be eligible for other personal hardship emergency grants. To find out contact the Department of Human Services on 1300 650 172 or visit its website at www.dhs.vic.gov.au/emergency.

Published by the Department of Primary Industries, 1 Spring Street, Melbourne, Victoria 3000 Australia February 2010
© The State of Victoria, 2010
This publication is copyright. No part may be reproduced by any process except in accordance with the provisions of the Copyright Act 1968.
Authorised by the Victorian Government, 1 Spring Street, Melbourne, Victoria 3000 Australia
ISBN 978-1-74217-350-4

Disclaimer
This publication may be of assistance to you but the State of Victoria and its employees do not guarantee that the publication is without flaw of any kind or is wholly appropriate for your particular purposes and therefore disclaims all liability for any error, loss or other consequence which may arise from you relying on any information in this publication.
For more information about DPI visit the website at www.dpi.vic.gov.au or call the Customer Call Centre on 136 186.

If you would like to receive this information/publication in an accessible format (such as large print or audio) please call the Customer Service Centre on: 136 186, TTY: 1800 122 969, or email customer.service@dpi.vic.gov.au

Appendix I Taskforce's trials

As required by its Terms of Reference, the Taskforce conducted the following series of trials to inform the recommendations in this report:

- installation of back-up generators and disconnection from the electricity supply on days of Total Fire Ban (30 participants)
- installation of stand-alone power supplies and disconnection from the electricity supply for the duration of the trial (10 participants)
- change in the network reclose function on days of Total Fire Ban (for approximately 1,200 participants supplied by 22kV powerlines) or for six weeks (for approximately 400 participants supplied by SWER powerlines).

The objectives of the trials were to:

- determine the willingness of Victorians to adopt these options
- determine the participants' responses to the trial
- identify the impact of the trial on the customers' reliability of supply
- gain a better understanding of the costs, benefits, risks and implementation issues.

I.1 Trial of back-up generators

During summer 2010/11, the Taskforce conducted a trial of back-up diesel generators. Approximately 1000 households were invited to participate in the trial, of which 79 responded positively.

The 30 most suitable sites were selected based on a set of criteria, including the following mandatory criteria:

- willing and authorised to enter into the legal agreement
- agreed to the electricity distributor providing information on their electricity supply to ESV for the purposes of the trial
- did not rely on electricity for water pumping for firefighting purposes
- was the owner of the property
- was not on life support equipment.

As a result, 18 sites were selected in the Daylesford area and 12 sites were selected in the Euroa area.

Some households that were invited to participate in the trial provided reasons for choosing not to do so. These reasons are listed in Table 29.

Reason given for not participating	No	Reason given for not participating	No
Property not occupied full time	11	Rely on electricity for water pumping	5
Age/health/inconvenience	11	Would not stay on a Total Fire Ban day	3
Cost of fuel too expensive	8	Do not support the trial	2
Already have a back-up power supply	6	Minimum load too high (Euroa area)	1
Generator too small (Daylesford area)	6	Too short notice/not enough information provided	1
Do not own property or are in process of selling	5	No reason provided	3

Table 29: Reasons offered for non-participation in trial

There are trade-offs associated with the size of generator – a smaller generator will only be able to supply essential loads (for example cordless phone, modem, computer, television, fridge, ceiling fan, water pump) rather than the total load of the household. However, the minimum load requirement of the larger generator may require appliances to be switched on to allow the generator to run. Alternatively, it can be shut down during low load periods.

The size of back-up generator selected for the trial was 11kVA.

The powerlines to those customers receiving a limited back-up supply system was to be turned off on days of very high, extreme and catastrophic fire risk, from 10am until the Fire Danger Index fell below 30.

Due to the benign fire weather conditions during the summer of 2010/11, there were no days of very high, extreme and catastrophic fire risk in the areas covered by the trial after the installation of the generators was complete. However, the back-up generators did operate when the electricity supply was interrupted, although there was at least one instance when the back-up generator failed to start automatically, as it was designed to do.

Participants in the back-up supply trial were required to complete a survey prior to the commencement of the trial to understand the expectations of the trial and following the trial to understand the experiences of the trial.

- A third of the sample expected no major problems pre-trial and a similar proportion did not experience any major problems during the trial. Pre-trial, 22 per cent expected that the cost of fuel/consumption/ inefficiency would be a major problem, but these problems were only experienced by 4 per cent. This is likely to be due to the fact that it was a benign fire season and so trial participants were not disconnected from the electricity grid on high fire risk days.
- Pre-trial, 63 per cent identified being able to generate power during outages as an advantage. This increased to 74 per cent post-trial.
- Pre-trial, there was a large gap between the participants' rating of the importance of bushfire safety and for electricity affordability and the participants' rating of the performance. Post-trial, there was also a large gap between performance and importance responses for reliability of supply.

I.2 Trial of stand-alone power supply systems

The Taskforce was specifically required to examine:

The potential for isolated households in selected areas to move to stand-alone power supplies disconnected from the grid. A trial should invite isolated household(s) in selected locations to go “off the grid” to establish whether stand-alone power supplies are a viable and practical measure in some circumstances to minimise fire starts.

The Taskforce conducted a trial in which a SAPS was installed at 10 locations in Victoria. The trial was intended to be conducted in a way that would replicate, to the extent possible, the conditions that would prevail with a large scale rollout of SAPS.

Approximately 200 households in the Daylesford and Euroa areas were invited to participate in the trial. Of these, 24 responded positively and 10 sites were identified as being suitable, with five sites in each of the Daylesford and Euroa areas.

Of the seven invitees who advised the reasons for declining the invitation to participate in the trial, two were of the view their site was not suitable, two were not prepared to accept any risk of inconvenience due to age or health, one was not living full time at the address and one was concerned about the cost of fuel.

The SAPS installed consisted of two 10kWh zinc bromine batteries, a 6kW inverter, DC regulator and associated electronics, either 3.2kW or 4.8kW of solar panels (depending on the participant's average daily energy consumption) and a 7kVA back-up diesel generator.

A new battery technology (zinc bromine) was trialled as part of the trial. The new battery technology has several advantages compared to conventional technology. Zinc bromine batteries are safer than wet lead acid batteries and the charge-discharge characteristics of zinc bromine batteries allow a smaller battery to be used with a longer life. Unfortunately a number of the batteries failed during the trial.

It was originally intended that the SAPS would be installed in December 2010 and January 2011. However, due to the weather conditions during this period (high rainfall in Victoria and flooding of the manufacturer's premises in Brisbane), installation was delayed with the first participants disconnected from the grid in December 2010 and the final participant not disconnected from the grid until April 2011.

The minimum period of the trial was three months, with the expectation that it would be extended over at least a 12 month period. One participant requested to be removed from the trial after three months, due to the difficulties experienced using the SAPS. A decision was made in July 2011 to not continue the trial as most of the Taskforce members felt there was sufficient information to hand to inform the Taskforce's recommendations related to SAPS.

The total cost of supply, delivery and installation of each SAPS system purchased by the Taskforce for the trial was about \$120,000. The cost was high as the battery technology is new and not yet produced in volume. According to the manufacturer, the cost could decrease to perhaps \$90,000 with volume production of the batteries. More cost-effective SAPS systems are available using a conventional battery technology and if customers are prepared to trade-off safety features, quality and quantity of the electricity produced and local noise levels.

Operating costs are additional and include fuel for the back-up generator and annual equipment servicing. Participants in the trial were required to pay for the operating costs of the SAPS system during the period of the trial, but did not pay for electricity during that

period; that is they were reimbursed the standing connection charge. The participants were reimbursed the cost of diesel fuel if it exceeded more than 80 per cent of the electricity bill that would have been paid if they were not on the trial.

Other costs associated with permanently disconnecting customers from the electricity grid include the cost of removal and disposal of the network assets that are no longer required. This is estimated to be in the order of \$25,000 per km of powerline.

The amount of energy produced by the solar panels in the trial was very low, particularly during June 2011 in the Daylesford area despite the level of solar radiation being higher than the June average¹¹⁶ (refer Figure 54). The solar energy was not sufficient to charge the batteries and therefore the back-up generators operated more than anticipated. In some cases this was exacerbated by the poor location of solar panels and the failure of batteries.

For these reasons, the fuel costs were higher than expected, and there was the inconvenience of refuelling and noise issues associated with the running of the back-up generator.

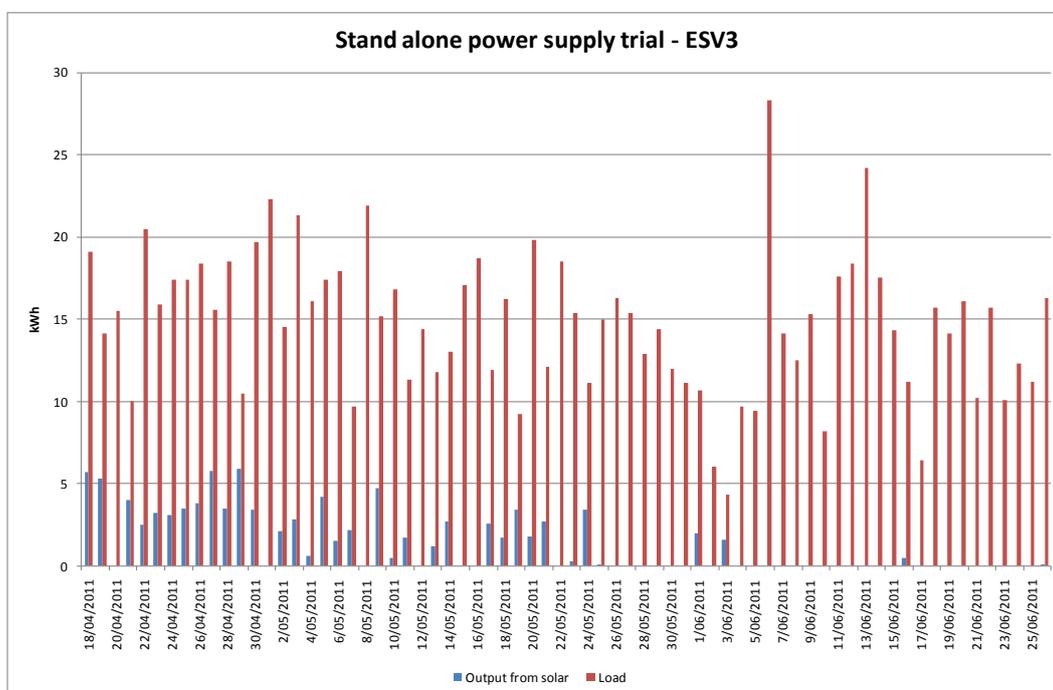


Figure 54: Example of load consumed by one trial participant in the Daylesford area (red bars) and the amount of solar energy produced (blue bars) during the April – June 2011 period

The high up-front cost of SAPS means that this option is only cost-effective where the cost to supply an individual customer using powerlines is higher than the cost of a suitable SAPS for that location.

The participants in the trial were surveyed before the trial to understand their expectations and again after the trial to understand their experiences. Alternative Technology Association (ATA) members with a SAPS were also invited to participate in the post-trial

¹¹⁶ The mean for June 2011 was 8.4 MJ m⁻² compared to a June mean of 6.2 MJ m⁻² (http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=193&p_display_type=dailyDataFile&p_startYear=2011&p_c=-1556794787&p_stn_num=088020). This compares to a mean for January of 26.1 MJ m⁻².

survey so their experiences could be compared with the trial participants. A total of 14 members of the ATA with SAPS volunteered to participate.

Compared to the trial participants, the ATA members had significantly more cost-effective SAPS (typically between \$6,000 and \$20,000 in total cost¹¹⁷) that were of lower capacity. They tended to have more energy efficient households with lower power consumption, a higher awareness of overall power usage and the contribution of various household appliances on electricity consumption, were more technically minded and had a better understanding of the SAPS.

While the ATA members surveyed were very satisfied with their SAPS, they did not believe that their stand-alone power supplies would suit everyone, for reasons including:

- overall management of the system – all SAPS systems require a certain level of expertise and management and were not entirely “set and forget”
- need to monitor and adjust household consumption – the ATA members did not have air conditioning, and some used gas-powered fridges or had them converted to run off a 24V DC supply
- battery-related issues – the ongoing management required, the fact that old technology is used in batteries (most were using lead-acid batteries), the expense, and concerns that batteries are not good for the environment
- the need for some technical expertise – technical skills can be hard to resource in rural locations.

Many of these issues and concerns were also raised by trial participants. As the trial participants are probably closer to the general community in terms of power usage, behaviours and attitudes (as compared to ATA respondents), their experiences were considered to be more indicative of the outcomes if SAPS were used more broadly.

I.3 Trialling a change in the network reclose function

The Taskforce conducted a number of trials to change the network reclose function over the 2010/11 summer period to understand the impact that this had on customers' supply reliability. There were four trial groups:

- Approximately 400 customers on SWER feeders – the operation of the ACR device was changed with a single fast protection for a six-week period from the middle of February to the end of March.
- Three groups of approximately 400 customers on 22kV feeders – the operation of the ACR device was to be changed on days of Total Fire Ban only, with the protection for one group set for one fast protection operation, the protection for one group set for one slow protection operation (as per the current suppression practice) and one group set for one fast and one slow protection operation (as recommended by the Royal Commission).

Suitable powerlines were identified for the trial and all customers that were supplied by those powerlines participated in the trial.

¹¹⁷ Many survey participants were uncertain of the total costs of their SAPS system because they had built up their systems incrementally over time and had used second-hand parts.

A number of participants in the ACR trials expressed either strong or extremely strong concerns regarding the trials, particularly the potential effect on supply reliability. Many of these had jumped to the conclusion that their electricity supply would be turned off.

However, summer 2010/11 was a benign weather season and the participants indicated that their reliability of supply was better during the trial period than during the same period in the previous year.

Appendix J Results from economics modelling

The Taskforce undertook preliminary indicative economic modelling to determine whether the Taskforce's recommendations would have a significant impact on the Victorian economy. The modelling provides an indication only of the magnitude of the impact associated with implementing the Taskforce's recommendations. The modelling does not take into consideration the benefit to the economy from a reduction in bushfires, noting that a reduction in bushfires started by powerlines may have a negligible impact on total bushfires.

The modelling was undertaken based on two packages of measures:

- Package A – a \$1 billion capital expenditure program (similar to package 3)
- Package B – a \$10 billion capital expenditure program (similar to package 6).

Two options for cost recovery were modelled:

- Option 1 – costs recovered from all Victorians
- Option 2 – costs recovered from electricity customers in the relevant electricity distribution area, consistent with the current regulatory regime.

The impact of the incremental capital expenditure programs (and associated cost recovery) is estimated to reduce Victorian real economic output (or real GSP) by:

- approximately \$0.5 billion with a \$1 billion capital expenditure program (with a net present value of around \$80 million using a 7 per cent discount rate)
- approximately \$20 billion with a \$10 billion capital expenditure program (with a net present value of around \$7.5 billion using a 7 per cent discount rate).

To place these numbers in perspective, the discounted present values are equivalent to approximately -0.03 per cent and -2.5 per cent, respectively, of the level of Victoria's real Gross State Product (GSP) in 2009-10.

The statewide impact is largely the same under the two cost recovery options, but the distribution of impacts differs. There is a greater reduction in economic output in Powercor's and SP AusNet's areas, offset by an increase in the rest of the state, when the costs are recovered from customers in Powercor's and SP AusNet's areas only.

The impact of the incremental capital expenditure programs (and associated cost recovery) is estimated to reduce Victorian real income by:

- approximately \$0.2 billion with a \$1 billion capital expenditure program (with a net present value of around \$30 million using a 7 per cent discount rate)
- approximately \$13 billion with a \$10 billion capital expenditure program (with a net present value of around \$5 billion using a 7 per cent discount rate).

To place these projections in perspective, at the state level, the discounted present value (using a 7 per cent discount rate) is equivalent to a one-off decrease in the *average* real income of all current Victorians of approximately \$5 and \$900 per person, respectively.

As with the real economic output, the statewide impact on real income is largely the same under the two cost recovery options, but the distribution of impacts differs. There is a greater reduction in real income in Powercor's and SP AusNet's areas, offset by an

increase in the rest of the state, when the costs are recovered from customers in Powercor's and SP AusNet's areas only.

The reduced economic activity associated with the capital expenditure program and associated cost recovery is projected to reduce Victorian employment over the period 2012 to 2040 by:

- a total of around 2,000 employee years¹¹⁸ with a \$1 billion capital expenditure program, or an average of around 70 full time equivalent (FTE) jobs per year
- a total of around 18,000 employee years with a \$10 billion capital expenditure program, or an average of around 600 FTE jobs per year.

At a statewide level the estimated impacts of the different cost recovery options on employment are largely the same.

¹¹⁸ An employee year is defined to be equivalent to one full time job held for a year or, for example 0.5 of a full time job held for two years.

Appendix K Recommendation on network reclose devices

Recommendation 2 states, in part, that:

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

This recommendation is provided in further operational detail below, to enable it to be implemented by the electricity distributors.

- (a) The operation of automatic network switches (ACRs and CBs) that turn powerlines on and off (the reclose function) should be changed on high fire risk days to limit the amount of energy released into the environment when powerline faults occur.
- (b) For those powerlines, the electricity distributors:
 1. must change the operation of all automatic network switches supplying powerlines that meet the threshold for **extreme and very high** fire loss consequence areas whenever conditions in those areas meet **Code Red day** criteria, such that:
 - a. the powerline is automatically turned off as quickly as possible if a powerline fault occurs
 - b. the powerline remains turned off pending operator intervention or confirmation that a fault is not still present
 2. must change the operation of all automatic network switches supplying powerlines that meet the threshold for **extreme and very high** fire loss consequence areas whenever conditions in those areas meet a **Total Fire Ban day** criteria, such that:
 - a. the powerline is automatically turned off as quickly as possible if a powerline fault occurs
 - b. the powerline is only automatically turned back on again once
 - c. if the powerline fault is still present, the powerline is automatically turned off again as quickly as possible and remains turned off pending operator intervention or confirmation that a fault is not still present

3. must change the operation of all automatic network switches supplying powerlines in all **other areas, except low** fire loss consequence areas, whenever conditions in those areas meet a **Total Fire Ban day** criteria, such that:
 - a. the powerline is automatically turned off as quickly as possible if a powerline fault occurs
 - b. the powerline is only automatically turned back on again once
 - c. if the powerline fault is still present, the powerline is automatically turned off after a delay of not more than the minimum time that will allow downstream automatic switches to act to limit adverse effects on customer supply reliability, and the powerline fault remains turned off pending operator intervention or confirmation that a fault is not still present.

Protection system sensitivity: Electricity distributors should set protection systems to detect and respond to faults with maximum sensitivity consistent with the load current or other standing current on the powerline; that is faults that involve low levels of fault current should be detected to the extent possible without excessive numbers of nuisance trips due to load current fluctuations, inrush current, cold load pick-up, direct-on-line motor starts and switching transients. The Taskforce understands that some protection system sensitivity settings (for example sensitive earth fault system minimum operating current) have remained unaltered for decades and determination of the sensitivity increase available without excessive numbers of nuisance trips may require significant investigation and protection relay modification.

Protection system speed of action: as quickly as possible means as quickly as can be achieved to minimise the likelihood of powerlines starting bushfires (as indicated by the arc ignition research) without excessive numbers of nuisance trips due to load current fluctuations, inrush current, cold load pick-up, direct-on-line motor starts, etc.

Delay time before reclose attempts: The Taskforce's arc ignition research indicates that a reclose delay of five seconds involves heightened risk of fire, whereas a delay of 30 seconds does not. The Taskforce understands that the longest multiple reclose sequence that has been used in the state to date is completed in 24 seconds. As there is precedence for this total reclose cycle duration it is recommended that a single 24 second delay in the absence of countervailing factors be used for the single reclose cycle. Such countervailing factors include proximity of the powerline to busy roads with heightened risk of "ear into pole" faults where long reclose delays may introduce other safety risks. In cases where countervailing factors are present, distributors should carry out a full safety risk analysis to determine the most appropriate reclose delay setting.

For the purposes of the recommendation, the threshold for:

- extreme fire loss consequence areas is the non-urban powerlines that represent the highest 50 per cent of the state's total possible fire loss consequence
- very high fire loss consequence areas is the non-urban powerlines that represent the next highest 30 per cent of the state's total possible fire loss consequence
- high fire loss consequence areas is the remaining non-urban powerlines that represent the lowest 20 per cent of the state's total possible fire loss consequence.

The thresholds are defined by fire loss consequence modelling of the whole state's electricity supply network under worst-case conditions.

Low fire loss consequence areas are those areas in which the land cannot carry fire.