ACIL ALLEN CONSULTING

REPORT TO
DEPARTMENT OF ECONOMIC DEVELOPMENT, JOBS, TRANSPORT AND RESOURCES

17 NOVEMBER 2015

REGULATORY IMPACT STATEMENT

BUSHFIRE MITIGATION REGULATIONS AMENDMENT

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Contents

List of boxes

List of figures

List of tables

Executive summary

Origins of initiative

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.

The Victorian Bushfires Royal Commission (Royal Commission) was established to inquire into and report on the causes and circumstances of the fires. It recommended the replacement of powerlines by putting them underground, insulating overhead powerlines or by using technology that greatly reduces the bushfire risk:

In September 2010 the Powerline Bushfire Safety Taskforce (“the Taskforce”) was formed to investigate the optimal way of implementing these recommendations.

The Taskforce presented its report to the Government in September 2011. The Taskforce recommended that the risk of powerlines starting bushfires could be reduced by:

- installing new technology that greatly reduces bushfire risk, that is, by installing:
  - Rapid Earth Fault Current Limiters (REFCLs) at specific points in the network to reduce the risk of polyphase powerlines starting fires (by automatically reducing the current in some types of powerline faults, and so reduce the risk of the fault starting a fire)
  - new generation Automatic Circuit Reclosers (ACRs) on Single Wire Earth Return (SWER) lines to reduce the risk of SWER lines starting fires (by enabling the devices to be set remotely so that they turn off those powerlines quickly when faults occur)
- putting powerlines underground or insulating conductors in the areas of highest bushfire risk.

In December 2011 the Government accepted the Taskforce’s recommendations and committed to a $750 million Powerline Bushfire Safety Program (PBSP).

The program comprises $250 million in government funding, as well as regulatory initiatives with estimated economic costs of $500 million. The $500 million (real, 2011) of regulatory initiatives reflects the Taskforce’s estimate of the economic costs of implementing its recommendation.

Proposed regulations

The implementation of the Taskforce’s recommendation is now the subject of proposed amendments to the Electricity Safety (Bushfire Mitigation) Regulations 2013.

The Taskforce’s Final Report noted that new information was expected to be available in the future, and so recommended that its findings be subject to review to ensure that the measures recommended were still cost-effective. Since 2011, testing of new technology and new analysis reviewing the potential costs and benefits of implementing the Taskforce’s recommendation have been undertaken. This Regulatory Impact Statement (RIS) incorporates this new information in its analysis.

The proposed regulations will implement the Taskforce’s recommendations by requiring that electricity distributors install REFCLs at specific points in the network, install ACRs on

SWER lines, and replace powerlines in the highest bushfire risk areas, where it is assumed that electricity distributors will not do so voluntarily on a timely basis.

The electricity distributors that will be most significantly impacted by the proposed regulations are AusNet Services and Powercor, with a relatively small impact on Jemena. The costs of the proposed regulations will fall upon the customers of those electricity distributors.

Why are these regulations required?

It is assumed that, in the absence of the proposed regulations, the Taskforce's recommendations will not be implemented on a timely basis under the economic and safety regulatory regime that applies to the Victorian electricity distributors, due to market and regulatory failures.

The electricity distributors have committed in their Bushfire Mitigation Plans to install a couple of trial REFCLs during the 2016-20 regulatory control period. Energy Safe Victoria, in its role as the safety regulator, has accepted these plans based on its understanding of the current best practice approach to energy safety and their understanding of the relevant risks.

In the absence of the proposed regulations, it is assumed that the electricity distributors would commence installing additional REFCLs in 2022, two years after a revenue determination for the 2021-25 regulatory control year period is made in around October 2020, and when they are satisfied that their trials have demonstrated that the technology is proven. It is further assumed that the rural electricity distributors would install one every two years, so that as the installation of one REFCL is completed, the installation of another REFCL commences.

It is assumed that, in the absence of regulations, Powercor would not install SWER ACRs in its lower consequence bushfire risk areas, and that the electricity distributors would not voluntarily put powerlines in the most dangerous areas of the state underground or insulate them. This is because the private incentives to do so are weak. Although these measures would reduce the likelihood of a bushfire, the electricity distributors may bear only a small proportion of the costs of major bushfires started by their assets, and so do not face a strong private incentive to change.

Even if there were sufficient private incentives, the revenue determined for the electricity distributors under the current regulatory regime may not include the costs associated with actions to reduce the likelihood of powerlines starting bushfires, in the absence of a regulatory obligation. In the absence of a regulatory obligation, the costs would only be included in the electricity distributor's revenue if it was determined by the economic regulator that there was a net benefit to the electricity distributor (and thereby its customers).

In theory, this could be offset by the threat of legal action if an electricity distributor is liable for damages caused by a fire started by their assets. However, the threat of legal action is weak. For example, when sued following the Black Saturday bushfires, the electricity distributors settled out of court. It is expected that the cost of settlement will either be passed on to customers under the current regulatory framework or that it will be covered by insurance (with any resulting increase in insurance premiums passed on to customers).

For these reasons, it is assumed that the proposed regulations are required to implement the Taskforce's recommendations.

Objective of the proposed regulations

The objective of the proposed amendments to the regulations is to reduce the likelihood that electricity distribution powerlines start bushfires. The objective is to reduce the likelihood of powerlines starting bushfires relative to the current likelihood, as regulated by the *Electricity Safety Act 1998* and the associated Electricity Safety (Bushfire Mitigation) Regulations 2013. Achieving this objective will reduce the incidence of bushfire ignition and the associated costs to the community.

Options to achieve the objective

Based on a preliminary assessment of a wide range options, the following options were short listed and assessed in detail in this Regulatory Impact Statement:

- **Option 1: Enhance the network protection for polyphase powerlines**
  - Option 1a: Amend the Electricity Safety (Bushfire Mitigation) Regulations 2013 regulations to require that an electricity distributor's bushfire mitigation plan's operation and maintenance plans set out how it would, within three years, enhance the network protection for polyphase powerlines to reduce the likelihood of a bushfire starting when a phase to earth fault occurs on a polyphase powerline in the highest consequence bushfire risk area. For the purposes of this option, the highest consequence bushfire risk area is the 15 zone substations listed in Appendix B.1.
  - Option 1b: As per option 1a, but with the highest consequence bushfire risk area defined as the 32 zone substations listed in Appendix B.2 and action to be taken within five years.
  - Option 1c: As per option 1a, but with the highest consequence bushfire risk area defined as the 45 zone substations listed in Appendix B.3 and action to be taken within seven years.
- **Option 2**: **Enhance the network protection for SWER powerlines**
  - Amend the Electricity Safety (Bushfire Mitigation) Regulations 2013 to require that an electricity distributor's bushfire mitigation plan's operation and maintenance plans set out how it would, within five years, enhance the network protection for SWER powerlines to reduce the likelihood of a bushfire starting when faults occur on those SWER powerlines.
- **Option 3: Powerlines in declared areas to be put underground or insulated**
  - Option 3a: Amend the Electricity Safety (Bushfire Mitigation) Regulations 2013 to require that an electricity distributor's bushfire mitigation plan sets out how powerlines in declared areas would, within seven years, be put underground or insulated.
  - Option 3b: Amend the Electricity Safety (Bushfire Mitigation) Regulations 2013 to require that an electricity distributor's bushfire mitigation plan sets out how powerlines that are replaced in declared areas would be put underground or insulated.

Enhancing network protection for polyphase powerlines (option 1)

The network protection for a polyphase powerline can be enhanced by installing a REFCL at the zone substation (ZSS) that supplies the polyphase powerline.

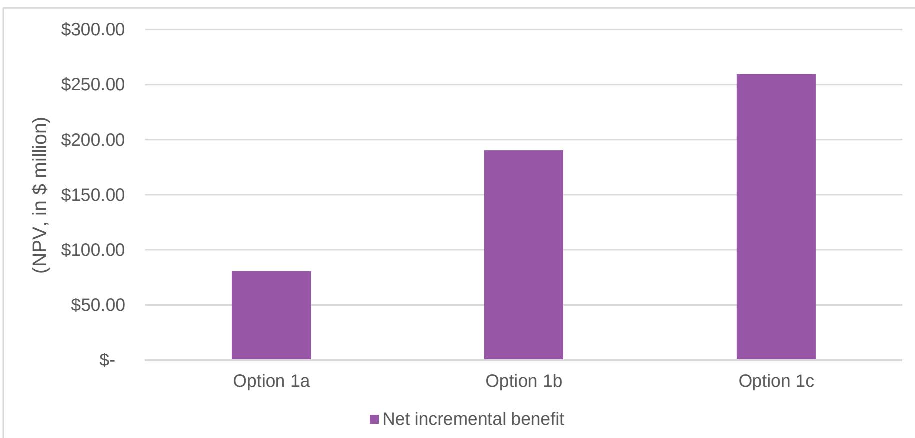
The net incremental benefits associated with the three sub options identified for enhancing network protection for polyphase powerlines were estimated by considering, the present value of:

- the direct costs associated with installing REFCLs at the ZSSs and the ancillary equipment required
- the avoided cost by installing REFCLs, and replacing ancillary equipment, earlier than would otherwise occur
- additional maintenance costs due to the installation of the REFCL
- additional costs incurred by customers that are directly connected to the electricity network
- administrative and compliance costs
- the benefits associated with an improvement in the bushfire risk
- the benefits associated with an improvement in the reliability of supply.

The costs and benefits were modelled over a 40 year period with a discount rate of 4.0 per cent.

The estimated net incremental benefits of each scenario are provided in Figure ES1. Each of the three scenarios has a net incremental benefit (in net present value terms), with the net incremental benefit increasing as the number of REFCLs installed increases. The benefit cost ratio is significantly greater than one for all options, ranging from 2.7 for option 1c to 3.0 for option 1b.

Figure ES1 **Estimated net incremental benefits of the scenarios to enhance network protection for polyphase powerlines**



Source: ACIL Allen

The reduction in the state-wide bushfire risk increases as the number of REFCLs installed increases. That is, the reduction in state-wide bushfire risk is greater under option 1b than under option 1a, and greater under option 1c than under option 1b.

The recommended option is to amend the Electricity Safety (Bushfire Mitigation) Regulations 2013 regulations to require that an electricity distributor's bushfire mitigation plan's operation and maintenance plans set out how it would, within seven years, enhance the network protection for polyphase powerlines to reduce the likelihood of a bushfire starting when a phase to earth fault occurs on a polyphase powerline in the area supplied by the 45 ZSSs listed in Appendix B.3 (option 1c).

There is a net benefit associated with this option and the reduction in the state-wide bushfire risk is the greatest of the three options considered.

Enhancing network protection for SWER powerlines (option 2)

The network protection for SWER powerlines can be enhanced by installing new generation SWER ACRs. The two rural electricity distributors have SWER powerlines in their electricity distribution areas. While one of these electricity distributors (AusNet Services) has installed new generation SWER ACRs on its SWER powerlines, the other electricity distributor (Powercor) has not installed them in the lower consequence bushfire risk areas.

The net benefits associated with installing SWER ACRs in the remaining areas of Powercor's electricity distribution network were estimated by considering the present value of:

- the direct cost of installing 1,064 new generation SWER ACRs
- the avoided cost by replacing protection devices earlier than would otherwise occur
- the avoided cost of manually resetting protection devices on SWER powerlines on fire ban days
- administrative and compliance costs
- the benefits associated with an improvement in the bushfire risk.

The costs and benefits were modelled over a 20 year period with a discount rate of 4.0 per cent.

The net benefit and benefit cost ratio associated with the proposed regulations to install new generation SWER ACRs on SWER powerlines is set out in Table ES1.

Table ES1 **Estimated net benefit associated with installing new generation SWER ACRs**

	2015 dollars	Benefit cost ratio
Present value of benefits	22,243,959	
Present value of net costs	27,209,067	
Present value of net benefit	**-4,965,109**	**0.82**

Source: ACIL Allen

The present value of net benefits has been estimated assuming that the average annual bushfire cost is $80 million. The Royal Commission identified that the risks associated with bushfire are likely to increase with the impact of climate change. If the average annual bushfire cost increases to $97.9 million with the impact of climate change, there is no net cost associated with installing new generation SWER ACRs on SWER powerlines.

On balance, given:

- the potential for each of the new generation SWER ACRs to avoid a single major one in 25 year bushfire, which could cost at least $300 million
- the potential for the average annual bushfire cost (around $80 million) to increase with the impact of climate change, which would increase the benefits associated with installing new generation SWER ACRs
- the relatively low unit cost of a new generation SWER ACR ($50,000 each)
- the modest cost to Powercor's consumers,

the preferred option is to amend the regulations to enhance network protection on SWER powerlines, rather than not to require them or to limit their installation to specific ZSSs.

It is therefore recommended that the Electricity Safety (Bushfire Mitigation) Regulations 2013 be amended to require that an electricity distributor's bushfire mitigation plan's operation and maintenance plans set out how it would, within five years, enhance the network protection for SWER powerlines to reduce the likelihood of a bushfire starting when faults occur on those SWER powerlines.

Powerlines in declared areas to be put underground or insulated (option 3)

The net benefits associated with the proposed regulations to require that powerlines in declared areas be put underground or insulated were estimated by considering the present value of:

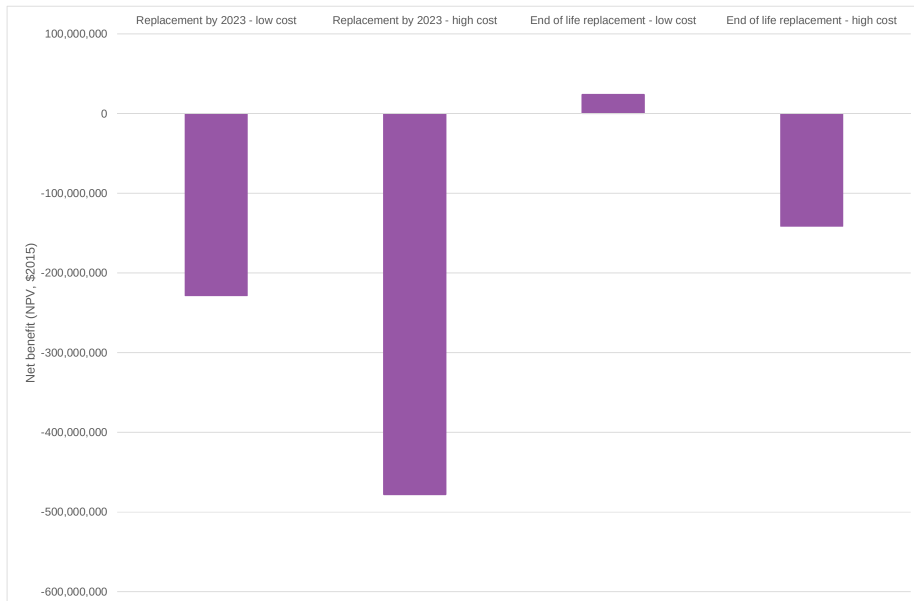
- the direct cost of putting powerlines underground or insulating conductors, in declared areas
- the direct cost for reconnecting customers to powerlines that are replaced
- the avoided cost by replacing powerlines earlier than would otherwise occur
- administrative and compliance costs
- the benefits associated with an improvement in the bushfire risk
- the benefits associated with an improvement in the reliability of supply.

The costs and benefits were modelled for a range of scenarios over a 50 year period with a discount rate of 4.0 per cent. The scenarios modelled considered replacement within seven years (option 3a) or at the end of their existing life (option 3b). As the end of life was unknown, it was assumed that, on average, powerlines would be replaced in 25 years (option 3b).

Each of these options was modelled based on the low end of costs and the high end of costs. The low end of costs assumed conductors would be insulated with the current technology (aerial bundled conductor or ABC) prior to 2020 and with new technology (carbon core conductor) from 2020. The high end of costs assumed that powerlines would be put underground or conductors would be insulated with the current technology.

The net benefits associated with the scenarios for replacing powerlines in a declared area are set out in Figure ES2.

Figure ES2 **Estimated net benefits associated with replacing powerlines within a declared area**



Source: ACIL Allen

Figure ES2 indicates that there is a net benefit and a benefits cost ratio greater than one to replace powerlines at the end of their life with the new technology (covered carbon core conductor). There is a net cost and a benefit cost ratio less than one for the other scenarios considered for putting powerlines underground or insulating conductors in declared areas (accelerated replacement by 2023 and replacement at the end of life with existing technologies).

On balance, the preferred option is to amend the regulations to require powerlines in declared areas to be insulated when they are replaced. It is currently estimated that there is a net benefit to do so using new technology, which is likely to be available when powerlines need to be replaced, and the impact on electricity customers' retail electricity bills is reasonable. It is considered prudent to proceed with this option given that it targets only the most dangerous areas of the state, results in a substantial reduction in the state's bushfire risk, and potentially avoids the very significant cost associated with a single major one in 25 year bushfire (at least $300 million).

It is therefore recommended that the Electricity Safety (Bushfire Mitigation) Regulations 2013 be amended to require that an electricity distributor's bushfire mitigation plan sets out how powerlines in declared areas would be put underground or insulated when they are replaced.

Summary of costs

Based on the net present value over the life of the assets, the costs, benefits and net benefits of the method of installation that yields the highest net benefit (or lowest net cost) for each of the three options are summarised in Table ES2.

Table ES2 **Costs, benefits and net benefits of the three options, net present value over the life of the assets, 2015 dollars**

	Install REFCLs (option 1c)	Install SWER ACRs (option 2)	Replace powerlines (option 3b)	
			Low cost	High cost
Costs	$151 million	$27 million	$25 million	$191 million
Benefits	$411 million	$22 million	$49 million	$50 million
Net benefits	$260 million	-$5 million	$23 million	-$141 million

Note: Low cost powerline replacement option – replace with new technology; High cost powerline replacement option – replace with existing technology. Numbers may not add due to rounding.

The cost of implementing these recommendations in total is therefore estimated to be between $203 million and $369 million (in present value terms).

If the regulations are amended, the costs incurred by the electricity distributors in meeting the regulations would be passed through to their customers in the form of increased distribution charges, which would increase retail electricity bills.

The total undiscounted costs associated with the recommended options for installing REFCLs, new generation SWER ACRs and replacing powerlines, by electricity distributor, are set out in Table ES3. Table ES3 also provides the estimated **worst case** maximum annual impact on a typical residential and small business customers' electricity bills, assuming that the costs are recovered through the variable component of the distribution charge, which is then reflected in the variable component of the retail charge.

The **worst case** maximum impact is estimated to be up to 1.0 per cent for customers in AusNet Services' area ($22-$30 for a household consuming 5,000kWh per annum and $112-150 for a small business consuming 25,000kWh per annum) and up to 0.5 per cent for customers in Powercor's area ($14-$17 for a household and $72-$87 for a small business). The impact on customers in Jemena's area is negligible ($0.22 for a household and $1.08 for a small business) and there is no impact for customers in CitiPower's and United Energy's areas.

Table ES3 **Undiscounted costs and maximum incremental impact on retail electricity bills associated with recommended options 1c, 2 and 3b**

	Undiscounted cost			Maximum incremental impact on retail electricity tariff
	Install REFCLs (option 1c)	Install SWER ACRs (option 2)	Replace powerlines (option 3b)	
	2015 dollars	2015 dollars	2015 dollars	cents per kWh
AusNet Services	$140.0 million		$222.7 million	0.15 – 0.30
Powercor	$154.5 million	$53.2 million	$185.1 million	0.14 – 0.15
Jemena	$2.2 million			0.00
Total	**$296.7 million**	**$53.2 million**	**$407.8 million**	

Note: Calculation of maximum incremental impact on tariff: WACC assumed to 6.0% (pre tax real); electricity delivered by the electricity distributors for 2016-20 is from their 2016-20 regulatory proposals; electricity delivered is assumed to grow from 2020-24 with the same compound annual growth rate as from 2015-20; the maximum estimated bill impact has been calculated on the basis of REFCL, SWER ACR and powerline costs only; the avoided costs and other benefits have not been deducted; the low end of the range is the installation of REFCLs and SWER ACRs; the high end of the range is the insulation of conductors at the end of their life, which is assumed to occur over a 7 year period around 2040 when the costs associated with the REFCLs and SWER ACRs have been substantially depreciated; the retail electricity tariff is in the order of 30 cents per kWh.

Source: ACIL Allen

The impact on competition of these price increases will be marginal, as the worst case maximum increase is modest and electricity costs tend to be a small proportion of a business's input costs. Energy intensive industries are generally directly connected to the transmission network and therefore do not pay distribution charges.

1 Introduction

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.

The 2009 Victorian Bushfires Royal Commission was established on 16 February 2009 to[1]:

> … 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 made 67 recommendations, of which eight related to reducing the likelihood of powerlines starting catastrophic bushfires. Of relevance to this Regulatory Impact Statement, the Royal Commission recommended the replacement of powerlines by putting them underground, insulating overhead powerlines or by using technology that greatly reduces the bushfire risk (recommendation 27)[2]:

> **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.

The Royal Commission acknowledged the technical complexity of two of its recommendations, and consequently suggested that an expert taskforce be formed to investigate further the optimal way of implementing these recommendations. In September 2010 the Powerline Bushfire Safety Taskforce ("the Taskforce") was formed, with representation from the electricity distributors, and experts in powerline and bushfire risk.

The Taskforce presented its report to the Government in September 2011. The Taskforce found that:

- the consequence of starting a bushfire varies across the state, and is determined by population exposure based on expected bushfire behaviour
- electrical arcs (caused by faults) can, in worst weather conditions, start a bushfire in milliseconds
- different types of electrical faults require different technological approaches

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 29

- new generation Automatic Circuit Reclosers (ACRs) are the most cost-effective means of treating risk on Single Wire Earth Return (SWER) lines – and lessen likelihood of ignition by 50 per cent
- Rapid Earth Fault Current Limiters (REFCLs) are the most cost-effective means of treating risk on polyphase lines – and lessen likelihood of ignition by 70 per cent
- powerline replacement (with insulated or underground cable) lessens likelihood of ignition by up to 99 per cent – but is the most expensive option of those considered.

The Taskforce recommended[3]:

> **Recommendation 1**
>
> Electricity distributors implement the 2009 Victorian Bushfires Royal Commission's recommendation 27 by:
>
> (a) installing new generation protection devices to instantaneously detect and turn off power at a fault on high fire risk days:
>
> - on SWER powerlines in the next five years (new generation SWER ACRs)
> - on 22kV powerlines[4] in the next 10 years (Rapid Earth Fault Current Limiters)
>
> (b) targeted replacement of SWER and 22kV powerlines[5] 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.

The Taskforce presented government with options of increasing cost within a notional cost envelope of $500 million to $3 billion. Reflecting the relative cost-effectiveness of new generation SWER ACRs and REFCLs, the Taskforce recommended that these technologies be deployed as a first priority. To the extent government believed there was merit in additional risk reduction, it could then fund that quantum of powerline replacement it believed was justified.

In December 2011 the Government accepted the Taskforce's recommendations and committed to a $750 million Powerline Bushfire Safety Program (PBSP).

The program comprises $250 million in government funding, as well as regulatory initiatives with estimated economic costs of $500 million. The $250 million in government funding (nominal) is allocated to the following initiatives:

- $200 million for the Powerline Replacement Fund (PRF)
- $40 million for backup electricity generators for people critically dependent on electricity supply
- $10 million for research and development – with a focus on those areas of uncertainty identified by the Taskforce.

The $500 million (real, 2011) of regulatory initiatives reflects the Taskforce's estimate of the economic costs of installing the following items:

- new generation SWER ACRs
- REFCLs

[3] Powerline Bushfire Safety Taskforce, *Final Report,* 30 September 2011, page 94

[4] Includes high voltage polyphase powerlines operating at different voltage levels

[5] Includes high voltage polyphase powerlines operating at different voltage levels

— heightened powerline construction standards in targeted areas.

These items are now the subject of proposed amendments to the Electricity Safety (Bushfire Mitigation) Regulations 2013.

Chapter 2 of this Regulatory Impact Statement (RIS) provides background information, including information on the electricity distribution system, how powerlines may start bushfires, technology options to reduce the likelihood that powerlines start bushfires, and the economic and safety regulatory regime that applies to the electricity distributors.

Chapter 3 sets out the nature and extent of the problem that the proposed regulations are designed to address, and considers the likelihood that electricity distribution powerlines may start bushfires and the technology options available to reduce the likelihood, the costs associated with bushfires, the market and regulatory failures that affect the likelihood that electricity distributors will take action to reduce the bushfire risk from powerlines, and the reduction in public risk if the likelihood that powerlines start bushfires is reduced.

Chapter 4 describes the objective of the proposed regulations, which is to reduce the likelihood that electricity distribution powerlines start bushfires.

Chapter 5 identifies a range of options to achieve the objective of the proposed regulations. A preliminary assessment is undertaken of these options to shortlist those that are subject to more detailed assessment in Chapter 6. The preferred options to meet the objective of the proposed regulations, drawing on the detailed assessment, are discussed in Chapter 7.

An implementation plan is included in Chapter 8 and an evaluation strategy is provided in Chapter 9.

The stakeholders that have been consulted in the development of this RIS are listed in Chapter 10.

2 Background

This chapter provides background information, which is relevant to this RIS, on:

— the electricity distribution system, in section 2.1
— the causes of powerline faults, in section 2.2
— the way in which powerlines may start bushfires, in section 2.3
— the variation across the state in the consequences of bushfires, in section 2.4
— the measures that have been taken since Black Saturday to reduce the likelihood that powerlines start bushfires, in section 2.5
— technology options that could further reduce the likelihood that powerlines start bushfires, in section 2.6
— the approaches to bushfire risk reduction, in section 2.7
— the safety and economic regulatory regime that applies to the electricity distributors, in section 2.8.

2.1 Electricity distribution system

Electricity supply system

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 one transmission business that owns and operates most of the transmission lines 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 electricity distribution area.
— **Retail** – electricity is sold to customers by the retailer.

The transmission network is more critical than the distribution network – a smaller network of lines supplies a much greater number of customers. An interruption on the transmission network has the potential to impact far more customers than an interruption on a distribution powerline.

The design, operation and maintenance of transmission powerlines is commensurate with the criticality of those powerlines. As a result, the number of bushfires started by transmission lines is less significant on a per kilometre basis (and in total) compared to distribution lines. The distribution network rather than the transmission network is therefore the subject of this RIS.

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.
- **Polyphase 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 1. 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 1. The electrical current returns through the ground rather than through a separate wire as occurs in polyphase 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 polyphase 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 1 km and often supply only one or two houses. They run at 240 or 415 volts.

Figure 1 **Examples of polyphase distribution powerline (on the left) and SWER line (on the right)**

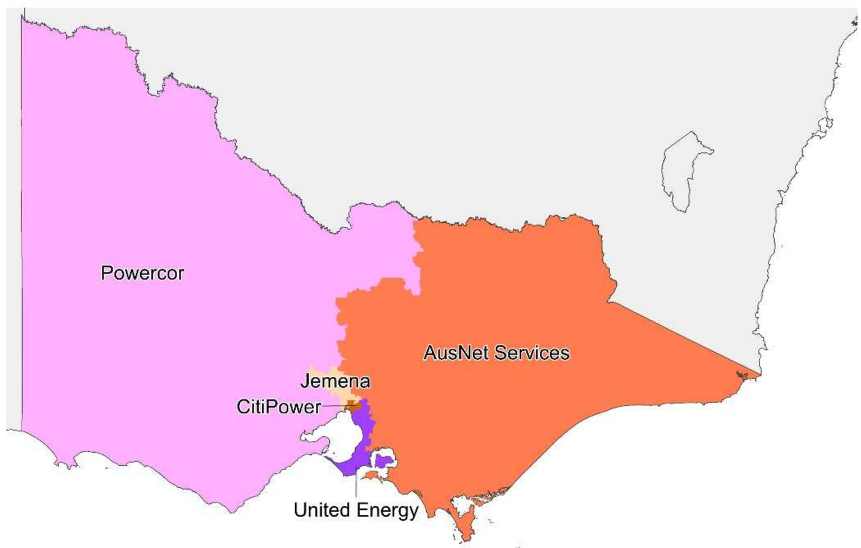
Source: Powerline Bushfire Safety Taskforce, *Final Report,* 30 September 2011, Figure 2

Following the 2009 Black Saturday bushfires, the polyphase and SWER powerlines in rural areas were the focus of the recommendations by the Victorian Bushfires Royal Commission.

Electricity distribution businesses

There are five electricity distributors that own and operate the electricity distribution networks in Victoria, each with a defined area as illustrated in Figure 2. Two electricity distributors own and operate most of the rural powerlines – Powercor in the west of the state and AusNet Services 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.

Figure 2 **Electricity distribution areas**



Note: This map is based on postcode boundaries and, as such, does not provide a precise reflection of the various distribution areas. It should only be used to provide a general indication of the distribution regions.
Source: ACIL Allen

The length of polyphase powerlines and SWER lines in Victoria by electricity distributor (except CitiPower [6]), is summarised in Table 1. As indicated in this table, 77 per cent of polyphase powerlines and 99 per cent of SWER lines in Victoria (excluding CitiPower's areas) are located in rural areas.

[6] CitiPower is not shown as its powerlines are all in urban areas.

Table 1 **Length of polyphase powerlines and SWER lines in Victoria (excluding CitiPower's area) as at September 2011**

Electricity distributor	Length of polyphase 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
AusNet Services	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**

Source: Powerline Bushfire Safety Taskforce, *Final Report,* 30 September 2011, Table 2

2.2 Powerline faults

Faults on powerlines may occur due to[7]:

- 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.

Of the fires thought to have been started by powerlines on Total Fire Ban days in Powercor's and AusNet Services' areas in 2008 and 2009[8]:

- the majority of bushfires (approximately 80 per cent) were started by the poles and wires, with a smaller proportion started by the auxiliary equipment mounted on the poles
- of these, 33 per cent were due to the external environment, 53 per cent were due to the failure of powerlines and 14 per cent were not clearly attributable to the external environment or the failure of powerlines
- of the bushfires started by the poles and wires, the majority were started by polyphase, rather than SWER, lines – approximately 1.6 fires were started for each 1,000km of polyphase lines and 0.3 fires were started for each 1,000km of SWER lines.

A powerline fault can result in a wire (phase) to earth fault or a wire to wire (phase to phase) fault. A SWER line has only a single wire and therefore a fault on a SWER line can only result in a wire (phase) to earth fault; not a wire to wire (phase to phase) fault.

Approximately 70 per cent of fires are started by phase to earth faults and 30 per cent are started by phase to phase faults.

2.3 Powerlines may start bushfires

When a powerline fault occurs, sufficient energy can be released 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

7 Powerline Bushfire Safety Taskforce, *Final Report,* 30 September 2011, page 38

8 Powerline Bushfire Safety Taskforce, *Final Report,* 30 September 2011, page 40

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 (a phase to earth fault)
- hot molten metal particles released when two live parts of powerlines make physical contact (a phase to phase fault), 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).[9]

With low vegetation moisture content and little air movement[10]:

- 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, that is, the higher the fault current, the higher the likelihood of a powerline starting a bushfire
- 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.

As molten metal particles have a high probability of igniting fuel, the only effective barrier is to prevent powerlines making physical contact. The electricity distributors install spreaders to prevent lines clashing and molten metal particles being emitted.

This RIS is focused on reducing the likelihood of bushfires starting by electric arcs.

2.4 Consequences of bushfires vary across the state

The fire loss consequence is the potential impact of a bushfire, in terms of loss of life and property. A particular location is considered to have a high fire loss consequence when a fire starting at that location has the potential for a high loss of property. A particular location 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 property.[11]

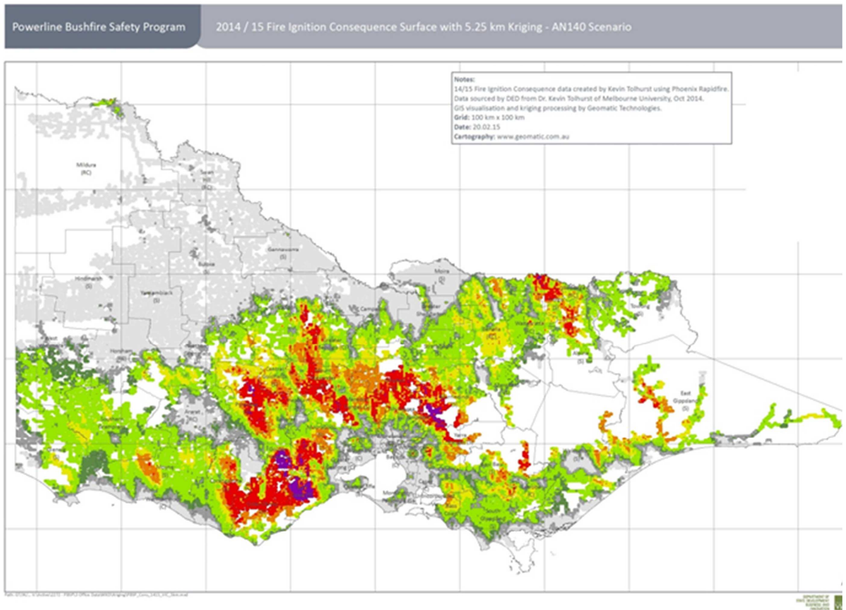
The consequence of a fire varies significantly by fire start location across the state, as illustrated in Figure 3, with the areas shaded red having a higher fire loss consequence and the areas shaded green having a lower fire loss consequence.

9 Powerline Bushfire Safety Taskforce, *Final Report,* 30 September 2011, page 41

10 Powerline Bushfire Safety Taskforce, *Final Report,* 30 September 2011, pages 41-42

11 Powerline Bushfire Safety Taskforce, *Final Report,* 30 September 2011, page 44

Figure 3 **Fire loss consequence map**



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. A large proportion of the state's fire loss consequence could be mitigated by targeting actions to a relatively small proportion of powerlines in the highest consequence bushfire risk areas. The proposed regulations are therefore targeted to actions in the consequence bushfire risk areas that are appropriate to the cost of those actions.

2.5 Reducing the likelihood that powerlines start bushfires

Following the Black Saturday bushfires, a wide range of measures have been taken to reduce the likelihood that powerlines start bushfires. Examples of the types of measures that have been taken are discussed in this section.

A number of changes have been made to the legislative and regulatory regime. These include:

— making it mandatory for the electricity distributors to prepare, submit and comply with an Electricity Safety Management Scheme

— increasing penalties if electricity distributors fail to submit a Bushfire Mitigation Plan

— requiring electricity distributors to comply with an approved Bushfire Mitigation Plan, with penalties for non-compliance

— explicitly requiring bushfire risks associated with the management of electricity distribution assets to be minimised

— requiring electricity distributors to prepare their Bushfire Mitigation Plans as part of their Electricity Safety Management Scheme and therefore provide a more comprehensive framework to the risk management approach to bushfire mitigation

— requiring powerlines to be inspected at least once every three years in hazardous bushfire risk areas and once every five years in other areas

- requiring electricity distributors to periodically inspect overhead private electric lines
- requiring inspectors to have satisfactorily completed a training course approved by the safety regulator, Energy Safe Victoria
- extending the power of Energy Safe Victoria to enable it to direct that vegetation be removed or to stop the planting of unsuitable vegetation under or near an electric line
- increasing the clearance distance required between overhead electric powerlines and trees
- introducing a financial incentive scheme (the F-factor) to encourage improvements in the management of electricity assets to reduce the number of fires started by electricity assets
- enhancing Energy Safe Victoria's governance arrangements
- including a specific objective for Energy Safe Victoria "to promote the prevention and mitigation of bushfire danger".

The electricity distributors have enhanced their inspection regimes with the use of, for example, high resolution digital photography, aerial photography, rod or boom mounted cameras, and thermal imaging.

As required, electricity distributors have been replacing, for example, poles (with concrete poles rather than wood poles, as appropriate), cross arms (with steel cross arms rather than wooden cross arms, as appropriate), and sections of conductor.

As an outcome of the Royal Commission, the ESV issued directions to the electricity distributors to prepare plans for the upgrade of assets that had been identified by the Royal Commission as having the potential to cause future bushfires. The two directions issued by ESV were:

- Installation of armour rods and vibration dampers – the direction required electricity distributors to install armour rods and vibration dampers in accordance with the Victorian Electricity Supply Industry (VESI) standards to reduce the likelihood of conductor failure as a result of Aeolian vibration.
- Installation of low voltage (LV) spreaders – the direction required electricity distributors to install LV spreaders in all spans of bare LV conductor in high bushfire risk areas and to fit additional spreaders where required to meet the relevant standards.

Following the release of the Taskforce's report, the electricity distributors changed the operation of automatic circuit reclosers (ACRs) to reduce the likelihood of powerlines starting bushfires, by reducing the number of operations on Total Fire Ban and Code Red days. AusNet Services replaced older ACRs with new generation ACRs on all SWER powerlines and Powercor did the same on SWER powerlines in the highest consequence bushfire risk areas.

2.6 Technology options to further reduce the likelihood that powerlines start bushfires

There are four technology options that could further reduce the likelihood that powerlines start bushfires:

- putting more powerlines underground
- insulating more overhead powerlines
- installing REFCLs

— installing new generation ACRs on all SWER lines, in particular, on Powercor's network in low consequence bushfire risk areas.

The types of powerlines for which these technology options reduce the bushfire risk are summarised below in Table 2. Table 2 also summarises the latest estimate from the CSIRO on the reduction in the likelihood of powerlines starting bushfires with the technology installed.

Table 2 **Applicability of technology options to polyphase and SWER lines**

Technology option	Reduce bushfire risk on polyphase lines?	Reduce bushfire risk on SWER lines?	Reduction in likelihood of bushfires
Putting powerlines underground	Yes	Yes	98 – 99%
Insulating overhead powerlines	Yes	Yes	96 – 98%
Installing REFCLs	Yes	No	48 – 60% (for a polyphase powerline)
Installing new generation ACRs on SWER lines	No	Yes	35 – 40%

Source: ACIL Allen

Each of these technology options is described in the following sections.

2.6.1 Putting powerlines underground

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 phase to earth faults will be experienced with an underground powerline.

The Taskforce estimated that the likelihood of powerlines starting bushfires is reduced by around 99 per cent by undergrounding cables. More recent analysis undertaken for the Department by CSIRO indicates that putting powerlines underground reduces the likelihood of powerlines starting bushfires by between 98 and 99 per cent.

The main issue with putting powerlines underground is the cost. The cost to put powerlines underground varies significantly across the state based on the terrain, soil conditions and dwelling density. Estimates of the capital costs to put powerlines underground are set out in Table 3.

Table 3 **Unit capital cost to put powerlines underground**

Powerline replacement option	Source	Range of unit capital costs (2015 dollars)
Underground SWER lines	Taskforce	$274,736– $423,702 per km
Underground SWER lines	Powerline Replacement Fund	$256,669 per km
Underground polyphase lines	Taskforce	$284,601 – $706,064 per km
Underground polyphase lines	Powerline Replacement Fund	$842,005 per km

Source: Taskforce: Powerline Bushfire Safety Taskforce, *Final Report,* 30 September 2011, Table 6, escalated by CPI from March 2011 to March 2015, Powerline Replacement Fund: revealed by the electricity distributors through a competitive process

2.6.2 Insulating 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.

The Taskforce estimated that the likelihood of powerlines starting bushfires is reduced by between 90 and 99 per cent by insulating overhead powerlines. CSIRO's more recent analysis indicates that insulating overhead powerlines reduces the likelihood of powerlines starting bushfires by between 96 and 98 per cent.

As with putting powerlines underground, the capital cost of insulated overhead powerlines varies significantly across the state based on the terrain and dwelling density. Soil conditions have less influence on the costs of insulated overhead wires than on the costs of underground cables. Estimates of the capital costs to insulate overhead powerlines are as set out in Table 4.

Table 4 **Unit capital cost to insulate overhead powerlines**

Powerline replacement option	Source	Range of unit capital costs (2015 dollars)
Insulate SWER lines	Taskforce	\$240,892 – \$388,761 per km
Insulate polyphase lines	Taskforce	\$243,109 – \$374,343 per km
Insulate polyphase lines	Powerline Replacement Fund	\$406,350 per km

Source: Taskforce: Powerline Bushfire Safety Taskforce, *Final Report,* 30 September 2011, Table 6, escalated by CPI from March 2011 to March 2015, Powerline Replacement Fund: revealed by the electricity distributors through a competitive process

2.6.3 Installing new generation REFCLs to protect polyphase lines

A new generation REFCL is a relatively recent advance on an old technology[12] that is able to reduce the fault current almost instantaneously when wire to earth faults occur. A REFCL is installed in a zone substation (ZSS) and will reduce the fault current when phase to earth faults occur on polyphase powerlines that are supplied by that ZSS.

The REFCL only operates:

- for phase to earth faults (around 70 per cent of faults on polyphase powerlines) and not phase to phase faults
- on polyphase powerlines, which comprise 67 per cent of Victoria's rural powerlines by length, and not SWER powerlines.

REFCLs have been used in Europe since the early 1990s (albeit in small numbers), mainly on underground cable networks, to improve safety and supply reliability, and have been used in New Zealand since 2007. The first Australian REFCL installation was at United Energy's Frankston South ZSS, which was commissioned in 2010.

The primary purposes of REFCLs have been a reduction in safety risk arising from underground cable faults and overhead conductors falling to the ground, and

[12] 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.

improvements in supply reliability. Fire safety has not been a material concern in Europe and New Zealand, and was not a consideration in the installation of the REFCL at Frankston South.

While REFCLs have traditionally not been used to reduce the likelihood of polyphase powerlines starting bushfires, the Taskforce investigated whether REFCLs could be used for this purpose.

Building on initial testing by the Taskforce in 2011, the PBSP has conducted a world-first test of REFCL technologies at Frankston South (2014) and is currently conducting further testing at Kilmore South (2015). These tests have been undertaken in collaboration with electricity distribution businesses, leading industry experts and original equipment manufacturers.[13]

The Frankston South test conclusively demonstrated the **capability** of REFCL technology to detect and suppress faults on the network which otherwise would lead to bushfires.[14] The precise test results have directly informed the performance standards which are now proposed for inclusion in the Bushfire Mitigation Regulations amendment.

The objective of the tests that are currently being undertaken at Kilmore South are to test the comparative performance of a range of REFCL configurations to identify optimal fault detection and suppression capability on a live network.

The Taskforce originally estimated that a REFCL would reduce the likelihood of polyphase powerlines starting bushfires by 70 per cent. Recent analysis undertaken for the Department by CSIRO indicates that installing a REFCL reduces the likelihood of bushfires starting by polyphase powerlines supplied by a ZSS by between 48 and 60 per cent. The CSIRO's figure takes into account that:

- REFCLs only address phase to earth faults, which comprise a subset of total faults on polyphase powerlines
- REFCLs will prevent at least 90 per cent of ignitions arising from phase to earth faults.

2.6.4 Installing new generation ACRs on SWER powerlines

To reduce the amount of time that people may be without power when faults occur, automatic switches called ACRs are installed to protect powerlines, both polyphase and SWER. An ACR on a polyphase powerline will protect that polyphase powerline; an ACR on SWER line will protect that SWER line.

When a fault occurs, the ACR turns off the powerline that is protected by the ACR. After a period of time, the ACR tries to turn the power back on to see whether the problem still exists.

Many ACRs on Victoria's electricity distribution system, particularly on SWER powerlines, do not detect low fault currents, have long operating times and cannot be controlled remotely to cost-effectively change settings on high fire risk days to balance the need for customer supply reliability, and bushfire risk.

There are also a significant number of boric acid blow-out fuses on the SWER network which, in the event of a fault, shut off power without a capacity to automatically re-establish current flow. In addition to having the same shortcomings as older style

[13] Further information on these tests is provided in section 3.1.3.

[14] The details of these trials are available in reports on the Department's website (www.ecodev.vic.gov.au).

SWER ACRs, these fuses, once "blown", require a manual visit by a crew to re-establish power.

New generation ACRs for SWER powerlines are able to be remotely controlled so that the settings can be cost-effectively 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.

For these reasons, the likelihood of a SWER powerline starting a bushfire can be lower with a new generation SWER ACR installed on that powerline, than with the older style of ACR or fuses.[15]

In 2013 Energy Safe Victoria commissioned research which determined the optimal settings for ACRs to minimise bushfire risk while maintaining supply reliability. This research concluded that delays in auto-reclosure should be 8 seconds or greater to avoid increased risk of sustained ignition. This figure has directly informed the performance standards proposed for inclusion in the Bushfire Mitigation Regulations amendment.

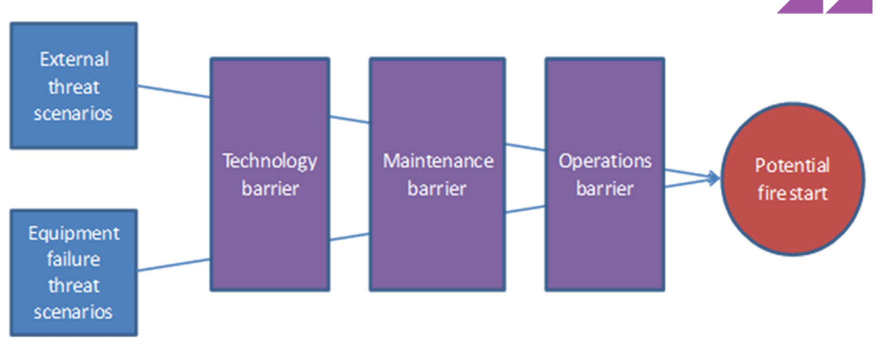
With the installation of new generation ACRs on SWER powerlines and a change in the network reclose function, the Taskforce estimated that the likelihood of SWER powerlines starting bushfires will be reduced by between 10 and 50 per cent, depending on the operation of the network reclose function.

More recent analysis undertaken by CSIRO indicates that the installation of new generation ACRs on SWER powerlines, and a change in the network reclose function reduces the likelihood of bushfires starting by those SWER powerlines by between 35 and 40 per cent.

2.7 Approaches to bushfire risk reduction

The Taskforce 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 4.

Figure 4 **Threat-barrier diagram for the ignition of bushfires**



Source: Powerline Bushfire Safety Taskforce, *Final Report,* 30 September 2011, page 53

[15] Powerline Bushfire Safety Taskforce, *Final Report,* 30 September 2011, page 49

Consistent with the earlier discussion on causes of powerline faults, Figure 4 indicates that the threats arise from faults on powerlines caused by the external environment and the failure of powerlines.

The sequence of 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 where the technology barrier does not
- 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 days of higher fire danger:

- **Weather:** Powerlines are designed for a maximum loading based on temperature and wind. On a higher fire danger day, the network may be operating at higher stresses due to the combination of very high temperatures, winds and loads.
- **Fuel**: Ignition of a fire becomes more likely as fuel dries.

Electricity distributors can strengthen precautions that prevent ignition of bushfires by powerlines. Other precautions that will prevent a fire, once ignited, developing into a major bushfire, whether started by powerlines or by other causes, are outside the control of the electricity distributors.

2.8 Regulatory regime that applies to electricity distributors

Electricity distributors are natural monopolies due to the high fixed costs of building an electricity distribution network. Each electricity distributor has an electricity distribution area in which it is the sole supplier of electricity, as illustrated in Figure 2.

Accordingly, the Victorian electricity distributors are subjected to economic regulation and safety regulation.

2.8.1 Economic regulation

Economic regulation is done nationally by the Australian Energy Regulator (AER). Electricity distribution businesses are subject to economic regulation by the AER in accordance with the National Electricity Law and the National Electricity Rules.

The AER is responsible for determining the revenues that electricity distributors can recover from their customers. The AER evaluates the revenue proposals of electricity distributors distribution businesses against the national electricity objective set out in the National Electricity Law, viz. 'to promote investment in, and efficient operation and use of, electricity services for the long term interests of electricity consumers'.

The revenues are determined on a five yearly basis through a building block approach. The building blocks comprise:

- a return on the regulated asset base
- a return of the regulated asset base (depreciation)
- operating expenditure
- the impact of incentive mechanisms
- corporate tax.

The economic regulatory regime is an incentive-based framework. The electricity distributors' revenues are determined on an ex ante basis (with limited ex post review) based on forecasts. Where the electricity distributors are able to realise efficiency benefits during a regulatory period (the actual costs are less than the forecast costs), they are able to retain the efficiencies for the balance of that regulatory period.

The revenue determination may include incentive schemes for operating expenditure and/or capital expenditure so that the efficiency benefits are shared with customers, with the electricity distributors retaining 30 per cent of the benefits and their customers retaining 70 per cent of the benefits.

Forecast capital expenditure

The return on and of the regulated asset base are influenced by the forecast capital expenditure for the forthcoming regulatory period.

The electricity distributors forecast capital expenditure for:

- augmentations of the network, to meet demand
- replacement of the network, to ensure that quality, reliability, security and safety of supply are maintained (not improved)
- connections, to connect new customers
- meeting any legislative or regulatory obligation
- non-network capital expenditure, for example, IT expenditure, motor vehicles etc.

The AER assesses the forecast capital expenditure on an ex ante basis and must accept the capital expenditure forecast by an electricity distributor where the costs meet the capital expenditure criteria. That is, it accepts the forecast where the costs[16]:

- are efficient
- would be incurred by a prudent operator
- are required to meet a realistic expectation of the demand forecast and cost inputs.

On an ex post basis, the AER assesses the efficiency and prudency of the actual capital expenditure. Where that capital expenditure is assessed to be efficient and prudent it is added to the regulatory asset base so that the electricity distributor earns a return on and of the asset for the life of that asset. Where the capital expenditure is assessed to be not efficient or not prudent, the capital expenditure is not added to the regulatory asset base and the electricity distributor is unable to recover the return on and of the asset from its customers.

Service-based incentive mechanisms

The electricity distributors have an incentive to outperform the revenue determined by the AER by reducing costs and thereby increasing their profits. To balance this incentive, the regime includes provision for various performance incentive schemes that encourage electricity distributors to maintain and improve performance, for example, supply reliability through the Service Target Performance Incentive Scheme and the number of fires started by the electricity distribution system through a fire incentive (or F-factor) scheme.

[16] National Electricity Rules, clause 6.5.7(c)

2.8.2 Safety regulation

Safety is regulated by Energy Safe Victoria (ESV) through state-based legislation and regulation.

The *Electricity Safety Act 1998* (the Act) establishes a process-based regulatory regime, which seeks to ensure that the full range of risks arising from the use of electricity are managed in a systematic way. The risk of powerlines starting bushfires is clearly only one of these categories of risk, albeit a very significant one.

The fundamental elements of this framework that apply to electricity distributors include general duties, Electricity Safety Management Schemes and Bushfire Management Plans. The key challenge with the safety regulatory regime is to ensure that the electricity distributors retain responsibility for the safety of their networks.

General duties

Part 10 of the Act establishes general duties that apply to major electricity companies (MECs), which include electricity distributors. Section 98 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) the bushfire danger arising from the supply network.

The penalties for breaching this provision are 300 penalty units ($45,501[17]) for a natural person and 1,500 penalty units ($227,505) for a body corporate.

Electricity Safety Management Schemes

Part 10 of the Act also requires MECs to submit an Electricity Safety Management Scheme (ESMS) to the ESV, for its acceptance. An ESMS sets out the safety management system that the MEC has in place to acquit its general duties.

A MEC must not operate a supply network unless an ESMS has been accepted (or provisionally accepted) by the ESV, and must comply with the ESMS.

Prior to considering whether to accept an ESMS, the ESV may require the ESMS to be validated by an independent party. ESV must accept an ESMS if it is satisfied that the ESMS is appropriate for the supply network to which it applies and complies with the Act and the regulations relating to ESMSs.

The ESV may determine an ESMS for a MEC if an ESMS has not been submitted by the MEC or not accepted by the ESV.

ESMSs are required to be revised at five yearly intervals and in certain specific circumstances, including when there are significant changes to the management of the system or to the state of technical knowledge that are of relevance to the ESMS.

The ESV may request a revised ESMS to be resubmitted at any time. The MEC may make a submission that the revision should not occur, should be in different terms from the proposed terms, or take effect at a later date than the proposed date. The ESV must accept or reject the submission.

Bushfire Management Plan

[17] As at 1 July 2015

Part 10 of the Act, states that an electricity distributor's ESMS must include a plan for the mitigation of bushfire danger in relation to the MEC's supply network.

Section 113A of the Act states that the Bushfire Mitigation Plan (BMP) must "include the prescribed particulars". The prescribed particulars, which are set out in the Electricity Safety (Bushfire Mitigation) Regulations 2013, are set out in Appendix A.

A MEC must not operate a supply network unless a BMP has been accepted (or provisionally accepted) by the ESV, and must comply with the BMP.

Prior to considering whether to accept a BMP, the ESV may require the BMP to be validated by an independent party. ESV must accept a BMP if it is satisfied that the BMP is appropriate for the "at-risk electric lines to which it relates".

The ESV may determine a BMP for a MEC if an ESMS has not been submitted by the MEC or not accepted by the ESV.

The provisions relating to the revision of ESMSs also apply to BMPs.

3 Nature and extent of the problem

This chapter sets out the nature and extent of the problem that the proposed regulations are designed to address, and considers the following:

- the ignition of bushfires, including the likelihood that electricity distribution powerlines may start bushfires and the technology options available to reduce the likelihood, in section 3.1
- the costs associated with bushfires, in section 3.2
- the market and regulatory failures that affect the likelihood that electricity distributors will take action to reduce the bushfire risk from powerlines, in section 3.3
- the reduction in public risk if the likelihood that powerlines start bushfires is reduced, in section 3.4.

3.1 Bushfire ignition

This section considers the likelihood that electricity distribution powerlines may start bushfires and the technology options available to reduce the likelihood.

- Background information on the 2009 Black Saturday bushfires and the relevant recommendation that was made by the Royal Commission are provided in section 3.1.1.
- The key findings and relevant recommendation of the Taskforce are discussed in section 3.1.2.
- The Government's response to the relevant sections of the Taskforce's report, through the establishment of the PBSP, is provided in section 3.1.3.
- The response by the electricity distributors to the recommendations of the Taskforce is provided in section 3.1.4.
- A summary of the key findings of the work undertaken since the 2009 Black Saturday bushfires and the actions remaining are summarised in section 3.1.5.

3.1.1 The Black Saturday bushfires

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.

The Royal Commission was established on 16 February 2009 to[18]:

> … 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.

[18] 2009 Victorian Bushfires Royal Commission, *Final Report: Summary*, July 2010, page 2

The Royal Commission summarised the impact of the Black Saturday fires as follows[19]:

> 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.

Historically, powerlines comprise one of three primary causes of bushfires, the others being arson and natural causes, generally lightning. Fires caused by powerlines are thought to constitute only a small minority of total fires, but appear to be over-represented in major fire events. Electricity system assets 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 11 major fires on Black Saturday that were investigated by the Royal Commission[20].

The Royal Commission found that[21]:

> Although the proportion of fires that are caused by electricity infrastructure is low – possibly about 1.5 per cent of all ignitions in normal circumstances – on days of extreme fire danger the percentage of fires linked to electrical assets rises dramatically. Thus, electricity-caused fires are most likely to occur when the risk of a fire getting out of control and having deadly consequences is greatest.

In its July 2010 Final Report, the Royal Commission concluded that[22]:

> 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. Of relevance to this RIS, the Royal Commission recommended the replacement of powerlines by putting them underground, insulating overhead powerlines or by using technology that greatly reduces the bushfire risk[23]:

> **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

---

19 2009 Victorian Bushfires Royal Commission, *Final Report: Summary,* July 2010, page 1

20 2009 Victorian Bushfires Royal Commission, *Final Report: Summary,* July 2010, page 12. While the Royal Commission did not attribute the cause of the Murrindindi bushfire to electricity system assets, in a subsequent class action, the State of Victoria argued that AusNet Services' assets were responsible for this fire, which caused 40 deaths. The Murrindindi matter was settled out of court on 6 February 2015 for $300 million.

21 2009 Victorian Bushfires Royal Commission, *Final Report: Volume 1: The Fires and the Fire Related Deaths,* July 2010, page 226

22 2009 Victorian Bushfires Royal Commission, *Final Report: Volume II, Fire Preparation, Response and Recovery*, July 2010, page 154

23 2009 Victorian Bushfires Royal Commission, *Final Report: Summary*, July 2010, page 29

completed in the areas of highest bushfire risk within 10 years and should continue in areas of lower bushfire risk as the lines reach the end of their engineering lives

- the progressive replacement of all 22-kilovolt distribution feeders with aerial bundled cable, underground cabling or other technology that delivers greatly reduced bushfire risk as the feeders reach the end of their engineering lives. Priority should be given to distribution feeders in the areas of highest bushfire risk.

The other seven electricity-related recommendations made by the Royal Commission have already been implemented. The recommendations and actions that have been taken are summarised in Table 5.

Table 5 **Implementation of the Royal Commission's recommendations**

Royal Commission recommendation		Action taken
28	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.	Regulation 7(1)(i) of the Electricity Safety (Bushfire Mitigation) Regulations 2013 requires that powerlines in hazardous bushfire risk areas are inspected at least every 37 months, and other powerlines are inspected at least every 61 months.
29	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 theoretical and practical training for asset inspectors.	Regulation 7(1)(j) of the Electricity Safety (Bushfire Mitigation) Regulations 2013 requires a distributor's Bushfire Mitigation Plan to include the details of the processes and procedures for ensuring that asset inspectors are competent and have satisfactorily completed a training course approved by Energy Safe Victoria.
30	The State amend the regulatory framework for electricity safety to require that electricity 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.	The Electricity Safety (Electric Line Clearance) Regulations 2010 were amended in 2013 following consideration of the Royal Commission's recommendation.
31	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.	The Bushfire Royal Commission Monitor assessed this recommendation as complete as at 31 July 2014.

	Royal Commission recommendation	Action taken
32	The State (through Energy Safe Victoria) require distribution businesses to do the following: ▪ disable the reclose function on the automatic circuit reclosers on all SWER lines for the six weeks of greatest risk in every fire season ▪ adjust the reclose function on the automatic circuit reclosers on all 22-kilovolt feeders on all total fire ban days to permit only one reclose attempt before lockout.	This recommendation was considered by the Powerline Bushfire Safety Taskforce which recommended that: ▪ the reclose function on automatic circuit reclosers in the worst bushfire risk areas be adjusted to two fast protection operations on Total Fire Ban days and one fast protection operation on Code Red days ▪ the reclose function on automatic circuit reclosers in the remaining rural areas be adjusted to one fast and one slow protection operation on Total Fire Ban and Code Red days ▪ until older style SWER automatic circuit reclosers are replaced, they be manually changed in the highest bushfire consequence areas during the worst bushfire period as declared by the Fire Services Commissioner. Electricity distributors are now operating automatic circuit reclosers in accordance with this recommendation.
33	The State (through Energy Safe Victoria) require distribution businesses to do the following: ▪ fit spreaders to any lines with a history of clashing or the potential to do so ▪ fit or retrofit all spans that are more than 300 metres long with vibration dampers as soon as reasonably practicable.	On 4 January 2011, the Director of Energy Safety made two directions – one requiring the fitting of armour rods and vibration dampers, and one requiring the fitting of spacers (spreaders) on all spans of bare low voltage conductor in hazardous bushfire risk areas, and that all spans in hazardous bushfire risk areas that do not comply with the required line separation standards be reconstructed or be fitted with spacers.
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.	A number of amendments were made to the *Electricity Safety Act 1998* in 2010 to strengthen the mandate of Energy Safe Victoria including: ▪ adding an objective to promote the prevention and mitigation of bushfire danger[24] ▪ adding a function to regulate, monitor and enforce the prevention and mitigation of bushfires that arise out of incidents involving electric lines or electrical installations[25].

Source: ACIL Allen based on the Royal Commission's recommendations as set out in its July 2010 Summary Report, pages 29-30

While these recommendations may contribute to a reduction in the likelihood that a powerline starts a bushfire:

— There are currently tens of millions of points of potential failure in 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. Any increase in maintenance is not expected to have a material impact on this already very low probability.

— Vegetation causes around 24 per cent of bushfires started by powerlines. While reducing the risks posed by hazard trees will reduce the likelihood that vegetation contact with powerlines will start bushfires, it will have no impact on the other ways in which powerlines start bushfires.

[24] Energy Safety Act 1998, section 6(ca)

[25] Energy Safety Act 1998, section 7(fa)

- The CSIRO estimated that changing the operation of an ACR on a polyphase powerline will reduce the likelihood of that polyphase powerline starting bushfires by only 9 per cent, while changing the operation of an ACR on a SWER line will reduce the likelihood of that SWER line starting bushfires by 35 to 40 per cent.
- The installation of spreaders (spacers) will reduce the likelihood of phase to phase faults but not phase to earth faults.

3.1.2 Powerline Bushfire Safety Taskforce

The Royal Commission acknowledged the technical complexity of its Recommendations 27 and 32, and consequently suggested that an expert taskforce be formed to investigate further the optimal way of implementing these recommendations. In September 2010 the Taskforce was formed, with representation from the electricity distributors, and experts in powerline and bushfire risk.

The Taskforce presented its report to the Government in September 2011. The Taskforce found that:

- the consequence of starting a bushfire varies across the state, and is determined by population exposure based on expected bushfire behaviour
- electrical arcs (caused by faults) can, in worst weather conditions, start a bushfire in milliseconds
- different types of electrical faults require different technological approaches
- new generation Automatic Circuit Reclosers (ACRs) are the most cost-effective means of treating risk on SWER lines – and lessen likelihood of ignition by 50 per cent
- REFCLs are the most cost-effective means of treating risk on polyphase lines – and lessen likelihood of ignition by 70 per cent
- powerline replacement (with insulated or underground cable) lessens likelihood of ignition up to 99 per cent – but is the most expensive option of those considered.

The Taskforce recommended[26]:

> **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 powerlines[27] in the next 10 years (Rapid Earth Fault Current Limiters)
>
> (d) targeted replacement of SWER and 22kV powerlines[28] 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.

[26] Powerline Bushfire Safety Taskforce, *Final Report,* 30 September 2011, page 94

[27] Includes high voltage polyphase powerlines operating at different voltage levels

[28] Includes high voltage polyphase powerlines operating at different voltage levels

The Taskforce presented government with options of increasing cost within a notional cost envelope of $500 million to $3 billion. Reflecting the relative cost-effectiveness of new generation SWER ACRs and REFCLs, the Taskforce recommended that these technologies be deployed as a first priority. To the extent government believed there was merit in additional risk reduction, it could then fund that quantum of powerline replacement it believed was justified.

Table 6 **Quantifying the Taskforce's recommendation**

Item	Quantity	Taskforce cost estimate ($2011)
New generation SWER ACRs	1,300 units	$43 million
REFCLs	108 units	$432 million
Powerline replacement	Varied according to option	

Source: Powerline Bushfire Safety Taskforce

The Taskforce acknowledged the need for further research and development to improve understanding of bushfire risk and technology capability. This formed the basis for the Taskforce's Recommendations 4 and 5 for $10 million in R&D funding ($2 million per year over 5 years).

3.1.3 Powerline Bushfire Safety Program

In December 2011 the Government accepted the Taskforce's recommendations and committed to a $750 million PBSP.

The program comprises $250 million in government funding, as well as regulatory initiatives with estimated economic costs of $500 million. The $250 million in government funding (nominal) is allocated to the following initiatives:

- $200 million for the Powerline Replacement Fund (PRF)
- $40 million for backup electricity generators for people critically dependent on electricity supply
- $10 million for research and development – with a focus on those areas of uncertainty identified by the Taskforce.

The $500 million (real, 2011) of regulatory initiatives reflects the Taskforce's estimate of the economic costs of installing the following items cited in Taskforce Recommendation 1:

- new generation SWER ACRs
- REFCLs
- heightened powerline construction standards in targeted areas.

These items are now the subject of proposed amendments to the Electricity Safety (Bushfire Mitigation) Regulations 2013.

Key findings of the PBSP

The PBSP has made several findings which build on the findings of the Taskforce, and directly influence the way its recommendations will be implemented:

- the technical capability and requirements of REFCLs to prevent bushfire ignition are now better understood
- the bushfire loss consequence of each location in the state is now estimated with a high degree of confidence

- the reduction in likelihood of ignition from a particular technology option has been identified through interrogation of historic fault data
- the costs of replacing powerlines with different technologies, and in different areas, have been determined through contractual engagement with electricity distributors.

These are discussed below.

Technical capability and requirements of REFCLs

As discussed in section 2.6.3, a REFCL (refer Figure 5) is a relatively recent advance on an old technology that is able to reduce the fault current almost instantaneously when phase to earth faults occur. A REFCL is installed in a ZSS and will reduce the fault current when phase to earth faults occur on polyphase powerlines that are supplied by that ZSS.

Figure 5 **Example of a REFCL, installed at Kilmore South ZSS, May 2015**

Source: Department of Economic Development, Jobs, Transport and Resources

In 2013 the PBSP established a REFCL trial to rigorously test REFCL technology on a real network with the following objectives:

- determine whether REFCL technology is effective in reducing fire starts from electric arcs in powerline faults on a real polyphase 22kV network
- determine the optimum operational settings for REFCLs to reduce fire starts initiated by electric arcs in powerline faults.

The trial aimed to quantify the powerline fire risk reduction benefits of REFCL technology in high fire risk areas of Victoria under worst case fire risk conditions. This includes the relative benefits of different REFCL variants.

Following 12 months of planning and preparation, a field test facility was designed and built near Frankston Victoria and a comprehensive research program of 259 tests, including 118 ignition tests under rigorously controlled conditions, was carried out during the first half of 2014 on the only Australian public electricity distribution network protected by a REFCL.

The specific findings of the research program are set out in Box 1.

Since the 2014 Frankston South trial, the PBSP has commissioned further research into optimising REFCL operation in actual Victorian networks. Specifically:

- **Springvale ZSS**. This site was used to best understand bushfire ignition processes of various types of vegetation commonly found below or near Victorian high voltage powerlines when they come in contact with a powerline (that is, which are most likely to cause a bushfire) and identify 'worst case' species for further testing of powerline protection technologies. The corresponding fault signature (a pattern of current variation unique to each species of vegetation) is also being determined and a reference database created. This information will inform future network operators, allowing for rapid response to those faults most likely to cause a bushfire.
- **Kilmore South ZSS**. This site is being used to determine the full optimisation of REFCL technology for introduction on the Victorian electricity distribution network. It will determine the comparative bushfire risk reduction benefits of different REFCL devices. It will also undertake REFCL-controlled vegetation fault tests on the worst risk vegetation species identified in the 2014 PBSP Vegetation Fault Signature test program (Springvale) and incorporate testing of Lo-Sag™ covered carbon core conductor samples. Testing at Kilmore South ZSS is scheduled to conclude at the end of 2015. Of the four design enhancements that were identified during the research program[29], three have been incorporated into the new REFCL that is currently being tested at Kilmore South.

[29] Refer to point 8 in Box 1.

Box 1 **Findings from the Department's research program with a REFCL**

1. **In worst case fire conditions, 'wire on ground' powerline faults on networks with traditional non-REFCL protection create an inherent risk of fire.** There is a very low threshold level of current into soil above which ignition is close to 100 per cent probable in today's non-REFCL networks.
2. **Existing non-REFCL Sensitive Earth Fault (SEF) protection schemes have the potential to prevent some fires.** However, they cannot eliminate the majority of fire risk from 'wire on ground' powerline faults. Other over-current earth fault protection schemes have limited if any, potential to cut fire risk.
3. **REFCLs dramatically reduce energy release into the environment from 'wire on ground' powerline faults**. They collapse the voltage on the fallen conductor to reduce fault current, reduce arc power and bring about faster arc self-extinction. Tests with and without a REFCL vividly demonstrate this dramatic reduction of arc energy.
4. **REFCLs can detect and respond to 'wire on ground' powerline faults that traditional non-REFCL network protection cannot 'see'**. For supply reliability and security purposes, traditional SEF protection is usually set to detect nine amps of fault current in rural networks. REFCLs detect two amps and tests demonstrated detection of less than one amp.
5. **REFCLs can significantly reduce fire risk for a wide range of 'wire on ground' powerline faults.** By detecting earth faults that traditional protection systems cannot 'see' and by dramatically reducing energy released into the local environment when earth faults occur, REFCLs reduce the chance of ignition across a wide range of earth faults.
6. **There are some 'wire on ground' powerline earth faults where today's REFCL products may not prevent ignition**. High current faults may result in bounce ignition before a REFCL has time to reduce the fault current. The reduction in residual fault current may not be sufficient to completely remove the risk of slower ground ignition.
7. **Though both REFCL variants reduce fire risk, [Ground Fault Neutralisers] GFNs offer superior fire risk reduction benefits compared to [Arc Suppression Coils] ASCs.** Test results indicate GFNs reduce bounce ignition risk more than ASCs. The residual current with an ASC is higher than with a GFN. However, today's GFN performs fault-confirmation and faulted feeder identification tests a few seconds after the fault and these tests require current flow that can sometimes be sufficient for ignition.
8. **REFCL designs can be improved to further reduce fire risk.** Four specific REFCL design improvement opportunities were identified that in total have the potential to eliminate fire risk from 'wire on ground' faults in worst case conditions. These opportunities apply more to GFNs than ASCs. They are:
   a) Increased fault detection sensitivity with increased tolerance for network imbalance
   b) Faster residual current compensation
   c) More accurate residual current compensation
   d) Fast reliable fault-confirmation and identification of the faulted-feeder.
9. **REFCLs offer benefits to public safety.** REFCLs quickly reduce the voltage on a fallen conductor and can potentially transform high voltage electrocution risk of irreversible serious internal and external burns, to low voltage electrocution risk of reversible injury that is responsive to immediate first aid, especially [cardio pulmonary resuscitation] CPR. A GFN has the potential to reduce voltage on a fallen conductor to levels where even low voltage electrocution risk is low.
10. **REFCLs offer benefits to supply reliability**. Improved supply reliability is a major motivator of utilities' adoption of REFCLs around the world. Experience at Frankston South supports published studies that show substantial improvements in reliability indices such as [the minutes off supply] SAIDI and [the frequency of momentary interruptions] MAIFI following REFCL installation.

Source: Marxsen Consulting, *REFCL Trial: Ignition Tests*, 4 August 2014, pages 8-9

Quantification of bushfire consequence

The PBSP used Phoenix RapidFire (a fire characteristic mapping model developed by Dr Kevin Tolhurst and colleagues at the Bushfire Cooperative Research Centre) to model fire behaviour and loss consequence, drawing on a range of relevant data inputs (fuels, weather, topography, fire suppression levels, assets and their values, and scenario conditions). This is the same model originally used by the Taskforce.

The Phoenix RapidFire model for 2014/15 produced an estimate of the number of houses that would be lost to a fire starting at each of 27,860 ignition points and assuming particular environmental and weather conditions prevail.

Each ignition point represents the estimate of fire loss for a grid cell measuring 2km x 2km. Ignition points within 1 km of a high voltage powerline were retained for inclusion in the final mapping.

The key assumptions underpinning the model are:

- Ash Wednesday weather conditions apply
- wind patterns recorded by an automatic weather station at Melbourne Airport in 1983 were applied state-wide
- a Forest Fire Danger Index (FFDI) of 140 is reached
- a first attack suppression effort has been applied so that easily suppressed fires, because of slow starts or easy access, were suppressed in the model
- fires were ignited once the calculated FFDI exceeded 23 – this had the effect of fires starting earlier at lower elevations than in higher elevations.

The analysis of bushfire risk is based on the potential loss of houses – other assets such as bridges, powerlines, telecommunication facilities, public buildings and other potential assets and values potentially impacted by bushfire were not considered.

In some instances, a data point will land on a location with fire characteristics which are not genuinely indicative of the surrounding terrain. Examples include farm dams or roads located in forested country. If read uncritically, such data anomalies would lead decision-makers to conclude fire risk was low for a given area, when in reality it is high (or vice versa).

To eliminate such anomalies, the PBSP has employed a geospatial information technique known as kriging. In brief, kriging increases or decreases the value of a given data point, based on the values of surrounding data points. This addresses the risk of an anomalous data point informing a decision about where (or where not) to deploy network safety assets.

The PBSP has determined that a 5km distance most appropriately eliminates data anomalies in the bushfire consequence modelling. The results of this modelling are shown in Figure 3.

Quantification of bushfire likelihood reduction

The PBSP engaged CSIRO to quantify the reduction in the likelihood of ignition from various technology options. The CSIRO estimates these likelihood reductions using its *Future Assets Model* (FAM).

The FAM estimates the performance of electricity distribution system technology options relative to what is presently installed on much of the distribution network. This is done by:

- identifying each potential type of fault
- using historic data (2006-2013) to quantify how many faults of each type have occurred

- identifying which types of fault a given technology can address
- estimating the percentage of that fault the technology can prevent from causing ignition.

The likelihood computations of the FAM are then combined with the geographically specific consequence information to identify the total risk reduction benefit of deploying a given technology option at that location. This is done at the level of individual power pole, and is expressed using the metric of “contribution to state-wide powerline bushfire risk reduction”. This forms the building blocks of all bushfire risk reduction estimates employed by the PBSP, and this RIS.

CSIRO’s modelling indicates that installing a REFCL, following the replacement of powerlines through the PRF, reduces the likelihood of bushfires starting by a polyphase powerline connected to a ZSS by between 48 and 60 per cent. CSIRO’s figure takes into account that:

- the REFCL will not prevent a polyphase powerline supplied by the ZSS starting a bushfire when a phase to phase fault occurs
- the REFCL will not prevent a polyphase powerline supplied by the ZSS starting a bushfire when a phase to earth fault occurs under all circumstances[30].

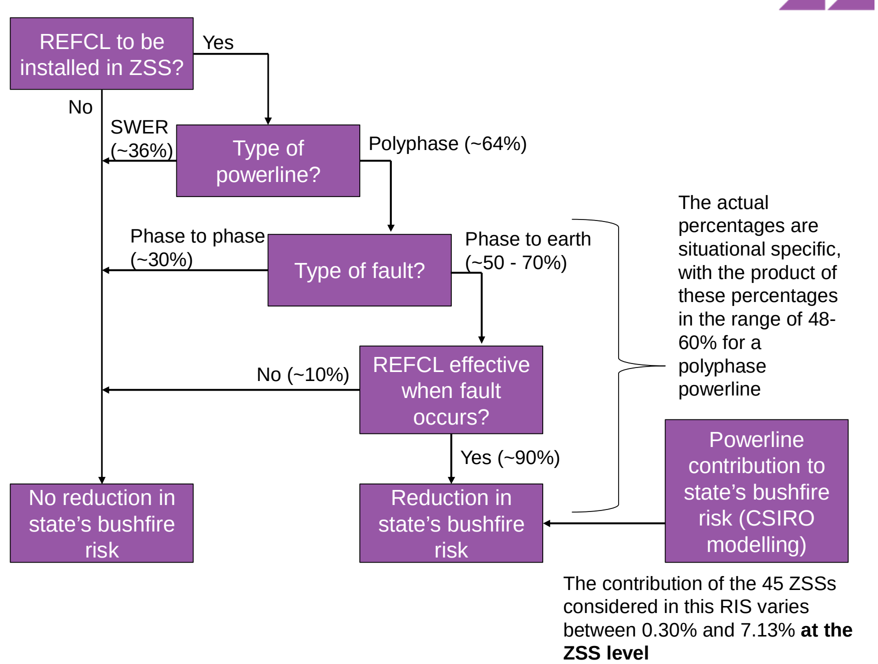
The reduction in bushfire risk at the ZSS level was estimated by CSIRO to be between 36 per cent and 55 per cent, based on the reduction in the likelihood of bushfires starting by a polyphase powerline connected to a ZSS, and the proportion of powerlines supplied by the ZSS being polyphase powerlines rather than SWER powerlines.

Figure 6 illustrates how the reduction in the bushfire risk is estimated for a powerline supplied by a ZSS when a REFCL is installed, with indicative percentages provided. These percentages are highly situational dependent.

The reduction in the bushfire risk at the ZSS level is the aggregate of the bushfire risk reductions for each of the powerlines supplied by that ZSS.

30 For example, when a high current fault occurs.

Figure 6 **Bushfire risk reduction for a powerline supplied by a ZSS with a REFCL installed**



Costs of powerline replacement

The PRF had, as of December 2014, completed 20 powerline replacement projects. These projects relied on delivery by the two rural electricity distribution businesses (AusNet Services and Powercor) who will be involved in regulated powerline replacement as discussed in this RIS. Consequently the cost information provided through these projects is regarded as highly indicative of future costs.

The costs for the 20 powerline replacement projects is summarised below in Table 7.

Table 7 **Costs for replacing powerlines under the Powerline Replacement Fund**

	Unit capital cost (per km)
Average of all projects	$321,840
By region	
▪ Dandenongs	$406,350
▪ Warburton	$890,716
▪ Otways	$258,414
By technology	
▪ Insulated conductor – 22kV	$406,350
▪ Undergrounding – 22kV	$842,005
▪ Undergrounding – SWER	$256,669

Note: The undergrounding of SWER

Source: Department of Economic Development, Jobs, Transport and Resources

In addition, the PBSP has entered into discussions with manufacturers of alternative conductor technologies (covered carbon core conductor) and conducted a Victorian field trial. The manufacturer has indicated that the cost of the conductor is $20,000 per km and that it could be available within the near term (i.e. within the period of time covered by these regulations). Based on estimates of powerline replacement developed by the Taskforce, the fully installed cost for replacing SWER powerlines with covered carbon core conductor is around $145,000 per kilometre and for replacing polyphase powerlines is around $195,000 per kilometre.

3.1.4 Response by the electricity distributors

The electricity distributors are proceeding to replace a small proportion of powerlines under the Victorian Government's Powerline Replacement Fund (PRF) and to install new generation ACRs on SWER powerlines. Notwithstanding, Powercor has 647 old style SWER ACRs and 417 "slow blow" boric acid fuses in the lower consequence bushfire risk areas still to be replaced.

Despite the capability of REFCLs to reduce the likelihood that polyphase powerlines will start bushfires, AusNet Services and Powercor have only committed to trial a couple of REFCLs each in their respective electricity distribution areas. Given their lack of experience with the new technology, and the risks associated with using unproven technology on a live network supplying customers, they are not prepared to commit to further installations until the trials have been successfully concluded.

Through their trials, they are seeking reassurance that the technical challenges associated with the installation of a REFCL in a ZSS can be addressed. These technical challenges include:

1. **Network compatibility**. With a REFCL operational, the high voltage system has a floating earth rather than a solid earth. For the earth fault protection to operate, all earths on the same high voltage system as the REFCL will need to have a floating earth, including capacitor banks, embedded networks and other ZSSs tied to that ZSS. This will require the replacement of some existing protection devices and additional protection devices.
2. **Network hardening**. When a REFCL operates, the voltage on the healthy phases will increase. Some equipment will need to be replaced to be able to withstand the increased voltages expected, but is currently unclear which equipment will need to be replaced with a number of different approaches currently being adopted in other jurisdictions.

3. **Network balancing**. The operation of the REFCL will be most effective where the three phases are balanced with respect to load and capacitive current. Some rebalancing may be required to optimise the operation of the REFCL. Through the Kilmore South trial, a lower cost approach to network balancing has been identified.
4. **Fault identification and reliability**. The REFCL is very sensitive and will detect faults that other protection devices do not, for example, cracked insulators. The number of faults detected is likely to increase and it may be difficult to identify where those faults have occurred.
5. **Changes of work practices**. The installation of a REFCL is a fundamental change in the way in which the network is protected and controlled. It will require changes to operational procedures, and training and change management of staff.

As a result of these technical challenges, the cost of the REFCL itself (estimated to be approximately $600,000 - $800,000) can be small relative to the cost of the associated ancillary works that may be required[31]. The cost associated with the ancillary works will vary considerably for each ZSS based on the individual circumstances. The Taskforce estimated the total costs to be in a range from around $1 million per ZSS to around $9 million per ZSS, depending on the amount of ancillary work required.

As discussed above, the electricity distributors are currently not prepared to commit to the installation of additional REFCLs until they have had the opportunity to trial REFCLs on their own networks.

For example, in its current annual Bushfire Mitigation Plan, AusNet Services states that:

> … a key driver for establishing a trial to research and develop REFCL technology within AusNet Services' network is to determine the suitability and effectiveness of this technology as a means of mitigating the risk of fire ignition associated with faults on complex rural distribution networks.

Powercor makes no reference to REFCLs in its Bushfire Mitigation Plan for the period 2014 to 2019, but is actively participating in the trial of a REFCL at AusNet Services' Kilmore South ZSS, and has proposed to trial two REFCLs during the 2016-20 period – one at Gisborne ZSS and one at Woodend ZSS.

Electricity distributors are required to revise their ESMSs, which incorporate their Bushfire Mitigation Plans, when the developments in technical knowledge make it appropriate to revise them. The electricity distributors consider that further developments in their technical knowledge of REFCLs are required before they initiate a revision to their Bushfire Mitigation Plans.

The ESV may request that the electricity distributors revise their ESMSs to include REFCLs. However, until all trials are concluded, the electricity distributors are most likely to submit that the technical knowledge is not sufficiently developed to include REFCLs in their ESMSs at this stage.

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

3.1.5 Further action required to reduce the likelihood that powerlines start bushfires

The information provided in sections 2 and 3.1 can be summarised as follows:

- The threat of powerlines starting bushfires arises from faults on the electricity supply system.
- The barriers to bushfire starts are technology, maintenance and operations.
- The majority of bushfires started by the electricity supply system on high fire danger days are started by faults on the poles and wires.
  - The majority of these bushfires are started by polyphase powerlines rather than SWER lines.
  - The majority of powerline faults on polyphase powerlines are phase to earth faults rather than phase to phase faults.
- When faults occur on fire ban days, powerlines can start bushfires very quickly. The higher the fault current, the higher the likelihood of a powerline starting a bushfire. (The likelihood is a function of the fault current squared and time.)
- The consequence of a powerline starting a bushfire varies across the state, with the likelihood of loss of property higher for bushfires starting in high consequence bushfire risk areas.
  - Electricity distributors can impact the likelihood of a powerline starting a bushfire but the consequence of a bushfire, once started, is outside their control.
  - If the likelihood of a powerline starting a bushfire in a higher consequence bushfire risk area is reduced, the reduction in consequence is likely to be greater than if the likelihood of a powerline starting a bushfire in a low consequence bushfire risk area is reduced.
- The likelihood and consequence of a powerline starting a bushfire is more significant on days of higher fire danger, when the moisture content of vegetation and combustible material near powerlines is lower.

A number of actions have been undertaken since the 2009 Black Saturday bushfires:

- The Government has committed funding to replace the most dangerous powerlines and powerline replacement has commenced.
- The electricity distributors have been installing new generation ACRs on SWER powerlines to reduce the likelihood that SWER powerlines start bushfires. However, Powercor has not yet installed them on SWER powerlines in the lower consequence bushfire risk areas.
- Further trials have been undertaken by the Department and the electricity distributors to provide greater assurance that the installation of REFCLs will reduce the likelihood of polyphase powerlines starting bushfires.

For the reasons set out below in section 3.3, the electricity distributors have not committed to the installation of REFCLs to reduce the likelihood that polyphase powerlines start bushfires, other than a small number of trial installations.

The objectives of the proposed regulations, as set out in section 4, are to address the market failures and reduce the risk to the public of powerlines starting bushfires.

3.2 Costs related to bushfires

This section considers:

- the incidence of bushfire, in section 3.2.1
- the costs associated with the Black Saturday bushfires, in section 3.2.2
- the expected costs associated with bushfires, in section 3.2.3
- the expected costs of bushfires started by powerlines, in section 3.2.4.

As the proposed regulations amend the Electricity Safety (Bushfire Mitigation) Regulations 2013, the information provided in this section is based on the costs provided in the February 2013 RIS for those regulations[32].

3.2.1 Incidence of bushfires

The Royal Commission summarised the incidence of major bushfires in Victoria from February 1851 to February 2007, as recorded in the Emergency Management Australia Disasters Database, in its final report[33]. The Royal Commission noted that[34]:

> Fifty-two significant bushfires have been recorded in Victoria since 1851, two-thirds of them in the past 60 years. Of the two-thirds, those that occurred on Black Friday (1939) and Ash Wednesday (1983) are the two most commonly compared with the fires of 7 February 2009.

Table 8 provides key statistics taken from the Royal Commission's summary. It shows that Victoria has historically suffered an average of one major bushfire every three years and that an average of 2.5 people per year are killed by bushfire. More than 77 buildings are lost per year on average, while more than 83,000ha of land is burned.

Table 8 **Incidence and consequences of major fires in Victoria 1851 – 2007 – summary statistics[35]**

Statistic	Total (1851 – 2007)	Annual average
Number of fires	52	0.33
Total fatalities	391	2.5
Buildings lost	More than 12,000	More than 77
Area burnt	More than 13 million ha	More than 83,000 ha

Source: Prepared by Jaguar Consulting for Energy Safe Victoria, *Regulatory Impact Statement, Electricity Safety (Bushfire Mitigation) Regulations 2013,* February 2013, Table 3.1

These estimates do not include the Black Saturday fires. Adding those fires clearly increases these totals and averages significantly.

For example, a total of 391 people had been killed by major bushfires in the 156 years prior to Black Saturday. Given that a further 173 people were killed on Black Saturday, the total over Victoria's history rises to 564 and the annual average to 3.6. Similarly, adding the 11 major fires occurring on Black Saturday to the 52 fires identified as

32 Prepared by Jaguar Consulting for Energy Safe Victoria, *Regulatory Impact Statement, Electricity Safety (Bushfire Mitigation) Regulations 2013,* February 2013, pages 22-27

33 2009 Victorian Bushfires Royal Commission, *Final Report: Volume I, The Fires and Fire Related Deaths*, July 2010, Appendix C

34 2009 Victorian Bushfires Royal Commission, *Final Report: Volume I, The Fires and Fire Related Deaths*, July 2010, page 2. The 1939 fires including fires resulted in 71 fatalities and 1.5-2.0 million hectares burnt; the Ash Wednesday fires resulted in 47 fatalities and 210,000 hectares burnt and the Black Saturday fires resulted in 173 fatalities and 365,000 hectares burnt

35 Note that estimates are not available for all of the reported types of loss for all of the bushfires reported by the Commission. Hence, the totals and averages reported in this table necessarily constitute under-estimates.

having occurred in Victoria since 1851 raises the average number of fires per annum to 0.41, equivalent to one major fire every 2.5 years.

3.2.2 Costs associated with the Black Saturday bushfires

The costs of bushfires were documented extensively by the Royal Commission.

Table 9 provides the Royal Commission's estimate of the January and February 2009 Victorian bushfires. These costs include loss of life, serious injuries and substantial property damage. They also include the cost of fire suppression efforts and the costs of providing emergency assistance.

Table 9 **Estimated major economic costs of Victoria's January – February 2009 bushfires, by cost item**

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

The Commission's estimate of the total cost of the Black Saturday fires was approximately $4.4 billion in 2009 dollars or $5.0 billion in 2014 dollars[36]. As the Commission inquired into 15 fires, this suggests that the average cost of each major fire was of the order of $330 million.

Even these estimates arguably understate the true costs involved since, while estimates of the statistical value of the lives lost were included, the Commission did not seek to estimate injury costs. A subsequent analysis found that "most victims of the Victorian bushfires either died or survived with minor injuries"[37]. However, that statement does not account for the impact of grief and psychological trauma, nor could that be costed in dollar terms.

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[36] The CPI for the weighted average of 8 capital cities was 92.9 in June 2009 and 105.9 in June 2014, as per the Australian Bureau of Statistics Catalogue 6401.0, Table 3.

[37] Peter A Cameron, Biswadev Mitra, Mark Fitzgerald, Carlos D Scheinkestel, Andrew Stripp, Chris Batey, Louiise Niggemeyer, Melinda Truesdale, Paul Holman, Rishi Mehra, Jason Wasiak and Heather Cleland, *Black Saturday: the immediate impact of the February 2009 bushfires in Victoria, Australia,* Medical Journal of Australia, Vol. 191 (1): 11-16, 2009

Fires ignited by electricity asset failures were responsible for a very large proportion of these costs. For example, it was reported that 70 per cent of the 173 deaths due to the Black Saturday fires resulted from fires ignited by electricity asset failures. However, this figure excludes the fatalities from the Murrindindi fire[38]. Including the Murrindindi fire as a fire ignited by electricity asset failures, the proportion of fatalities increases to 93 per cent.

Evidence to the Royal Commission also indicated that major fatal fires had been ignited due to electricity asset failures in 1969, 1977 and 1983[39].

3.2.3 Expected cost of bushfires

As noted above, the average cost of each fire that broke out on Black Saturday was in the order of $330 million. Similarly, the bushfires occurring in Canberra in 2003 were estimated to have a cost of $340 million, while the Ash Wednesday fires of 1983 were estimated to cost around $450 million (all in 2014 dollars).

Research conducted by the Bureau of Transport and Regional Economics (BTRE) in 2001[40] provides a broader database on the costs of bushfires. This research, which considered the costs associated with a wide range of natural disasters occurring across Australia over a period of more than three decades (1967 - 1999) costing more than $10 million, found that:

> The costs ($2.5 billion) associated with bushfires represent a relatively small proportion (7.1 per cent) of the total disaster costs. However, as discussed later in this chapter, bushfires are the most hazardous type of disaster in terms of deaths and injuries.

Bushfire was found to be the fourth most frequent natural disaster.

The BTRE's estimate of the cost of bushfire in Australia over this period can be considered to be an under-estimate of the true costs of bushfires for two main reasons.

First, BTRE notes that it is not clear that the database it uses to generate these estimates includes the cost of forestry losses, which constituted a major part of the value of the losses in a number of recent fires including those of Ash Wednesday (1983) and those in Canberra (2003).

Second, the BTRE found that $1.4 billion of the $2.5 billion cost comprised the value of fatalities and injuries based on a Value of a Statistical Life (VSL) of $1.3 million[41] and the cost of a serious injury of $317,000. By contrast, the Australian Government's Office of Best Practice Regulation currently recommends a VSL, based on the Willingness to Pay (WTP) methodology, of $4.2 million[42]. This suggests that the value of deaths and injuries over the period was $4.5 billion in 2014 dollars.

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38 AusNet Services made a $300 million settlement in relation to the Murrindindi bushfire.

39 Evidence of Tim Tobin SC. See: *70% of deaths from power line failure: lawyer*. The Age, 10 September 2009

40 Bureau of Transport and Regional Economics, *Economic Costs of Natural Disasters in Australia,* Report No. 103, 2001

41 The BTRE's figure for a serious injury was $317,000 or 0.24 times the value for a fatality. This compares to the valuation of a serious injury being typically 0.2 times for a fracture, 0.3 times for an amputation and 0.75 times for severe depression based on a global and Dutch study of disability weights as reported in Marlies E.A. Stouthard, Marie-Louise Essink-Bot, Gouke J. Bonsel, Jan J. Barendregt, Pieter G. N. Kramers, Harry PA van de Water, Louise J. Gunning-Schepers, Paul J. van der Maas, *Disability Weights for Diseases in the Netherlands*, 1997

42 Australian Government, Office of Best Practice Regulation, *Best Practice Regulation Guidance, Value of Statistical Life*, December 2014, page 1

The remaining $1.1 billion of costs (i.e. those not related to fatalities and injuries) identified in the BTRE paper was $1.7 billion in 2014 dollars[43].

This implies that the best estimate of the costs of bushfires in Australia in the period studied by the BTRE is $6.3 billion in 2014 dollars, or $195 million per annum. As noted above, this adjusted figure still potentially excludes the value of forestry losses.

The BTRE paper identified 22 bushfires over the relevant period that had caused damage in excess of $10 million in value. Given the total cost of these fires of $6.3 billion (in 2014 dollars), this implies an average cost per fire of $284 million. This is consistent with the figures cited above in respect of the Black Saturday fires, the Ash Wednesday fires and the Canberra fires of 2003.

The BTRE study estimated that the average annual cost to Victoria of bushfires in the years between 1967 and 1999 was $32.4 million. However, as demonstrated above, adjusting the national figures presented by BTRE for this period to account for the current recommended VSL and updating the remaining costs for CPI raises the BTRE estimates by a factor of 2.5. Applying this multiple to the estimated costs for Victoria over the period gives a likely average annual historical cost of bushfires in Victoria of $81 million.

Recent research suggesting that the incidence of extreme weather conditions – including those that are conducive to bushfire – is increasing, also suggests that the future cost of bushfires is likely to be substantially greater than the historical cost.

For example, the UN Inter-Governmental Panel on Climate Change reported in 2014 that "it is likely that the frequency of heat waves has increased in large parts of Europe, Asia and Australia"[44] and that there is a high likelihood that an increase in wildfires in Australia can be attributed to climate change[45]. In addition, there is a high level of confidence of a greater likelihood of injury and death due to more intense heat waves and fires[46].

The New South Wales Government, in a 2010 review of the expected impacts of climate change on natural hazards profiles, similarly concluded that[47]:

> The frequency of very high or extreme fire-risk days is projected to increase in the Riverina Murray and across New South Wales. Increases in temperature, evaporation and high-risk fire days are likely to influence fire frequency and intensity across the region, and the fire season is likely to be extended.

The Royal Commission also identified that the risks associated with bushfire are likely to increase with the impact of climate change.[48]

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43 The CPI for the weighted average of 8 capital cities was 67.4 in June 1998 and 105.9 in June 2014, as per the Australian Bureau of Statistics Catalogue 6401.0, Table 3.

44 Intergovernmental Panel on Climate Change, *Climate Change 2014, Synthesis Report, Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)], page 53

45 Ibid, pages 50 and 51

46 Ibid, page 69

47 NSW Government. Department of Environment, Climate Change and Water, *Impacts of Climate Change on Natural Hazards Profile Riverina Murray Region,* 2010, page 8

48 2009 Victorian Bushfires Royal Commission, *Final Report: Summary,* July 2010, page 1

3.2.4 Cost of fires due to electricity assets

As suggested above, there is considerable uncertainty as to the overall contribution of electricity assets to the costs imposed by bushfires. While the Royal Commission found that only around 1.5 per cent of all bushfire ignitions are due to this cause, it noted that such ignitions were most likely to occur in extreme conditions in which bushfires are most likely to have disastrous consequences.

This observation has two important implications. First, the contribution of electricity assets to the overall cost of bushfires is inevitably far higher than this figure (1.5 per cent of ignitions) would imply. Second, the contribution of electricity assets to the cost of major bushfires is significantly greater than their contribution to the costs of all bushfires.

The Royal Commission found that around 70 per cent of the Black Saturday fatalities were due to fires caused by electricity assets (or 93 per cent including the Murrindindi bushfire), while around half of the major fatal bushfires of 1969, 1977 and 1983 had been ignited due to electricity asset failures[49].

Moreover, the Royal Commission argued that the ageing nature of Victoria's electricity assets meant that their contribution to fire ignition, and hence bushfire costs, would increase in the future in the absence of policy action. This factor must also be weighed in determining the base case against which the potential benefits of the proposed regulations are to be considered.

It must also be noted that the above estimates of the expected annual cost of bushfires relates *solely* to major bushfires (defined as those causing losses valued in exceed of $10 million, using the conservative BTRE methodology). Thus, the likely proportion of these costs attributable to failures in electricity assets is, as noted above, higher than that applicable to bushfires as a whole.

Given the combination of the above factors, particularly the observation that 50 per cent of major fires occurring during the last three catastrophic bushfire outbreaks in Victoria (those of 1977, 1983 and 2009) were caused by electricity assets, an indicative estimate of the proportion of major bushfire costs likely to be attributable to electricity asset failures in the future, in the absence of specific policy action, of around 50 per cent is considered reasonable.

As noted above, the average annual costs of major bushfires in Victoria are estimated to be in the order of $81 million, based on BTRE's study over the 1967-1999 period. If electricity asset failures are responsible for 50 per cent of this total, the cost of fires caused by electricity assets could be of the order of $40.5 million per annum on average.

There is no known study that is equivalent to the BTRE study for the period since 2000. However, the figure can be updated based on the costs associated with the Black Saturday bushfires.

The estimated total cost of the Black Saturday bushfires, as set out in Table 9, is $4.4 billion in 2009 dollars or $5.0 billion in 2014 dollars. The bushfires started by electricity assets resulted in 93 per cent of the fatalities, 86 per cent of the houses lost and 76 per cent of the area burnt. By allocating each cost item in Table 9 to electricity assets on the basis of whether the costs are most likely driven by fatalities, houses burnt or areas burnt (or a combination of all three), the proportion of the costs associated with

49 2009 Victorian Bushfires Royal Commission, *Final Report: Volume II, Fire Preparation, Response and Recovery*, July 2010, Chapter 4

the Black Saturday bushfires that is attributable to electricity related fire starts is estimated to be 84 per cent or $4.2 billion.

If it is assumed that major bushfires occur every 25 years and only this bushfire is considered within the 2000-34 period, the average annual cost of fires caused by electricity assets is $119 million. The weighted average annual cost of fires caused by electricity assets over the 1967-2034 period is therefore assumed to be $81.0 million. For the purposes of this analysis, this has been rounded to $80 million.

As the sample of major bushfires is relatively small, and the magnitude of costs associated with bushfires is a function of the response to the bushfire rather than the cause of the fire start, it is not possible to allocate this cost based on the type of powerline and how the fire started.

There is the widely discussed probability that changing weather patterns will increase the incidence and severity of bushfires[50]. To the extent that this occurs, the expected future cost of bushfires will increase, leading to a proportionate increase in the expected cost of bushfires due to failures in electricity system assets.

3.3 Market and regulatory failures

In the absence of the market and regulatory failures discussed in this section, and the misalignment of risks between the electricity distributors and the Government, as discussed in section 3.4, the electricity distributors would be more likely to:

- install REFCLs in the highest consequence bushfire risk areas on a more timely basis to reduce the likelihood that polyphase powerlines start bushfires
- install new generation SWER ACRs to reduce the likelihood that SWER powerlines start bushfires
- put powerlines in the most dangerous areas of the state underground or insulate the conductors.

However, a number of market and regulatory failures affect the likelihood that electricity distributors will take these actions to reduce the likelihood that powerlines start bushfires. The main market and regulatory failures are the public good nature of the benefits of reducing bushfire risks; and the way distributors, as natural monopolies, are regulated. These market and regulatory failures are discussed in more detail in the following sections.

3.3.1 Public good

The benefits from improved powerline bushfire safety have the characteristics of a public good. That is, the benefits are non-rival (one person benefiting from improved safety does not decrease anyone else's benefit) and non-excludable (it is not possible to prevent someone from benefiting from the improvement in safety). This means that the benefits of improved bushfire safety are not limited to a particular electricity distributor and its customers.

There are five electricity distributors that operate in Victoria. The area in which each electricity distributor operates is illustrated in Figure 2. A bushfire that is ignited by powerlines in one electricity distribution area may move into a different electricity distribution area. As a result, a bushfire that is avoided in one electricity distribution

50 See for example the references cited in section 3.2.3

area may have a benefit for Victorians that would have been in the path of the bushfire but do not reside in that electricity distribution area.

The major economic costs that were incurred as a result of Victoria's January-February 2009 bushfires, as estimated by the Royal Commission, are set out in Table 9. Of these costs:

- approximately 32 per cent of the costs will be incurred by those in the bushfire affected areas[51]
- approximately 68 per cent of the costs will be incurred by Victorians more broadly[52]
- a very small proportion (less than 2 per cent) of the costs will be incurred by the electricity distributors themselves.

The electricity distributors were sued in relation to the Black Saturday bushfires that were caused by powerlines.[53] However, the settlements are paid either through insurance or there is an expectation that the costs will be passed through to their electricity customers.[54] As a result, the electricity distributors' owners do not necessarily bear the costs associated with their powerlines starting bushfires.

Because the full benefits of improving powerline bushfire safety do not accrue directly to the electricity distributors, the incentives for improving powerline bushfire safety are weak. In the absence of additional incentives for making this investment, distributors may not invest to the level considered appropriate by the Government to improve powerline bushfire safety.

3.3.2 Regulated natural monopolies

Electricity distribution businesses are natural monopolies due to the high fixed costs of building an electricity distribution network. Accordingly, as discussed in section 2.8.1, electricity distributors are subject to economic regulation by the AER.

The AER is responsible for determining the revenues that distributors can recover from their customers. In determining the revenue, the AER assesses an electricity distributor's forecast capital expenditure on an ex ante basis and must accept the capital expenditure forecast by an electricity distributor where the costs meet the capital expenditure criteria. That is, it accepts the forecast where the costs[55]:

- are efficient
- would be incurred by a prudent operator
- are required to meet a realistic expectation of the demand forecast and cost inputs.

The investment required to improve powerline bushfire safety would only meet the capital expenditure criteria where there is a net benefit to the electricity distributor (and thereby its customers) or there is a legislative or regulatory obligation to make that investment.

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51 Assumes that the costs associated with loss and damage to public infrastructure, valuation of lives lost and timber costs will be paid for by those in bushfire areas. As some or all of the costs associated with repairing public infrastructure may be paid for by a wider group, this may overstate the proportion of costs incurred by those in bushfire areas.

52 Assumes that the costs associated with fighting fires, payment of insurance claims, the Victorian Bushfire Recovery and Reconstruction Authority, asset damage incurred by Telstra and Melbourne Water, and the Royal Commission will be paid for by Victorians more broadly.

53 For example, refer http://www.abc.net.au/news/2014-07-15/black-saturday-bushfire-survivors-secure-record-payout/5597062

54 http://www.asx.com.au/asxpdf/20141223/pdf/42vp8mspj44j8v.pdf

55 National Electricity Rules, clause 6.5.7(c)

As discussed above, the benefits from improved powerline bushfire safety have the characteristics of a public good and so there may not be a net benefit to the electricity distributor from the investment required to improve powerline bushfire safety.

Service-based incentive mechanisms

The revenue determination also includes service-based incentive mechanisms to ensure that the incentive to reduce costs is balanced by an incentive to maintain or improve service.

A service incentive scheme (or S-factor scheme) was originally incorporated into the Victoria electricity distributors' revenue determinations in 2001. Since 2006, the S-factor scheme has provided an incentive to improve **average** reliability where it is efficient to do so based on the value that customers place on reliability. Electricity distributors are rewarded when the average reliability improves and are penalised when the average reliability deteriorates.

Where there is not a legislative or regulatory obligation to improve reliability, any investment to improve the reliability of the electricity distribution network is funded through the S-factor scheme. In this way, customers only pay for reliability improvements when they are delivered rather than in anticipation of reliability improvements that may not be delivered.

The Royal Commission raised concerns that the S-factor scheme biases investment in reliability improvements towards areas of high population, rather than to areas of the network where there is a high bushfire risk.

> The Australian Energy Regulator's Mr Chris Pattas, General Manager of the Network Regulation South Branch, agreed that a distribution business might target reliability in high-density areas because if it misses reliability targets in those areas it will be penalised more heavily than it would be for missing targets in low-density areas. The areas of highest risk of bushfire are, however, areas of low-density population, and Mr Pattas could not point to any incentive for a distribution business to focus on reliability in low-density areas. Similarly, Mr Fearon of Energy Safe Victoria stated that the 'current generation' of incentive arrangements go to average performance and that SWER lines are low-priority reliability targets.[56]

Following the Black Saturday bushfires, the Victorian Government introduced an F-factor scheme into the economic regulatory framework. Under the F-factor, the electricity distributors are rewarded if the number of fires started by powerlines decreases and are penalised if the number of fires started by powerlines increases. While the S-factor scheme is based on average reliability and is therefore skewed towards "high density areas", the F-factor scheme is based on the absolute number of fires and is therefore skewed towards areas where the likelihood of fires starting is higher.

However, the F-factor scheme is relatively weak, with the penalties and rewards payable based on $25,000 per fire when the number of fires started increases or decreases. The incentive rate was set at a relatively low level because the number of fires started can vary significantly from year to year based on weather conditions. There is the potential for windfall gains or losses for the electricity distributors if the target is not set appropriately and there is a sustained period of benign or severe weather conditions. The potential for windfall gains and losses are mitigated through a low incentive rate.

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56 2009 Victorian Bushfires Royal Commission, *Final Report, Volume II: Fire Preparation, Response and Recovery*, July 2010, page 157

The annual target under the F-factor scheme is currently 870 fires per year[57]. The actual number of fires started in 2012, 2013 and 2014 was 638, 925 and 974, respectively. This resulted in a net payment by customers to the electricity distributors of $5.8 million in 2012 and net payments by the electricity distributors to customers of $1.4 million in 2013 and $2.6 million in 2014. This will only incentivise relatively low cost investment to reduce the number of fires started in areas where there is a concentration of fires starting.

Incentive to improve powerline safety under the economic regulatory regime

Under the existing economic regulatory regime, in the absence of a specific obligation to improve powerline bushfire safety in the highest consequence bushfire risk areas, the electricity distributors are only incentivised to improve powerline bushfire safety where there is a net benefit to do so. This is more likely to occur in more populous areas where the investment to improve bushfire safety also improves reliability. However, there is no assurance that the investment will be targeted to the highest consequence bushfire risk areas.

3.4 Reduction in public risk

The technologies that are available to improve powerline bushfire safety are discussed in section 3.1.2. As discussed in that section, recent analysis by the CSIRO for the Department would indicate that the likelihood of powerlines starting bushfires will reduce by:

- between 98 and 99 per cent by putting lines underground
- between 96 and 98 per cent by insulating overhead powerlines
- between 48 and 60 per cent for polyphase powerlines only connected to a ZSS with a REFCL installed
- between 35 and 40 per cent on SWER powerlines only by installing new generation SWER ACRs and with a change in operation of the ACRs.

As discussed in sections 3.1 and 3.2.4, while the proportion of bushfires that are started by powerlines is generally low, bushfires started by powerlines are most likely to occur in extreme conditions in which bushfires are most likely to have disastrous consequences, as occurred in 1969, 1977, 1983 and 2009. The risk to the public will reduce if the likelihood that powerlines start bushfires is reduced, particularly on high fire ban days.

The technology options that reduce the likelihood of powerlines starting bushfires may also manage public risk in two other ways:

- by reducing the likelihood of shocks and electrocution
- by improving the reliability of supply on high fire risk days.

Reducing the likelihood of powerlines starting bushfires

The Government is committed to reducing the public risk associated with powerlines starting bushfires and therefore supported the Taskforce's recommendations for the electricity distributors to install REFCLs and new generation SWER ACRs, and to replace powerlines in the most dangerous areas of the state.

[57] Energy Safe Victoria, *Safety Performance Report on Victorian Electricity Networks 2013*, July 2014, page 23

If there was an alignment of risk between the Government and the electricity distributors, the electricity distributors would include the installation of REFCLs and new generation SWER ACRs in their Bushfire Mitigation Plans that are required to be submitted to the energy safety regulator as part of their Electricity Safety Management Schemes. Similarly, the Bushfire Mitigation Plans would also require that powerlines in the most dangerous areas of the state be put underground or insulated.

However, under the current economic and safety regulatory regime, the electricity distributors are required to implement the "lowest cost technically acceptable" solution to mitigate their bushfire risk. The electricity distributors' and Government's views are not aligned as to whether the installation of REFCLs and new generation SWER ACRs and putting powerlines underground or insulating them in the most dangerous areas of the state are the lowest cost technically acceptable solutions to improving bushfire safety.

While the Government considers the risk associated with polyphase powerlines starting bushfires outweighs the technical risk associated with the installation of REFCLs, the electricity distributors consider the technical risk associated with REFCLs is currently too high to proceed installing them on a widespread basis until their technology trials are complete. Until these trials are complete, they do not consider REFCLs to be "technically acceptable".

Similarly, while the Government considers the risk associated with powerlines starting bushfires outweighs the cost associated with putting powerlines underground or insulating them in the most dangerous areas of the state, the electricity distributors consider the cost is too high to provide assurance that they are able to recover their costs through the regulatory framework.

To a lesser extent, while the Government considers the risk associated with SWER powerlines starting bushfires outweighs the cost associated with installing new generation SWER ACRs in the lower consequence bushfire risk areas, Powercor is concerned that the cost will be too high to ensure that they are able to recover their costs through the regulatory framework in the absence of a regulatory obligation.

Reducing the likelihood of shocks and electrocution

Where powerlines are put underground or are insulated, there is a reduced safety risk of contact with live overhead wires, and thus a reduced likelihood of shocks and electrocutions from the powerlines. This benefit from putting powerlines underground is not clear cut because fault currents can also be much greater than with bare overhead wire, leading to safety issues if underground cables are inadvertently dug up.

As identified by the recent ignition testing of a REFCL, REFCLs will also reduce the risk of shocks and electrocution.

> REFCLs quickly reduce the voltage on a fallen conductor and can potentially transform high voltage electrocution risk of irreversible serious internal and external burns, to low voltage electrocution risk of reversible injury that is responsive to immediate first aid, especially CPR. A GFN has the potential to reduce voltage on a fallen conductor to levels where even low voltage electrocution is low.[58]

Improving the reliability of supply on high fire risk days

Communities are reliant on a power supply, particularly the welfare of vulnerable members of the community, including the very young, elderly and the sick who may be

[58] Marxsen Consulting, *REFCL Trial: Ignition Tests*, 4 August 2014, page 9

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 2009[59]:

> 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.

In a submission to the Taskforce, the Victorian Farmers Federation raised concerns regarding the impact of a loss of electricity supply on the welfare of animals[60]:

> ... 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.

A reliable power supply is also required by communities on high risk fire days 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, and for pumps for fuel or water.

In a submission to the Taskforce, the Upper Goulburn Community Radio Inc. identified these risks[61]:

> 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.
>
> …
>
> Many people rely on the internet for emergency information as well along with the many telephones that require mains power for operation as well ….

Where powerlines are put underground or insulated, the number of supply interruptions (particularly transient interruptions) is reduced.

However, this benefit is not clear cut where powerlines are put underground. 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.

REFCLs have traditionally been installed in Europe and New Zealand to improve the reliability of supply. As identified by the recent ignition testing of a REFCL[62]:

> Improved supply reliability is a major motivator of utilities' adoption of REFCLs around the world. Experience at Frankston South supports published studies that show substantial improvements in reliability indices such as [the minutes off supply] SAIDI and [the frequency of momentary interruptions] MAIFI following REFCL installation.

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

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

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

62 Marxsen Consulting, *REFCL Trial: Ignition Tests*, 4 August 2014, page 9

The Taskforce made the following recommendation in response to the Royal Commission's recommendation on the operation of ACRs[63]:

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 area of the area so that at a fault there are:

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

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

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

The Taskforce recognised that these types of changes to the operation of ACRs that are required to minimise bushfire risk can be in conflict with the reliability of supply to customers. The Taskforce identified a number of ways in which the impact of a change in the operation of ACRs on the reliability of supply could be mitigated. The Taskforce recommended that "the electricity distributors act to minimise the potential … to adversely affect customers' reliability of supply"[64].

One of the ways to mitigate the impact of this recommendation on customers' reliability of supply is to replace the old style SWER ACRs with new generation SWER ACRs. The new generation SWER ACRs enable the electricity distributor to change the operation of the SWER ACRs remotely so that the changed operation occurs for the minimum time necessary.

63 Powerline Bushfire Safety Taskforce, *Final Report,* 30 September 2011, pages 112-113

64 Powerline Bushfire Safety Taskforce, *Final Report,* 30 September 2011, page 113

4 Objective of the proposed regulations

The objective of the proposed regulations is to reduce the likelihood that electricity distribution powerlines start bushfires. The objective is to reduce the likelihood of powerlines starting bushfires relative to the current likelihood, as regulated by the *Electricity Safety Act 1998* and the associated Electricity Safety (Bushfire Mitigation) Regulations 2013. Achieving this objective will reduce the incidence of bushfire ignition and the associated costs to the community.

The objective is based on the *likelihood* of electricity distribution powerlines starting bushfires rather than the *consequence* of a bushfire starting, as:

- all bushfire starts have the potential to cause a devastating bushfire:
  - the likelihood of a devastating bushfire is higher on days of higher fire danger
  - the likelihood of a devastating bushfire is higher in higher consequence bushfire risk areas than in lower consequence bushfire risk areas
- once started, the consequence of a bushfire is outside the control of the electricity distributor.

To ensure the appropriate balance of a reduction in public risk, cost, and the implementability of the proposed regulations, the proposed regulations will aim for the Victorian electricity distributors to:

- reduce the likelihood of electricity distribution polyphase powerlines starting bushfires in the highest consequence bushfire risk areas by enhancing the network protection for powerlines supplied by designated zone substations within seven years
- reduce the likelihood of SWER powerlines starting bushfires by enhancing network protection on SWER powerlines within five years
- reduce the likelihood of powerlines starting bushfires in the most dangerous areas of the state (declared areas[65]) by requiring powerlines in these areas to be put underground or insulated.

The proposed regulations will specify an outcome to be achieved, rather than prescribe a particular technology option. This enables the electricity distributors to install more cost-effective technology options as these are developed, although there is currently only a limited range of technologies that will meet the proposed regulations.

The objective of the proposed regulation is referenced to the fire loss consequence mapping, which was discussed in section 3.1.2. Recognising that there are diminishing returns as technology options are installed in areas of lower consequence bushfire risk areas, the proposed regulations will target actions in the consequence bushfire risk areas that are appropriate to the cost of those actions. That is, it is proposed that the highest cost actions (putting powerlines underground or insulating conductors) will

[65] A declared area is an area proposed to be declared, under the proposed regulations, by the Emergency Management Commissioner in which powerlines will be required to be put underground or insulated. The areas in question will be declared based on the risk posed to human life and property arising from local characteristics which influence potential bushfire consequence including typical fuel load, slope, ease of access by fire fighting personnel, and ease of egress for inhabitants seeking to escape. The proposed declared areas are listed in Appendix D.

apply only in the most dangerous areas of the state, the installation of REFCLs will apply only in the highest consequence bushfire risk areas, and the installation of lower cost new generation SWER ACRs will apply across the SWER network.

The electricity distributors will be able to choose the sequence in which the proposed regulations are implemented to enhance network protection of polyphase powerlines. It is proposed that the regulations will list the ZSSs that have the greatest potential to reduce bushfire risk with the network protection for polyphase powerlines enhanced. The ZSSs will be assigned a value between one and five, with those ZSSs with the greatest potential to reduce bushfire risk assigned a value of five and those with the lowest potential to reduce bushfire risk assigned a value of one. The proposed regulations will specify an aggregate value to be achieved by the electricity distributors within a period of time.

5 Options to achieve the objective

A range of options have been identified to achieve the objectives as set out in section 4, by reducing the likelihood that electricity distribution powerlines start bushfires.

The options are described in section 5.2. A preliminary assessment of the options is undertaken in section 5.3. The options that will be subject to a more detailed assessment are summarised in section 5.4.

5.1 Base case

All options are considered relative to the base case, which assumes the continuation of the status quo as at July 2015. Under the base case, electricity distributors are complying with their existing ESMSs and BMPs including:

- putting powerlines underground, insulating overhead powerlines and installing REFCLs where there is a net benefit for them to do so
  - AusNet Services has installed a REFCL at Kilmore South ZSS (one transformer only) and is installing a REFCL at Woori Yallock ZSS, and Powercor has proposed to install REFCLs at Gisborne and Woodend during the 2016-20 period[66], to trial the new technology on their distribution networks
- installing new generation ACRs on SWER powerlines in the highest consequence bushfire risk
- installing spreaders on polyphase powerlines to mitigate the likelihood of conductors clashing causing phase to phase faults
- installing armour rods and vibration dampers to reduce the likelihood of conductor failures
- inspecting powerlines within the prescribed timeframes, using enhanced techniques and inspectors that have satisfactorily completed a training course approved by the ESV
- replacing poles, cross arms, sections of powerlines etc, as required
- clearing vegetation from powerlines
- limiting the number of times that ACRs operate on Total Fire Ban and Code Red days.

In addition:

- the Government is funding the replacement of powerlines in the most dangerous areas of the state through the PRF
- it is assumed that the electricity distributors will commence installing REFCLs at the rate of one every two years commencing in 2022, when the current and planned trials are complete.

It has been assumed that the electricity distributors will commence REFCLs in 2022 under the base case on the basis that:

66 Refer Powercor Australia, *2016-2020 Price Reset, Appendix E, Capital expenditure*, April 2015, page 132. In addition, Powercor has proposed that an additional six REFCLs be classified as "contingent projects", refer Powercor Australia, *2016-2020 Price Reset, Appendix L, Managing Uncertainty*, April 2015, page 40.

- the electricity distributors have only proposed to install a couple of trial REFCLs during the 2016-20 regulatory control period
- a decision will be made on the revenue to be earned by the electricity distributors during the 2021-25 regulatory control period around October 2020
- assuming that the revenue determination for the 2021-25 regulatory control period included the expenditure for REFCLs, and the trials demonstrated that the technology was proven, the installation of REFCLs would commence two years later (commencing 2022).

It has been assumed that each electricity distributor would install one REFCL every two years on the basis that:

- There is a two year lead time to install a REFCL. As the installation of one REFCL is completed, the installation of the next REFCL would commence. This allows for any learnings from the installation of one REFCL to be incorporated into the installation of the next REFCL.
- The law of diminishing returns applies such that the most significant benefits are delivered from the first few REFCLs. As shown in Table 11, 50 per cent of the potential reduction in bushfire risk is achieved with the installation of 11 REFCLs, four of which will be installed prior to 2020. From the electricity distributors' perspective, the imperative to install additional REFCLs significantly declines after the first 11.
- A small specialised workforce with the appropriate knowledge and skills would be employed over a longer period of time to install REFCLs, with minimal risk that a shortage of skills leads to increases in cost.

5.2 Identification of options

The options have been identified through a process that considers the existing safety and technical regulatory regime and the existing economic regulatory regime for electricity distributors, the recommendations of the Royal Commission, and the recommendations of the Taskforce.

An overview of the options is provided in Table 10, with more detailed descriptions provided in the following sections. The options are categorised in accordance with the *Victorian Guide to Regulation*.

The options identified in Table 10 are not all mutually exclusive. For example, one of the variants of option 1 could be implemented in conjunction with one of the variants of option 3.

Table 10 **Overview of options**

Type of regulatory option	Ref.	Option description	Impacts polyphase powerlines?	Impacts SWER powerlines?
Extending the coverage of existing regulation	**1**	**Enhance the network protection for polyphase powerlines**		
	1a	Electricity Safety (Bushfire Mitigation) Regulations 2013 – amend these regulations to require that an electricity distributor's bushfire mitigation plan's operation and maintenance plans set out how it would, within **three years**, enhance the network protection for polyphase powerlines to reduce the likelihood of a bushfire starting when a phase to earth fault occurs on a polyphase powerline in the highest consequence bushfire risk area. For the purposes of the analysis of this option, the highest consequence bushfire risk area is the **15 zone substations** listed in Appendix B.1.	Yes	No
	1b	Electricity Safety (Bushfire Mitigation) Regulations 2013 – as per option 1a, but with the highest consequence bushfire risk area defined as the **32 zone substations** listed in Appendix B.2 and action to be taken within **five years**.	Yes	No
	1c	Electricity Safety (Bushfire Mitigation) Regulations 2013 – as per option 1a, but with the highest consequence bushfire risk area defined as the **45 zone substations** listed in Appendix B.3 and action to be taken within **seven years.**	Yes	No
	2	**Enhance the network protection for SWER powerlines**		
	2	Electricity Safety (Bushfire Mitigation) Regulations 2013 – amend these regulations to require that an electricity distributor's bushfire mitigation plan's operation and maintenance plans set out how it would, within five years, enhance the network protection for SWER powerlines to reduce the likelihood of a bushfire starting when faults occur on those SWER powerlines.	No	Yes
	3	**Powerlines in declared areas to be put underground or insulated**		
	3a	Electricity Safety (Bushfire Mitigation) Regulations 2013 – amend these regulations to require that an electricity distributor's bushfire mitigation plan sets out how powerlines in declared areas would, **within seven years**, be put underground or insulated.	Yes	Yes
	3b	Electricity Safety (Bushfire Mitigation) Regulations 2013 – amend these regulations to require that an electricity distributor's bushfire mitigation plan sets out how powerlines **that are replaced** in declared areas would be put underground or insulated.	Yes	Yes
	4	**Put powerlines underground in the highest consequence bushfire risk areas**		
	4a	Electricity Safety (Bushfire Mitigation) Regulations 2013 – amend these regulations to require that an electricity distributor's bushfire mitigation plan includes plans to put **polyphase powerlines** in the highest consequence bushfire risk areas underground, within seven years. For the purposes of this option, the highest consequence bushfire risk area is defined as the 32 zone substations listed in Appendices B 1 and B.2.	Yes	No
	4b	Electricity Safety (Bushfire Mitigation) Regulations 2013 – amend these regulations to require that an electricity distributor's bushfire mitigation plan includes plans to put **SWER powerlines** underground, within five years.	No	Yes
	5	**Insulate powerlines in the highest consequence bushfire risk areas**		
	5a	Electricity Safety (Bushfire Mitigation) Regulations 2013 – amend these regulations to require that an electricity distributor's bushfire mitigation plan includes plans to insulate overhead **polyphase powerlines** in the highest consequence bushfire risk areas, within seven years. For the purposes of this option, the highest consequence bushfire risk area is defined as the 32 zone substations listed in Appendices B.1 and B.2.	Yes	No
	5b	Electricity Safety (Bushfire Mitigation) Regulations 2013 – amend these regulations to require that an electricity distributor's bushfire mitigation plan includes plans to insulate all overhead **SWER powerlines**, within five years.	No	Yes
Strengthen existing market-based instruments	**6**	**Amend the service incentive scheme**		
	6a	Service incentive scheme – amend the service incentive scheme by **increasing the incentive rate** applied for rewarding (penalising) electricity distributors for improvements (deteriorations) in supply reliability.	Yes	Yes
	6b	Service incentive scheme – amend the service incentive scheme by **disaggregating the scheme** into two separate schemes – one that applies only in the highest consequence bushfire risk areas, and one that applies in the rest of the electricity distributor's area.	Yes	Yes
	7	**Amend the F-factor scheme**	Yes	Yes

5.2.1 Option 1: Amend the regulations to enhance the network protection for polyphase powerlines

The first option to meet the objective to reduce the likelihood that powerlines start bushfires is to amend the Electricity Safety (Bushfire Mitigation) Regulations 2013 to require that an electricity distributor's bushfire mitigation plan's operation and maintenance plans set out how it would, within seven years, enhance the network protection for polyphase powerlines to reduce the likelihood of a bushfire starting when a phase to earth fault occurs on a polyphase powerline in the highest consequence bushfire risk areas.

As discussed in section 2.2, section 113A of the Act requires an electricity distributor to prepare a BMP that sets out the company's proposals for mitigation of bushfire in relation to its supply network.

The BMP is required to be prepared in accordance with the Electricity Safety (Bushfire Mitigation) Regulations 2013 and submitted to Energy Safe Victoria for acceptance every five years.

Regulation 7 sets out the prescribed particulars for a Bushfire Mitigation Plan. These are set out in Appendix A.

It is proposed to amend the regulation so that an additional particular is prescribed in Regulation 7 for inclusion in the BMP. It is proposed that the additional particular would be performance-based and would require an electricity distributor's operation and maintenance plans to set out how, in the event of a phase to earth fault on a polyphase powerline, it would substantially reduce the energy produced (the fault current squared times time) so that the likelihood of ignition is close to zero.

The particular has been developed in consultation with experts, based on the REFCL testing program, to minimise the likelihood of ignition following a phase to earth fault, recognising the practical limitations of the REFCL technology. The proposed particular would require:

- voltage on the faulted conductor to be reduced to 250 volts or less within two seconds
- for a resistance value equal to the nominal phase to ground voltage divided by 31.75, the voltage on the faulted conductor to be reduced to:
  - 1,900 volts within 85 milliseconds
  - 750 volts within 500 milliseconds
  - 250 volts within 2.0 seconds
- during diagnostic tests:
  - fault current limited to 0.5 amps
  - thermal energy limited to a maximum current squared times time value of 0.10 amps-squared seconds.

The ignition tests that were conducted by the Taskforce and subsequently conducted by the Department confirm that, if the fault current and voltage is reduced in accordance with this requirement, the likelihood of a bushfire starting is substantially reduced.

At this stage, the only technology that is known to meet this requirement is a REFCL. For the purposes of this RIS, it is assumed that the electricity distributors would install a REFCL at ZSSs to meet this requirement.

For the purposes of the proposed regulations, the highest consequence bushfire risk areas have been identified by reference to:

- Those areas with the highest fire loss consequence as indicated by the CSIRO's fire loss consequence mapping, which is provided in Figure 3.
- Those areas which yield the greatest risk reduction per dollar spent.
- Expert judgement by the Emergency Management Commissioner of those areas where the following factors influence the actual harm to life and property from a bushfire:
  - the capacity of local roads to accommodate sudden surges of traffic from evacuees, or fire crews seeking access
  - proximity of residents to the point of ignition (that is, the further from the ignition point, the more time to evacuate or otherwise prepare for a bushfire)
  - general fire history (that is, observed localised fire behaviour resulting from decades of professional fire management, which does not necessarily conform to modelling outputs).

The law of diminishing returns is evident with the installation of REFCLs – when the REFCLs are ranked from those with the highest contribution to bushfire risk reduction to the lowest contribution to bushfire risk reduction, the additional contribution to bushfire risk reduction decreases significantly as REFCLs are installed, as illustrated in Table 11.

Table 11 **Potential bushfire risk reduction associated with the installation of REFCLs**

Number of ZSSs with REFCLs installed	Proportion of the total bushfire risk reduction that is attributable to REFCLs
11	50%
30	80%
45	90%
93	100%
189	100%

Table 11 indicates that 90 per cent of the bushfire risk reduction potential from installing REFCLs can be achieved by installing REFCLs in just 45 ZSSs, or 24 per cent of the state's ZSSs.

Three options for the definition of the highest consequence bushfire risk areas will be considered in this RIS. Option 1a comprises the 15 ZSSs that are in the top 20 ranked ZSSs when each of the three methodologies identified above are applied. Option 1a does not comprise the top 11 ZSSs ranked only by reference to Table 11 as there is little difference between the bushfire risk associated with ZSS ranked number 11 and the ZSSs ranked numbers 12 and 13. Such an approach also does not take into account the other two methodologies (reduction in bushfire risk per dollar spent and the expert judgement).

Option 1b comprises 32 ZSSs, including the top 30 ranked ZSSs when each of the three methodologies identified above are applied, and ZSSs that are in areas designated as the highest priority for action by the Emergency Management Commissioner. Option 1b does not comprise the top 30 ZSSs ranked only by reference to Table 11 as there is little difference between the bushfire risk associated with ZSS ranked number 30 and the ZSS ranked number 31. It also does not take into account the other two methodologies (reduction in bushfire risk per dollar spent and the expert judgement).

Option 1c comprises the 32 ZSSs in option 1b and an additional 13 ZSSs that:

- are in the top 45 ranked ZSSs when ranked based on the risk reduction per dollar spent
- are within the logistical capability of the electricity distributors to deliver within the timeframe of the proposed regulatory obligation
- yield significant non-bushfire benefits (reliability improvements)
- in aggregate, fall within the overall constraint of consumer willingness to pay. Customer research undertaken by the Taskforce revealed that, on average, participants were prepared to pay 8 per cent more for their electricity to reduce the likelihood of powerlines starting bushfires with no deterioration in the reliability of their electricity supply, and 2 per cent more with a deterioration in the reliability of supply.[67]

For the purposes of the analysis, the definition of the highest consequence bushfire risk area, and the number of ZSSs within the highest consequence bushfire risk area, for each option are summarised in Table 12.

Table 12 **Options to reduce fault current and voltage**

Option	Definition of highest consequence bushfire risk area used for the purposes of the RIS	Number of ZSSs in the highest consequence bushfire risk area
1a	Zone substations listed in Appendix B.1	15
1b	Zone substations listed in Appendix B.2	32
1c	Zone substations listed in Appendix B.3	45

Source: Department of Economic Development, Jobs, Transport and Resources based on CSIRO modelling

5.2.2 Option 2: Amend the regulations to enhance the network protection for SWER powerlines

The second option to meet the objective to reduce the likelihood that powerlines start bushfires is to amend the Electricity Safety (Bushfire Mitigation) Regulations 2013 to require that an electricity distributor's bushfire mitigation plan's operation and maintenance plans set out how it would, within five years, enhance the network protection for SWER powerlines to reduce the likelihood of a bushfire starting when faults occur on those SWER powerlines.

As discussed in section 2.2, section 113A of the Act requires an electricity distributor to prepare a BMP that sets out the company's proposals for mitigation of bushfire in relation to its supply network.

The BMP is required to be prepared in accordance with the Electricity Safety (Bushfire Mitigation) Regulations 2013 and submitted to Energy Safe Victoria for acceptance every five years.

Regulation 7 sets out the prescribed particulars for a Bushfire Mitigation Plan. These are set out in Appendix A.

It is proposed to amend the regulation so that an additional particular is prescribed in Regulation 7 for inclusion in the BMP. It is proposed that the additional particular would

[67] Powerline Bushfire Safety Taskforce, *Final Report*, 30 September 2011, page 51

be performance-based and would require an electricity distributor's operation and maintenance plans to set out how it would, within five years, be able to remotely control devices on SWER powerlines that automatically interrupt and reclose an electric circuit, with a predetermined sequence of opening and reclosing, resetting, hold closed, or lockout.

At this stage, the only technology that is known to meet this requirement is a new generation SWER ACR. For the purposes of this RIS, it is assumed that the electricity distributors would ensure that all existing protection devices on SWER powerlines that do not meet these requirements are replaced with new generation SWER ACRs.

It is noted that all electricity distributors except Powercor have already installed new generation SWER ACRs across their SWER networks and Powercor has already installed new generation SWER ACRs in the highest consequence bushfire risk areas.

5.2.3 Option 3: Amend the regulations to require powerlines in declared areas to be put underground or insulated

The third option to meet the objective to reduce the likelihood that powerlines start bushfires is to amend the Electricity Safety (Bushfire Mitigation) Regulations 2013 to require that an electricity distributor's bushfire mitigation plan sets out how powerlines in declared areas would be put underground or insulated, either within seven years or when they are replaced.

As discussed in section 2.2, section 113A of the Act requires an electricity distributor to prepare a BMP that sets out the company's proposals for mitigation of bushfire in relation to its supply network.

The BMP is required to be prepared in accordance with the Electricity Safety (Bushfire Mitigation) Regulations 2013 and submitted to Energy Safe Victoria for acceptance every five years.

Regulation 7 sets out the prescribed particulars for a Bushfire Mitigation Plan. These are set out in Appendix A.

It is proposed to amend the regulation so that an additional particular is prescribed in Regulation 7 for inclusion in the BMP. The two options that have been identified for the additional particular are that it would require an electricity distributor's BMP to set out how:

- **Option 3a**: the powerlines in declared areas would, within seven years, be put underground or insulated.
- **Option 3b**: powerlines replaced in declared areas would be put underground or insulated.

Under option 3a, the outcome to be achieved is that powerlines in a declared area are to be put underground or insulated within seven years.

Under option 3b, the outcome to be achieved is that, over time, as spans of a powerline in a declared area are replaced, they would be put underground or insulated.

5.2.4 Option 4: Amend the regulations to put powerlines underground

As discussed in section 3.1.2, the likelihood that powerlines start bushfires can be reduced by putting powerlines underground.

As an option to amending the regulations to enhance the network protection for polyphase powerlines, regulation 7 of the Electricity Safety (Bushfire Mitigation) Regulations 2013 could be amended to require the electricity distributors to put polyphase powerlines in the highest consequence bushfire risk areas underground.

As an option to amending the regulations to enhance the network protection for SWER powerlines, regulation 7 of the Electricity Safety (Bushfire Mitigation) Regulations 2013 could be amended to require the electricity distributors to put SWER powerlines underground.

5.2.5 Option 5: Amend the regulations to insulate powerlines

As discussed in section 3.1.2, the likelihood that powerlines start bushfires can also be reduced by insulating overhead powerlines.

As an option to amending the regulations to enhance the network protection for polyphase powerlines, regulation 7 of the Electricity Safety (Bushfire Mitigation) Regulations 2013 could be amended to require the electricity distributors to insulate polyphase overhead powerlines in the highest consequence bushfire risk areas.

As an option to amending the regulations to enhance the network protection for SWER powerlines, regulation 7 of the Electricity Safety (Bushfire Mitigation) Regulations 2013 could be amended to require the electricity distributors to insulate SWER powerlines.

5.2.6 Option 6: Strengthen the service incentive scheme

As discussed in section 3.3.2, the electricity distributors are currently incentivised to reduce the number of powerline faults, which may lead to a fire start, through a service incentive scheme.

However, the service incentive scheme incentivises improvements in *average* reliability across an electricity distributor's area and therefore the electricity distributors are incentivised to reduce the number of powerline faults in high populous areas rather than low populous areas. That is, the service incentive scheme is not targeted to reducing the number of powerline faults based on fire loss consequence.

The service incentive scheme could be strengthened to increase the incentive for electricity distributors to reduce the number of faults in the higher consequence bushfire risk areas by:

- **Option 6a**: increasing the incentive rate applied for rewarding (penalising) electricity distributors for improvements (deteriorations) in supply reliability. The incentive rate that is currently applied is based on the Value of Customer Reliability (VCR) as determined by the Australian Energy Market Operator (AEMO). AEMO's current determination of the VCR is $24.76 per MWh for Victorian residential electricity customers and around $45 per MWh for agricultural, commercial and industrial customers.
- **Option 6b**: disaggregating the service incentive scheme into two separate schemes – one that applies only in the highest consequence bushfire risk areas, and one that applies in the rest of the electricity distributor's area. There is currently one service incentive scheme that applies across each electricity distributor's area.

5.2.7 Option 7: Strengthen the F-factor scheme

As discussed in section 3.3.2, the electricity distributors are currently incentivised to reduce the number of fires started by powerlines through an F-factor scheme. However, the scheme is currently relatively weak and will only incentivise relatively low cost investment to reduce the number of fires started in areas where there is a concentration of fires starting. This may or may not be based on fire loss consequence.

The F-factor scheme could be strengthened to increase the incentive for electricity distributors to reduce the number of fire starts in the higher consequence bushfire risk areas.

5.3 Preliminary assessment of options

The set of available options has been refined using a preliminary analysis. This analysis has considered existing information on the costs of each option and the likely effectiveness of each option. A summary of the outcomes of the preliminary analysis is provided in Table 13, and the analysis is discussed in further detail below.

Table 13 **Preliminary assessment outcomes**

Option	Effectiveness	Cost	Option to be considered further?
Option 1a – amend the regulations to enhance the network protection for polyphase powerlines supplied by the 15 zone substations listed in Appendix B.1	Medium	Medium	Yes
Option 1b – amend the regulations to enhance the network protection for polyphase powerlines supplied by the 32 zone substations listed in Appendix B.2	Medium	Medium	Yes
Option 1c – amend the regulations to enhance the network protection for polyphase powerlines supplied by the 45 zone substations listed in Appendix B.3	Medium	Medium	Yes
Option 2 – amend the regulations to enhance the network protection for SWER powerlines	Medium	Low	Yes
Option 3a – amend the regulations to require powerlines in declared areas to be put underground or insulated	High	High	Yes
Option 3b – amend the regulations to require powerlines in declared areas to be put underground or insulated as the powerlines are replaced	High	High	Yes
Option 4a – amend the regulations to require polyphase powerlines to be put underground	High	Very high	No
Option 4b – amend the regulations to require SWER powerlines to be put underground	High	Very high	No
Option 5a – amend the regulations to require polyphase overhead powerlines to be insulated	High	Very high	No
Option 5b – amend the regulations to require SWER overhead powerlines to be insulated	High	Very high	No
Option 6a – strengthen the service incentive scheme by increasing the incentive rate	Low	Low	No
Option 6b – strengthen the service incentive scheme by disaggregating the scheme	Low	Low	No
Option 7 – strengthen the F-factor scheme by increasing the incentive rate	Low	Low	No

5.3.1 Option 1: Amend the regulations to enhance the network protection for polyphase powerlines

As discussed in section 5.2.1, it is expected that an obligation on electricity distributors to enhance the network protection for polyphase powerlines in the highest consequence bushfire risk areas is most likely to be met in the short term through the installation of REFCLs.

As discussed in section 3.1.2, ignition testing by the Taskforce and the Department has demonstrated that the installation of REFCLs is expected to be an effective way of reducing the bushfire risk from phase to earth faults on polyphase powerlines. Analysis undertaken for the Department by CSIRO indicates that installing a REFCL at a ZSS reduces the likelihood of bushfires starting by powerlines connected to the ZSS by between 48 and 60 per cent.

The cost of installing a REFCL and ancillary equipment was estimated by the Taskforce to be between $1 million and $9 million per ZSS.

On this basis, an obligation to enhance the network protection for polyphase powerlines in the highest consequence bushfire risk areas will be considered further through detailed cost-benefit analysis.

5.3.2 Option 2: Amend the regulations to enhance the network protection for SWER powerlines

As discussed in section 5.2.2, it is expected that an obligation on electricity distributors to enhance the network protection for SWER powerlines would be met by replacing existing older style protection devices with new generation SWER ACRs.

As discussed in section 3.1.2, analysis undertaken for the Department by CSIRO indicates that replacing an existing older style protection devices with a new generation SWER ACR, and changing the operation of the ACR, reduces the likelihood of bushfires starting by SWER powerlines by between 35 and 40 per cent.

The cost of installing a new generation SWER ACR was estimated by the Taskforce to be $30,000 each.

On this basis, an obligation to enhance the network protection for SWER will be considered further through detailed cost-benefit analysis.

5.3.3 Option 3: Amend the regulations to require powerlines in declared areas to be put underground or insulated

As discussed in sections 2.6.1 and 2.6.2, the costs associated with putting powerlines underground or insulating overhead powerlines are very high. However, the incremental cost of putting powerlines underground or insulating them is reduced significantly when this is done when the powerline is due for replacement.

If the replacement of powerlines is targeted to the most dangerous areas of the state only, then this very high cost may be justified on the basis of the very high cost of a single major one in 25 year bushfire (at least $300 million) that may be avoided.

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

These options will therefore be considered further through detailed analysis.

5.3.4 Option 4: Amend the regulations to put powerlines underground

As discussed in section 3.4, putting powerlines underground would reduce the likelihood of bushfires starting by 98 to 99 per cent. Putting powerlines underground is therefore a highly effective way to meet the objective of reducing the likelihood that powerlines start bushfires.

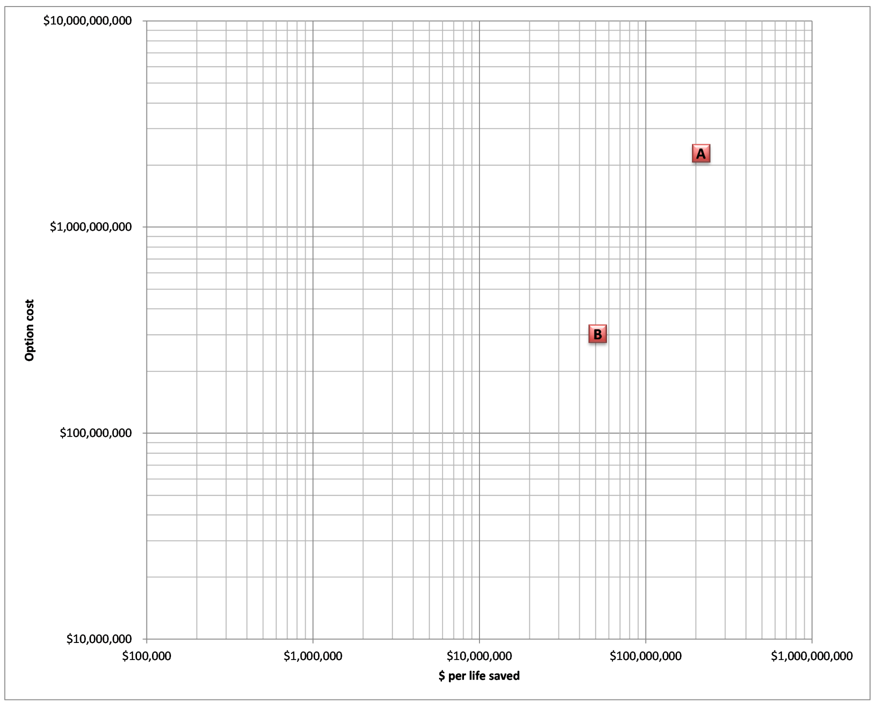
However, the cost of putting powerlines underground is very high.

Putting polyphase powerlines underground in the highest consequence bushfire risk areas

The capital costs and cost per life saved for putting polyphase powerlines underground and installing REFCLs, in the highest consequence bushfire risk areas, are compared in Figure 7.

Figure 7 is based on analysis undertaken by the Taskforce, with the costs updated with information obtained in the process of preparing this RIS. For the purposes of this analysis, the highest consequence bushfire risk areas are those defined as "very high" consequence by the Taskforce. The analysis compares putting 5,715 km of polyphase powerlines underground at a cost of $400,000 per km with the installation of 46 REFCLs at a cost of approximately $6.6 million each.

Figure 7 **Comparison of capital costs and cost per life saved by putting polyphase powerlines underground and installing REFCLs in the highest consequence bushfire risk areas**



Note: A- putting polyphase powerlines underground; B – installing REFCLs
Source: ACIL Allen based on analysis undertaken by the Powerline Bushfire Safety Taskforce

Figure 7 indicates that the capital costs and cost per life saved by putting polyphase powerlines underground in the highest consequence bushfire risk areas are significantly higher than by installing REFCLs.

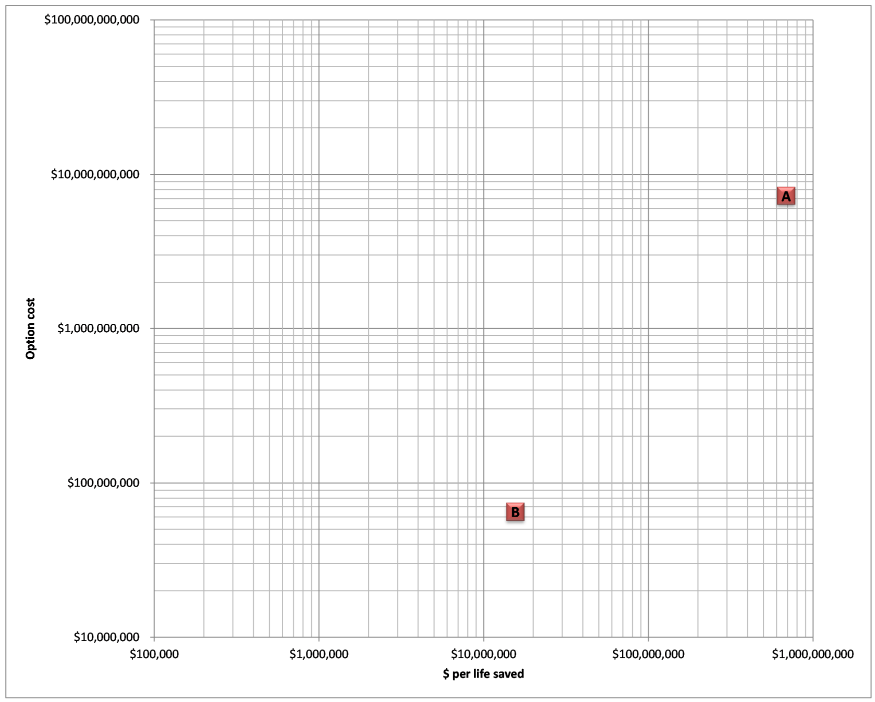
While putting polyphase powerlines underground is more effective at reducing the likelihood of powerlines starting bushfires than installing REFCLs, it is considered to be prohibitively costly given the very high capital cost and cost per life saved.

Putting SWER powerlines underground

The capital costs and cost per life saved for putting SWER powerlines underground and installing new generation SWER ACRs, are compared in Figure 8.

Figure 8 is based on analysis undertaken by the Taskforce, with the costs updated with information obtained in the process of preparing this RIS. The analysis compares putting 28,004 km of polyphase powerlines underground at a cost of $260,000 per km with the installation of 1,300 new generation SWER ACRs at a cost of approximately $50,000 each.

Figure 8 **Comparison of capital costs and cost per life saved by putting SWER powerlines underground and installing new generation SWER ACRs**



Note: A- putting SWER powerlines underground; B – installing new generation SWER ACRs
Source: ACIL Allen based on analysis undertaken by the Powerline Bushfire Safety Taskforce

Figure 8 indicates that the capital costs and cost per life saved by putting SWER powerlines underground are orders of magnitude higher than by installing new generation SWER ACRs.

While putting SWER powerlines underground is more effective at reducing the likelihood of powerlines starting bushfires than installing new generation ACRs, it is considered to be prohibitively costly given the very high capital cost and cost per life saved.

5.3.5 Option 5: Amend the regulations to insulate powerlines

As discussed in section 3.4, insulating overhead powerlines would reduce the likelihood of bushfires starting by 96 to 98 per cent. Insulating overhead powerlines is therefore a highly effective way to meet the objective of reducing the likelihood that powerlines start bushfires.

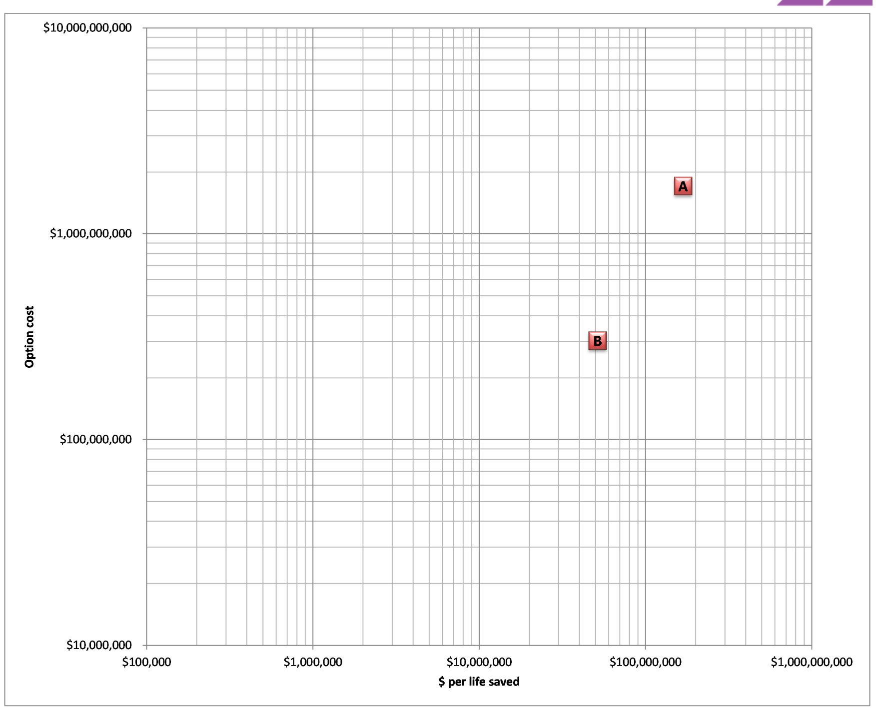
However, the cost of insulating overhead powerlines is very high.

Insulating polyphase powerlines in the highest consequence bushfire risk areas

The capital costs and cost per life saved for insulating polyphase overhead powerlines and installing REFCLs, in the highest consequence bushfire risk areas, are compared in Figure 9.

Figure 9 is based on analysis undertaken by the Taskforce, with the costs updated with information obtained in the process of preparing this RIS. For the purposes of this analysis, the highest consequence bushfire risk areas are those defined as “very high” consequence by the Taskforce. The analysis compares insulating 5,715 km of polyphase powerlines underground at a cost of $300,000 per km with the installation of 46 REFCLs at a cost of approximately $6.6 million each.

Figure 9 **Comparison of capital costs and cost per life saved by insulating polyphase overhead powerlines and installing REFCLs in the highest consequence bushfire risk areas**



Note: A- insulating polyphase overhead powerlines; B – installing REFCLs
Source: ACIL Allen based on analysis undertaken by the Powerline Bushfire Safety Taskforce

Figure 9 indicates that the capital costs and cost per life saved by insulating polyphase overhead powerlines in the highest consequence bushfire risk areas are significantly higher than by installing REFCLs.

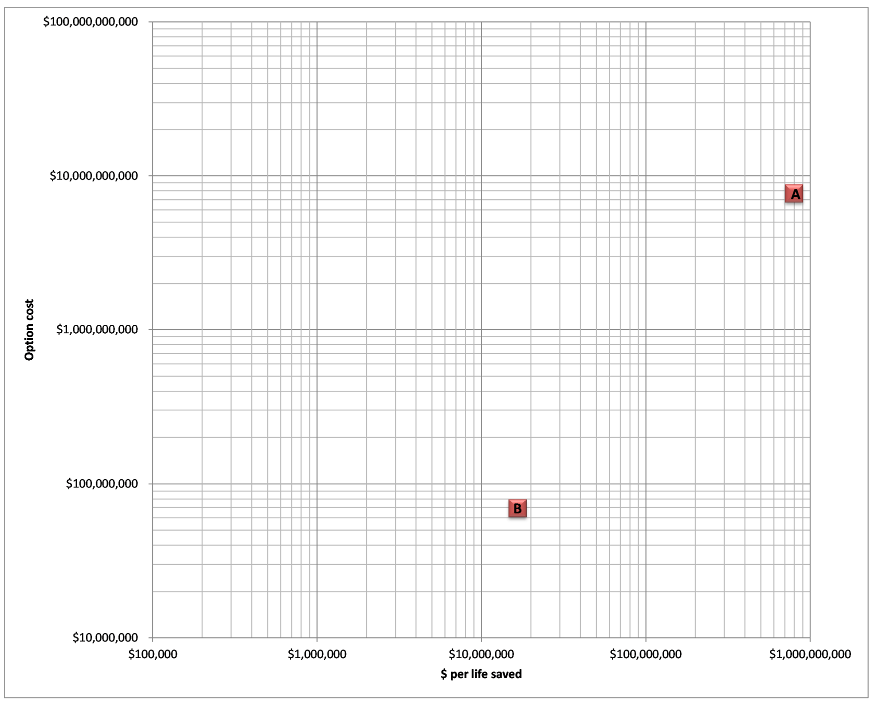
While insulating overhead polyphase powerlines is more effective at reducing the likelihood of polyphase powerlines starting bushfires than installing REFCLs, it is considered to be prohibitively costly given the very high capital cost and cost per life saved.

Insulating SWER powerlines

The capital costs and cost per life saved for insulating SWER overhead powerlines and installing new generation SWER ACRs are compared in Figure 10.

Figure 10 is based on analysis undertaken by the Taskforce, with the costs updated with information obtained in the process of preparing this RIS. The analysis compares putting 28,004 km of polyphase powerlines underground at a cost of $257,000 per km with the installation of 1,300 new generation SWER ACRs at a cost of approximately $50,000 each.

Figure 10 **Comparison of capital costs and cost per life saved by insulating SWER overhead powerlines and installing new generation ACRs**



Note: A- insulating polyphase SWER powerlines; B – installing new generation ACRs
Source: ACIL Allen based on analysis undertaken by the Powerline Bushfire Safety Taskforce

Figure 10 indicates that the capital costs and cost per life saved by insulating SWER overhead powerlines are orders of magnitude higher than by installing new generation SWER ACRs.

While insulating SWER overhead powerlines is more effective at reducing the likelihood of SWER powerlines starting bushfires than installing new generation ACRs, it is considered to be prohibitively costly given the very high capital cost and cost per life saved.

5.3.6 Option 6: Strengthen the service incentive scheme

As discussed in section 3.3.2, the economic regulatory regime that applies to the Victorian electricity distributors includes a service incentive scheme that provides an incentive to improve reliability of supply, where it is efficient to do so, based on the value that customers place on reliability. Investment to improve reliability, which also reduces the likelihood of powerlines starting bushfires, is more likely to occur in highly populous areas rather than in the less populous areas that have a higher fire loss consequence.

There are two options for amending the service incentive scheme so that it may provide a stronger incentive for reducing the likelihood of powerlines starting bushfires:

- **Option 6a**: increasing the incentive rate applied for rewarding (penalising) electricity distributors for improvements (deteriorations) in supply reliability.
- **Option 6b**: disaggregating the service incentive scheme into two separate schemes – one that applies only in the highest consequence bushfire risk areas, and one that applies in the rest of the electricity distributor's area.

The incentive rate for the service incentive scheme is currently based on the value that customers place on reliability as determined by AEMO.[68] The VCR represents customers' willingness to pay for a reliable electricity supply and is determined through a customer survey.

The VCR is a dollar value that customers would pay to avoid minutes off supply.

If the incentive rate for the service incentive scheme is increased, electricity customers will effectively pay more for increases in average reliability than they have indicated they are prepared to pay. This option would distort an otherwise efficient price signal and therefore will not be considered further through detailed cost-benefit analysis.

If a separate service incentive scheme is created in each electricity distribution area to cover the highest consequence bushfire risk areas, the electricity distributors will have an incentive to improve the average reliability in the highest consequence bushfire risk areas based on the incentive rate that applies. A separate service incentive scheme would therefore better target the highest consequence bushfire risk areas.

However, the incentive rate for the separate service incentive scheme would be set based on the value that consumers in that area place on reliability. As the higher consequence bushfire risk areas are generally less populous areas of the electricity distribution area[69], the incentive rate will be lower for the scheme in the higher consequence bushfire risk areas than the incentive rate that applies across the electricity distribution area.

As the incentive rate for the separate service incentive scheme in the highest consequence bushfire risk areas will be lower than that which applies to the whole electricity distribution area, it will not provide sufficient incentive for REFCLs to be installed.

New generation SWER ACRs are already installed in the highest consequence bushfire risk areas. The new generation SWER ACRs that remain to be installed are in the lower consequence bushfire risk areas. This option will have no impact on the

[68] Refer Australian Energy Market Operator, *Value of Customer Reliability – Application Guide; Final Report,* December 2014

[69] The high consequence bushfire risk areas exclude the more populous Melbourne metropolitan and Geelong metropolitan areas.

incentive to install new generation SWER ACRs in the lower consequence bushfire risk areas.

As this option would not be effective in meeting the objective, it will not be considered further through detailed cost-benefit analysis.

5.3.7 Option 7: Strengthen the F-factor scheme

As discussed in section 3.3.2, the economic regulatory regime that applies to the Victorian electricity distributors includes an F-factor scheme that provides an incentive to reduce the number of bushfires started by powerlines, based on a "reward" (or incentive rate) of $25,000 for each fire avoided.

The objectives of the proposed regulations cannot be achieved by the F-factor because the scheme is a relatively weak, broad-based incentive.

The penalty is broad-based in that it is based on the total number of fires started by a distributor's assets over a five year period (rather than the scale or consequences of the fire), and so incentivises distributors to invest in measures across their entire network to avoid fires in areas where ignition due to their assets is most likely (which may not be the areas of their network where the consequences of ignition are most severe).

The incentive is relatively weak because while it is sufficient to incentivise distributors to invest in low-cost measures to avoid fires in general, it is not strong enough to incentivise investment in high-cost measures that reduce the risk of major bushfires.

Furthermore, as reported in the Department of Primary Industry's consultation paper regarding the F-factor, the scheme can result in windfall gains and losses due to factors outside the control of the distributor (source: http://www.energyandresources.vic.gov.au/energy/about/legislation-and-regulation/f-factor-scheme/consultation-paper).

This scheme is therefore not considered to be effective in achieving the objectives of these regulations.

The Government is currently reviewing the F-factor scheme to determine how it could best complement the proposed regulations.

5.4 Options for further consideration

Based on the preliminary assessment of options, the following options will be considered in more detail in the following sections:

- **Option 1: Enhance the network protection for polyphase powerlines**
  - Option 1a: Amend the Electricity Safety (Bushfire Mitigation) Regulations 2013 regulations to require that an electricity distributor's bushfire mitigation plan's operation and maintenance plans set out how it would, within **three years**, enhance the network protection for polyphase powerlines to reduce the likelihood of a bushfire starting when a phase to earth fault occurs on a polyphase powerline in the highest consequence bushfire risk area. For the purposes of this option, the highest consequence bushfire risk area is the **15 zone substations** listed in Appendix B.1.
  - Option 1b: As per option 1a, but with the highest consequence bushfire risk area defined as the **32 zone substations** listed in Appendix B.2 and action to be taken within **five years**.

  - Option 1c: As per option 1a, but with the highest consequence bushfire risk area defined as the **45 zone substations** listed in Appendix B.3 and action to be taken within **seven years**.
- **Option 2**: **Enhance the network protection for SWER powerlines**
  - Amend the Electricity Safety (Bushfire Mitigation) Regulations 2013 to require that an electricity distributor's bushfire mitigation plan's operation and maintenance plans set out how it would, within five years, enhance the network protection for SWER powerlines to reduce the likelihood of a bushfire starting when faults occur on those SWER powerlines.
- **Option 3: Powerlines in declared areas to be put underground or insulated**
  - Option 3a: Amend the Electricity Safety (Bushfire Mitigation) Regulations 2013 to require that an electricity distributor's bushfire mitigation plan sets out how powerlines in declared areas would, within seven years, be put underground or insulated.
  - Option 3b: Amend the Electricity Safety (Bushfire Mitigation) Regulations 2013 to require that an electricity distributor's bushfire mitigation plan sets out how powerlines that are replaced in declared areas would be put underground or insulated.

6 Assessment of the options

The options to be subject to a more detailed cost benefit analysis were identified in chapter 5. These options are assessed in this chapter:

- the sources of data for the cost benefit analyses are discussed in section 6.1
- the proposed regulations to enhance the network protection for polyphase powerlines in the highest consequence bushfire risk areas (option 1) are assessed in section 6.2
- the proposed regulations to enhance the network protection for SWER powerlines (option 2) are assessed in section 6.3
- the proposed regulations to require powerlines in declared areas to be put underground or insulated (option 3) are assessed in section 6.4.

6.1 Data sources

The analysis of costs and benefits relies on data from a number of sources. These include:

- a data request sent to the four Victorian electricity distributors likely to be affected by the proposed regulations to enhance network protection for polyphase powerlines (option 1): AusNet Services, Powercor, Jemena and United Energy
- an assessment of the reduction in bushfire risk with the installation of a REFCL, new generation SWER ACRs and powerline replacement, by ZSS, undertaken by CSIRO for the Department
- data provided by Powercor on the installation of new generation SWER ACRs in its electricity distribution area
- reports prepared for the Department on the international experience with REFCLs[70], options for modifying surge arresters with REFCLs[71] and the results of ignition testing on a REFCL installed at Frankston South[72]
- reports prepared by the Victorian Bushfire Royal Commission and the Powerline Bushfire Safety Taskforce
- costs for putting powerlines underground and insulating overhead powerlines as revealed to the Department through the Powerline Replacement Fund
- other publicly available information including data from AEMO on the value of customer reliability and the Australian Energy Regulator (AER) on the relative value that customers place on the frequency and duration of sustained interruptions and the frequency of momentary interruptions
- information provided during the stakeholder consultation.

The data and methodology from the first two sources are discussed below.

[70] Connetics, *REFCL International Experience,* January 2015

[71] Swedish Neutral, *GFN Ground Fault Neutralizer, Necessary surge arrester modification when changing neutral treatment from low impedance to GFN grounding, Available options,* January 2015

[72] Marxsen Consulting, *REFCL Trial: Ignition Tests,* 4 August 2014

6.1.1 Electricity distributor data request

ACIL Allen, in conjunction with the Department, developed a data request to be sent to the four electricity distributors likely to be affected by the proposed regulation to enhance network protection for polyphase powerlines (option 1) – AusNet Services, Powercor, Jemena and United Energy[73].

The data request sought to obtain data on both the costs and benefits of the proposed regulations at the ZSS level. It had two sections: the first section asked for general information for each feeder by ZSS; the second asked for estimates of the costs to install a REFCL by ZSS. The following information was gathered:

- General information (by feeder):
  - ZSS, feeder name, feeder length, number of phases on that feeder and voltage
  - reliability data for each year from 2010 to 2014:
    - number of sustained interruptions and per cent phase to phase and phase to earth faults
    - minutes off supply and per cent phase to phase and phase to earth faults
    - number of momentary interruptions – full feeder
    - number of momentary interruptions – part feeder
  - safety information for each year from 2010 to 2014 (HV non SWER feeders only):
    - number of ground fires initiated by phase to earth faults on that feeder
    - number of electric shocks reported on that feeder
    - number of electrocutions on that feeder
  - number of complaints received regarding quality of supply issues on that feeder
  - customer number and energy consumption, including per cent energy usage by residential customers and non-residential customers
  - number of customers connected at 22kV
- REFCL installation cost information (by ZSS):
  - estimated cost of the REFCL
  - ancillary works required, including number and unit cost for each piece of ancillary equipment needing to be replaced
  - degree to which network has been optimised for the installation of the REFCL and ancillary works at the ZSS (scale from 1 – no optimisation; to 5 – full optimisation)
  - estimated year in which the REFCL would be put into service with the proposed regulation
  - annual phasing of costs for installing the REFCL and ancillary equipment
  - depreciation period for REFCL and ancillary equipment
  - avoided costs, including current expected replacement schedule for ancillary equipment
  - estimated maintenance cost for the ZSS with and without the REFCL.

The original data request was provided to the electricity distributors in April 2015 requesting the information to be provided for the ZSSs that the Department assessed,

[73] The one ZSS for which data was provided by United Energy was subsequently removed from the analysis as the bushfire risk for that ZSS was very low relative to other ZSSs in the state.

at that time, were in the highest consequence bushfire risk areas. The first set of completed data requests were provided in May 2015, with a series of follow up questions to clarify the information provided.

Following further analysis by the Department, the list of ZSSs was modified, and information for additional ZSSs was provided in July and August 2015.

6.1.2 Reduction in bushfire fire risk

As discussed in section 3.1.3, CSIRO developed a Future Assets Model (FAM) to quantitatively estimate performance of electricity distribution system technology options, including the installation of REFCLs and new generation SWER ACRs, and the replacement of powerlines, relative to idealised conventional technology options. In this context, performance is measured in terms of the relative rate of detected faults (relative detected fault rate) and the relative rate of potentially fire-starting fires (relative pre-ignition fault rate).

The FAM estimates the relative rate for total faults and a relative rate for pre-ignition faults for every combination of root cause and asset impact for which a fault has been observed on the electricity distribution network since 2006.

The relative rates of faults and pre-ignitions for future technology options are then used to quantitatively estimate:

- the rate of bushfire ignitions for a given technology option in specified installation situations and environmental conditions in the field
- the rates of faults and ignitions for a portfolio of assets of different technology options installed across a region or network, which provides a risk reduction metric.

The FAM outputs a set of relative "pre-ignition" fault rates (that is, the number of potentially fire-starting faults relative to a conventional technology option) for each technology option, root cause and asset impact combination. The calculated values do not vary with situation but are dependent on measures of fire weather (meteorological conditions).

CSIRO also provided the relative fire loss consequence for each ZSS based on state-wide fire loss consequence modelling.[74]

6.2 Analysis of costs and benefits – enhancing network protection for polyphase powerlines (option 1)

The costs associated with the proposed regulations to enhance the network protection for polyphase powerlines in the highest consequence bushfire risk areas (option 1) are discussed in section 6.2.1, the benefits are discussed in section 6.2.2, and the net benefits are discussed in section 6.2.3.

[74] Refer to section 3.1.2 for a discussion on fire loss consequence modelling

6.2.1 Analysis of costs – enhancing network protection for polyphase powerlines (option 1)

The costs associated with the proposed regulations to enhance the network protection for polyphase powerlines in the highest consequence bushfire risk areas (option 1) can be divided into five categories:

- direct cost of installing REFCLs, including network compatibility, hardening and balancing costs
- avoided cost by installing REFCLs, and replacing ancillary equipment, earlier than would otherwise occur
- additional maintenance costs due to the installation of the REFCL
- additional costs incurred by customers that are directly connected to the 22kV system
- administrative and compliance costs.

Each of these costs is discussed in the following sections.

Costs of installing REFCLs, including network compatibility, hardening and balancing

The electricity distributors were requested to provide estimates of the costs for installing REFCLs, including ancillary equipment required, for each of the 45 ZSSs listed in Appendix B.3.

The estimated costs for the REFCL and ancillary equipment varied over a wide range – from $2.2 million to $22.1 million, in the final group of 45 ZSSs modelled. The variation in costs was due to:

- whether the transformers in the ZSS were of the same configuration – in a small number of cases, two REFCLs are required in a ZSS
- the REFCL technology assumed
- the extent to which the load on the ZSS was not balanced
- the extent to which it is expected that existing equipment will need to be replaced
- the extent to which the ZSS design has been optimised for the installation of the REFCL.

A breakdown of the component costs, as revealed by the electricity distributors, is provided in Table 14. The variation in the quantities of components required, and the variation in component costs, leads to the variation in the total cost for the REFCL.

Table 14 **Variation in the estimated cost of a REFCL**

Component	Variation in cost
REFCL, including design, civil works, installation and commissioning	$1.8 million - $3.4 million
Station lightning arresters	0 – 45 @ approx. $1,000 each
Station services transformer	0 – 2 @ approx. $150,000 each
Station services low voltage transfer switch	0 – 1 @ approx. $150,000 each
Capacitor banks	0 – 2 @ approx. $500,000 each
Feeder lightning arresters	0 – 8,224 @ approx. $1,000 each
Conductor phase movement	0 – 85 @ approx. $4,000 each
Switch upgrades	0 – 48 @ approx. $25,000 each
Polyphase ACR upgrades	0 – 18 @ approx. $70,000 each
Three phase regulators	$0 - $375,000
Line capacitors	$0 - $100,000
Line insulators	$0 - $500,000
Distribution transformers	$0 - $3.0 million
Other works	$0 - $7.0 million

Source: Electricity distributors' data requests

When a REFCL is installed, the voltages increase to much higher levels for a short period of time when a fault occurs. The existing equipment may not be able to withstand these higher voltages. A variety of approaches can be adopted to address this issue:

- the equipment is stressed during the commissioning phase and replaced where it fails
- the equipment is replaced over time as it fails
- the equipment is replaced when the REFCL is installed.

In a report to the Department, Connetics advised that[75]:

> Under-rated equipment was found on the Orion network, but their risk model and actual experiences indicate that it is not always necessary or viable to replace this equipment at the time of REFCL installation.

The lowest cost estimates are for ZSSs where much of the equipment is relatively new and can withstand the higher voltage levels, or where the equipment will be replaced if it fails, whether during commissioning or over time. By contrast, AusNet Services and Powercor have assumed that all affected equipment will need to be replaced and as a result the cost estimates provided by them are much higher than those provided by Jemena and United Energy or previously considered.

The detailed design work for most of the ZSSs considered has not been undertaken and estimates have been developed by comparing the circumstances of the ZSS to a reference ZSS. As a result, there has been no optimisation of the ZSSs, and no consideration as to whether existing equipment should be removed or replaced.

For these reasons, ACIL Allen has made one adjustment to the costs as submitted by AusNet Services and Powercor. ACIL Allen has assumed that only one in three lightning arresters will be replaced. The reduction in the number of lightning arresters may result by the distributors adopting one or more of the following approaches:

- only replacing the lightning arresters where they fail, either through stress testing or over time, noting that some lightning arresters may be appropriately rated,

[75] Connetics, *REFCL International Experience,* January 2015, page 1

particularly as the higher voltages may not need to be withstood for a long period of time with the REFCL installed

- rationalising the number of lightning arresters installed
- connecting the lightning arresters in a 'Neptune' formation, where one new lightning arrester is connected in series with three existing lightning arresters.

The resultant reduction in the cost of installing the 45 REFCLs, including ancillary equipment, is set out in Table 15.

Table 15 **Estimated total cost of installing REFCL, including ancillary equipment**

	Estimated cost range	Average	Total
Cost as provided by distributors	$2,190,000 - $22,068,193	$9,214,295	$414,643,286
Cost after ACIL Allen adjustment	$2,190,000 - $15,972,193	$6,593,980	$296,729,086

Source: Distributor data request, ACIL Allen analysis

These costs exclude any overhead costs that would be incurred by the electricity distributor, regardless of whether a REFCL is installed, as these costs are not incremental to the base case.

As a comparison, in its proposal to the Australian Energy Regulator as part of the 2016-20 revenue determination process, Powercor proposed a cost of $10.5 million per REFCL. It should be noted that this cost includes an allocation of overhead costs[76].

It is expected that the costs may reduce over time as the electricity distributors become more familiar with the technology and optimise the design of the network. For example, testing at the Kilmore South ZSS has revealed that there may be a more efficient method for balancing the network than assumed in the cost estimates provided.

Given the uncertainty as to the actual costs that will be incurred, sensitivity analysis has been undertaken, with no reduction to the costs proposed by the electricity distributors, to understand the significance of the cost reduction assumed.

In addition to the estimated costs, distributors also indicated a suggested schedule for the installation of REFCLs, as well as an indication of the distribution of costs prior to installation.

For the purposes of this analysis, the number of REFCLs that have been assumed to be installed in each year for each option, as determined by Department based on the information provided by the electricity distributors, is summarised in Table 16.

[76] Refer Powercor Australia, *2016-2020 Price Reset, Appendix L, Managing Uncertainty*, April 2015, page 40 in which Powercor proposed to install six REFCLs at a total cost of $63 million ($2015).

Table 16 **REFCL installation schedule**

Year	Number of REFCLs installed in each year		
	Option 1a	Option 1b	Option 1c
2016	5	5	5
2017	5	5	5
2018	5	5	5
2019	0	8	8
2020	0	9	9
2021	0	0	6
2022	0	0	7
Total	**15**	**32**	**45**

Source: Department in consultation with the electricity distributors

Table 17 shows how distributors expect to phase the costs of the installation of the REFCLs, including ancillary equipment. AusNet Services and Powercor both propose phasing the costs over two years in most cases, while Jemena proposes to incur the entire cost in the year of installation.

Table 17 **Phasing of costs for installing the REFCL and ancillary equipment**

Distributor	Per cent cost in year prior to REFCL installation	Per cent cost in year of REFCL installation
AusNet Services	40	60
Powercor	20	80
Jemena	0	100

Note: AusNet Services proposes an alternative schedule at Woori Yallock and Wodonga and Tallangatta, with 30 per cent of the cost two years prior to installation; 50 per cent in the year before installation; and 20 per cent in the year of installation.

Source: Distributor data request

Avoided costs

It was assumed that the AusNet Services and Powercor would commence installing REFCLs at the rate of one every two years from 2022, and Jemena would install one REFCL in 2024, following the completion of current and planned trials. It was assumed that the REFCLs would be installed in descending order of the potential to reduce bushfire risk with the REFCL with the highest potential for a reduction in bushfire risk installed first.

The electricity distributors were requested to provide an estimate of when the ancillary equipment would be replaced if the REFCL was not installed.

While AusNet Services provided a detailed schedule identifying a year in which the ancillary equipment would otherwise be replaced, the other electricity distributors did not on the basis that the equipment would be replaced based on condition rather than in a specific year.

It was assumed that the ancillary equipment would be replaced in the year nominated by AusNet Services, or the year in which a REFCL would be installed in the absence of the proposed regulations, whichever occurred first.

The present value of the avoided costs for the ZSSs in Powercor's and Jemena's areas was assumed to be 20 per cent of the present value of the cost for installing the REFCL and ancillary equipment. This was assumed through a conservative consideration of the ratio of AusNet Services' present value of the avoided costs to the present value of the cost for installing the REFCL and ancillary equipment, which ranged from 20 per cent to 47 per cent, with an average of 34 per cent.

Additional maintenance costs

The electricity distributors were requested to provide an estimate of the additional annual maintenance costs that would be incurred for a ZSS with the installation of a REFCL.

The additional annual maintenance costs were provided by AusNet Services and Jemena. The additional annual maintenance costs for ZSSs in Powercor's area were estimated based on the costs submitted by the other electricity distributors. The additional annual maintenance costs that have been included in the analysis are set out in Table 18. The additional annual maintenance costs are not material to the analysis.

Table 18 **Additional maintenance costs estimated to be incurred following the installation of a REFCL**

Distributor	Additional annual maintenance costs, per ZSS
AusNet Services	$6,000
Powercor	$5,000
Jemena	$1,500

Source: Distributor data request; ACIL Allen assumption for Powercor

The additional maintenance costs were assumed to be incurred in each year following the year of installation of the REFCL.

Additional costs incurred by customers connected directly to the 22kV network

When a REFCL is installed, the earth "floats" rather than is "fixed". All equipment installed on the 22kV network must similarly have a "floating" earth, including equipment that is owned by customers that are connected directly to the 22kV network. This may require some equipment in a high voltage customer's substation to be replaced.

The electricity distributors were requested to provide the number of customers that are directly connected to the 22kV network supplied by each ZSS.

There are a total of 92 customers connected directly to the 22kV network across the 45 ZSSs, with the number varying between 0 and 8 per ZSS, and an average of 2.0 direct connect customers per ZSS.

The costs that would be incurred by these customers are not known. For the purposes of this analysis, ACIL Allen has conservatively estimated that the costs incurred by each of these customers will be $100,000 on the basis that surge arresters and voltage transformers may need to be replaced, and that these costs would be incurred in the year that the REFCL is installed.

However, it is noted, that many customers may not need to undertake any works.

Administrative and compliance costs

The electricity distributors and ESV will incur additional costs under the proposed regulations due to the need to update existing Bushfire Mitigation Plans (BMPs). BMPs will need to be updated as the proposed regulations take effect to account for differences in operating procedures when REFCLs are in place.

It is expected that AusNet Services and Powercor will need to submit an amendment to their BMP under all scenarios if the proposed regulations are approved. Jemena will need to submit an additional amendment to their BMP under option 1c if the proposed regulations are approved.

Once the amended BMPs have been approved the schedule for amending and renewing BMPs is assumed to be the same as in the base case.

The costs associated with developing and updating BMPs were estimated in 2013 by Jaguar Consulting in the RIS for the *Electricity Safety (Bushfire Safety) Regulations 2013.* The total cost of an initial BMP was estimated at $10,241 for each distributor and the cost of amendments to an existing BMP was estimated at $4,780. Annual costs to ESV for assessing and approving BMPs was estimated at $33,000.

These estimates were based on cost data provided in September and October 2012. We have inflated the figures using all groups capital city CPI data for September 2012 and March 2015, as provided in Table 19.

Table 19 **Estimated costs for amending the Bushfire Mitigation Plans**

Cost type	$2012	$2015
Cost of initial BMP – per distributor	10,241	10,744
Cost of amendments to BMP – per distributor	4,780	5,015
Cost to ESV of assessing BMP – all BMPs	33,000	34,621

Note: Cost to ESV is for all BMP assessments, not just those that AusNet Services and Powercor are expected to submit.
Source: Jaguar Consulting 2013, ABS Cat. No 6401.0

The total additional administrative and compliance costs under options 1a and 1b are estimated to be $44,651, and under option 1c are estimated to be $49,666. This cost is expected to be an overestimate because the cost to ESV includes the total annual cost to ESV of assessing BMPs.

Modelling the costs for installing a REFCL

The present value of the costs associated with installing a REFCL at each of the ZSSs has been estimated by modelling the costs for installing the REFCL and ancillary equipment, the costs incurred by customers connected directly to the 22kV network, the additional maintenance costs and the administrative and compliance costs less the avoided costs.

The costs have been modelled over a 40 year period, to 2055. This period was selected based on the estimated life of the REFCL and ancillary equipment. The life of the secondary equipment associated with the REFCL has been assumed to be 20 years and the life of the other equipment in excess of 40 years. The model therefore assumes that the secondary equipment associated with the REFCL will be replaced 20 years after installation of the REFCL.

The cost of the secondary equipment has been assumed to be $1,000,000 for Powercor and $1,480,000 (in 2015 dollars) for the other electricity distributors, based on information provided by the electricity distributors.

A discount rate of 4.0 per cent has been used, consistent with the *Victorian Guide to Regulation*.

The electricity distributors have indicated that a REFCL has been installed or will be installed at the following ZSSs, regardless of whether the regulations are amended:

- Gisborne
- Kilmore South (one transformer)
- Woodend
- Woori Yallock.

That is, a REFCL will be installed at these ZSSs in the base case. The costs and benefits associated with these ZSSs have therefore not been included in the modelling.

The estimated present value of the costs for the remaining ZSSs are set out in Table 20.

Table 20 **Estimated present value of costs associated with installing a REFCL for those ZSSs not in the base case**

Zone substation	Present value of costs (2015 dollars)				
	REFCL and ancillary equipment	Additional maintenance costs	Direct connected customers	Avoided costs	Total net costs
Ararat	$4,591,553	$68,954	$0	$0	$4,660,507
Bairnsdale	$8,426,911	$102,106	$0	-$2,067,454	$9,034,475
Ballarat	$10,337,272	$80,814	$683,843	-$2,061,440	$8,597,548
Ballarat South	$10,307,200	$85,088	$266,699	-$8,833,006	-$303,989
Barnawartha	$3,420,558	$92,046	$164,385	-$1,428,938	$6,156,440
Belgrave	$5,000,127	$96,977	$256,441	-$3,747,171	$1,606,374
Benalla	$8,360,893	$87,304	$237,094	-$1,015,299	$4,358,127
Bendigo	$5,076,497	$68,954	$227,975	-$2,568,351	$6,116,941
Bendigo TS	$7,144,691	$85,088	$355,599	-$2,085,552	$1,591,437
Camperdown	$5,517,266	$85,088	$0	-$1,103,453	$4,498,901
Castlemaine	$5,781,873	$94,156	$384,615	-$1,782,290	$7,896,392
Charlton	$7,495,514	$76,705	$82,193	-$1,156,375	$5,104,270
Colac	$8,911,448	$94,156	$673,077	$0	$2,365,466
Coolaroo	$2,264,609	$21,826	$79,031	-$843,229	$3,840,827
Corio	$4,216,146	$72,753	$395,157	-$2,707,576	$4,946,835
Eaglehawk	$7,073,422	$89,533	$739,645	-$1,414,684	$6,487,916
Eltham	$4,627,205	$92,046	$246,578	-$3,082,356	$1,883,473
Ferntree Gully	$4,387,450	$92,046	$164,385	-$2,242,991	$2,400,890
Geelong	$6,044,244	$76,705	$82,193	-$1,208,849	$4,994,292
Hamilton	$6,928,526	$68,954	$75,992	-$1,385,705	$5,687,766
Kalkallo	$5,434,866	$96,977	$0	-$3,897,254	$170,657
Kilmore South (2nd transformer)	$4,609,753	$92,046	$0	-$3,122,370	$2,409,473
Kinglake	$3,960,471	$107,440	$0	-$3,345,417	$1,356,382
Koroit	$5,084,250	$68,954	$227,975	-$1,016,850	$4,364,329
Lang Lang	$5,209,852	$87,304	$79,031	-$5,448,799	$473,697
Lilydale	$5,398,116	$96,977	$427,402	-$1,516,946	$3,859,241
Mansfield	$5,031,290	$96,977	$0	-$1,421,473	$3,979,918
Maryborough	$7,644,616	$89,533	$0	-$3,780,496	$2,165,903
Merbein	$5,328,638	$72,753	$0	-$1,528,923	$6,205,227
Moe	$5,525,582	$92,046	$328,771	-$2,618,543	$2,509,725
Myrtleford	$4,526,572	$96,977	$0	-$3,498,541	$1,125,009
Ringwood North	$4,495,118	$92,046	$0	-$5,578,723	$397,303
Rubicon A	$5,868,586	$107,440	$0	$0	$4,587,164

Zone substation	Present value of costs (2015 dollars)				
	REFCL and ancillary equipment	Additional maintenance costs	Direct connected customers	Avoided costs	Total net costs
Sale	$5,164,267	$82,744	$151,984	-$2,336,741	$3,062,254
Seymour	$9,176,671	$112,987	$192,308	-$11,349,528	-$1,867,562
Stawell	$5,789,487	$68,954	$227,975	-$1,157,897	$4,928,518
Terang	$6,508,513	$72,753	$158,063	-$1,915,794	$4,823,535
Wangaratta	$9,671,560	$102,106	$88,900	-$2,680,512	$3,298,403
Waurn Ponds	$7,853,681	$80,814	$256,441	-$925,059	$3,789,771
Winchelsea	$4,625,297	$89,533	$0	-$12,171,020	-$2,308,454
Wodonga and Tallangatta	$14,267,084	$92,046	$410,964	-$11,249,584	$3,520,509
Wonthaggi	$5,744,186	$82,744	$151,984	-$1,570,736	$6,620,201
Administrative and compliance costs	$49,665				$49,665
Total	**$262,881,526**	**$3,613,452**	**$7,816,701**	**-$122,865,926**	**$151,445,753**

Note: Three ZSSs that are in the base case are not included in this table

Source*:* ACIL Allen

6.2.2 Analysis of benefits – enhancing network protection for polyphase powerlines (option 1)

The benefits associated with the installation of REFCLs that have been quantified in the analysis are:

- an improvement in bushfire risk
- a reduction in the number of minutes that customers are off supply due to electricity interruptions
- a reduction in the number of momentary interruptions (those less than a minute in duration).

Improvement in bushfire risk

The benefit associated with an improvement in bushfire risk with the installation of a REFCL in each ZSS is a function of:

- the estimated cost of bushfires
- the fire loss consequence associated with the ZSS after the replacement of powerlines in the most dangerous areas of the state, as a proportion of the state's fire loss consequence prior to the implementation of any treatments[77]
- the estimated reduction in bushfire risk by installing a REFCL earlier than it would otherwise have been installed.

As discussed in section 3.2.4, the average annual cost of bushfires started by electricity assets is estimated to be $80 million.

The fire loss consequence associated with all ZSSs was provided by CSIRO for four scenarios with different levels of powerline replacement. The analysis has been undertaken based on the level of powerline replacement undertaken to date. Sensitivity analysis has been undertaken using the three other scenarios.

The estimated reduction in bushfire risk by installing a REFCL was provided by CSIRO, for all zone substations other than Kilmore South. The sequence with which

[77] Treatments include the replacement of powerlines, replacement of SWER ACRs and two trial REFCLs.

bushfire reduction activities are undertaken is important in attributing a reduction in bushfire risk. The reduction in bushfire risk associated with installing REFCLs was estimated assuming that some bushfire reduction measures have already been undertaken since Black Saturday and SWER ACRs have been installed.

The reduction in bushfire risk at the ZSS level (as distinct from the likelihood of a polyphase powerline starting a bushfire) was estimated to vary between 36 per cent and 55 per cent based on the proportion of feeders supplied by the ZSS that were polyphase powerlines, the proportion of faults that were phase to earth faults, and the effectiveness of the REFCL in reducing bushfires, and assuming that powerlines have been replaced under the PRF.

The estimated reduction in bushfire risk for Kilmore South was estimated based on:

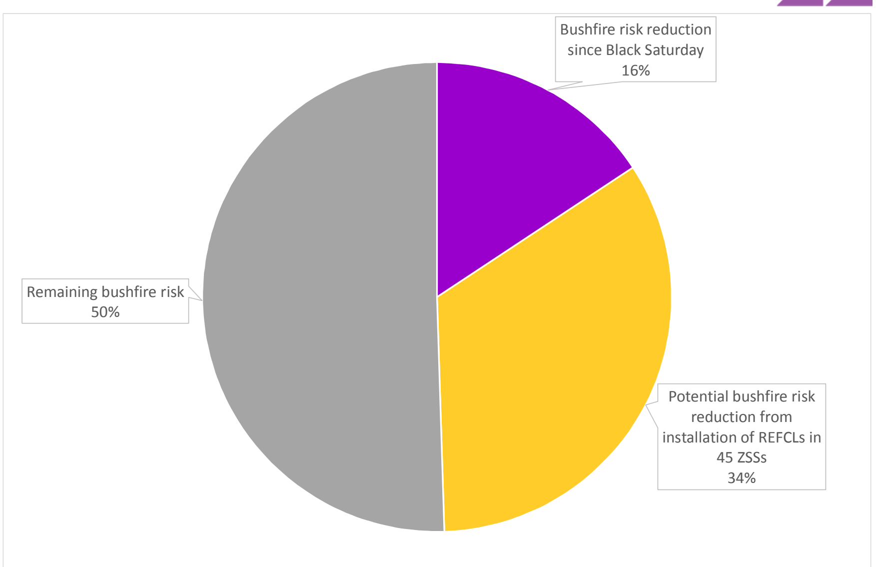
- the proportion of faults on feeders supplied by the second transformer that were phase to earth faults, which was assumed to be 74 per cent
- the estimated proportion of faults for which the REFCL is effective.

It was assumed that the REFCL would be effective for 90 per cent of faults. This is based on a report to the Department from Connetics, which stated that[78]:

> A further independent study by Auckland University … of their REFCL installation found that 91% of all earth faults were compensated successfully.

The estimated contribution of REFCLs to a reduction in the state's bushfire risk is illustrated in Figure 11. While the REFCLs are expected to have a significant impact on the state's bushfire risk, a substantial bushfire risk remains to be addressed by other measures.

Figure 11 **Contribution of REFCLs to a reduction in the state's bushfire risk**



The improvement in bushfire risk was equal to the product of the estimated cost of bushfires, the fire loss consequence associated with the ZSS as a proportion of the

78 Connetics, *REFCL International Experience*, January 2015, page 17

state's fire loss consequence, and the estimated reduction in bushfire risk by installing a REFCL.

The present value of the improvement in bushfire risk was calculated for each ZSS over a 40 year period with a discount rate of 4.0 per cent. The improvement in bushfire risk was assumed to occur in each year following the year in which the REFCL was installed.

The estimated present value of the benefits associated with an improvement in bushfire risk for each ZSS (excluding those in the base case) is set out in Table 21. Table 21 also includes the relative bushfire risk associated with each ZSS, with those ZSSs with the highest bushfire risk prior to the installation of a REFCL having a rating of 5, and those with the lowest bushfire risk prior to the installation of a REFCL having a rating of 1.

Reduction in minutes off supply

The benefit associated with a reduction in the minutes off supply with the installation of a REFCL in each ZSS is a function of:

- the energy consumption by customers that are supplied by each feeder connected to each ZSS
- the value that customers place on reliability
- the proportion of faults on each feeder that are phase to earth faults
- the estimated reduction in minutes off supply when a phase to earth fault occurs
- the period of time that the REFCL is installed when it would otherwise not be installed under the base case.

As part of the data request, the electricity distributors provided the energy consumption for each feeder, by residential and non-residential customers, and the proportion of faults that were phase to earth faults.

As discussed previously, AEMO publishes the value that customers place on reliability VCR. The VCR is used throughout the National Electricity Market for planning and operational purposes. The most recently published VCRs that are applicable to Victoria are provided in Table 22.

Table 21 **Estimated present value of benefits associated with an improvement in bushfire risk with the installation of a REFCL for those ZSSs not in the base case**

Zone substation	Present value of bushfire benefits (2015 dollars)	Bushfire risk associated with ZSS prior to installation of REFCL
Ararat	$4,207,865	1
Ballarat	$11,143,188	4
Ballarat South	$8,927,137	5
Bairnsdale	$5,324,935	4
Bendigo TS	$8,573,239	5
Belgrave	$4,832,866	3
Bendigo	$4,639,681	1
Benalla	$18,944,743	2
Barnawatha	$5,965,781	3
Camperdown	$8,158,104	4
Colac	$14,357,945	5
Castlemaine	$8,854,925	4
Coolaroo	$206,676	1
Corio	$4,123,234	1
Charlton	$1,202,818	2
Eaglehawk	$9,146,586	5
Eltham	$1,815,749	2
Ferntree Gully	$1,688,113	2
Geelong	$10,087,609	4
Hamilton	$6,331,478	2
Kinglake	$5,788,373	4
Kalkallo	$4,920,135	3
Kilmore South (2nd transformer)	$1,825,581	3
Koroit	$6,236,302	2
Lilydale	$5,736,634	3
Lang Lang	$5,563,760	1
Merbein	$5,107,241	1
Moe	$3,969,351	3
Maryborough	$9,640,639	5
Mansfield	$3,379,015	2
Myrtleford	$6,718,600	3
Rubicon A	$3,357,294	4
Ringwood North	$1,841,904	2
Sale	$3,194,547	1
Seymour	$4,944,208	5
Stawell	$4,593,303	1
Terang	$6,197,974	2
Wonthaggi	$5,000,311	1
Winchelsea	$6,703,862	5
Wangaratta	$4,314,874	5
Wodonga and Tallangatta	$5,545,096	3
Waurn Ponds	$6,828,688	4
Total	**$249,940,362**	

Note: Three ZSSs that are in the base case are not included in this table. The bushfire risk associated with the ZSS prior to the installation of the REFCL is a relative scale, with 5 being those ZSSs with the highest bushfire risk and 1 being those ZSSs with the lowest bushfire risk.

Source: ACIL Allen

Table 22 **Value of customer reliability**

Customer segment	VCR ($ per kWh)
Residential	$24.76
Commercial	$44.72
Industrial	$44.06
Agricultural	$47.67

Source: Australian Energy Market Operator, *Value of Customer Reliability – Application Guide, Final Report,* December 2014, page 4

The electricity distributors were not able to differentiate the energy consumption on each feeder by commercial, industrial and agricultural customers. For the purposes of this analysis, we have therefore used a VCR of $24.76 per kWh for residential customer load and $45.00 per kWh for non-residential customer load.

The estimated reduction in the minutes off supply from phase to earth faults was conservatively estimated by ACIL Allen at 30 per cent (that is approximately 21 per cent of total minutes off supply) based on information provided in a recent report to the Department on ignition tests on a REFCL at Frankston South. That report referred to[79]:

- overseas installations of REFCLs that were motivated by supply reliability benefits
- a study by Auckland University of a pilot REFCL installation that reduced the minutes off supply by 62 per cent.

It is recognised that reliability may deteriorate if existing equipment is not replaced at the time of installation of the REFCL, and the number of equipment failures increases. As the estimated costs include most of the costs estimated by the electricity distributors for network hardening, the estimate of reliability benefits has assumed minimal equipment failures from the year following installation of the REFCL.

Reliability may also deteriorate because of the very sensitive setting required under the proposed regulations (0.5 amps during diagnostic tests). The very sensitive setting may result in the detection of a large number of faults that are currently not being detected (for example, a cracked insulator). These types of faults may also be very difficult to detect and therefore, depending on operational practices, supply may not be able to be restored for some time after a fault occurs.

The very sensitive setting may also cause the REFCL to trip a whole feeder when a fuse blows, rather than allow the fuse to isolate the faulted section of the feeder, and thereby causing the supply to more customers to be interrupted.

AusNet Services is in the process of upgrading its distribution feeder automation. It is of the view that reliability improvements should be attributed to the distribution feeder automation, with residual reliability improvements attributed to the installation of the REFCL.

There is currently no operational experience with the REFCL to be able to quantify the deteriorations in reliability that may result. The minutes off supply assumed is therefore conservative – it is approximately one third of the benefits identified from the Auckland University study. Breakeven analysis has been undertaken to understand the reduction in minutes off supply required so that the net benefit, when considering reliability benefits alone, is zero for each electricity distribution area.

[79] Marxsen Consulting, *REFCL Trial: Ignition Tests,* 4 August 2014, page 83

The benefits associated with a reduction in the minutes of supply (B_R) for each feeder supplied by a ZSS is calculated as follows:

$$B_R = \frac{(E_R + E_{NR})}{Mins\ per\ year - Mins\ off\ supply} \times \frac{(VCR_R \times E_R + VCR_{NR} \times E_{NR})}{(E_R + E_{NR})} \times 0.3 \times F_{\emptyset-e} \times Mins\ off\ supply$$

where:

E_R is the energy consumed by residential customers on the feeder

E_{NR} is the energy consumed by non-residential customers on the feeder

Mins per year is the total minutes in the year

Mins off supply is the current minutes off supply on the feeder

VCR_R is the VCR for residential customers

VCR_{NR} is the VCR for non-residential customers

$F_{\Phi\text{-}e}$ is the proportion of faults on the feeder that are phase to earth faults

The benefits associated with a reduction in the minutes off supply are assumed to commence in the year following installation of the REFCL and continue until the REFCL is installed under the base case. The benefits associated with a ZSS are the sum of the benefits associated with each feeder that is supplied by that ZSS.

The present value of a reduction in minutes off supply was calculated for each ZSS over a 40 year period with a discount rate of 4.0 per cent.

Reduction in the number of momentary interruptions

The benefit associated with a reduction in the number of momentary interruptions with the installation of a REFCL in each ZSS is a function of:

- the energy consumption by customers that are supplied by each feeder connected to each ZSS
- the value that customers place on reliability
- the proportion of faults on each feeder that are phase to earth faults
- the value that customers place on the frequency of momentary interruptions relative to minutes off supply
- the period of time that the REFCL is installed when it would otherwise not be installed under the base case.

As discussed above:

- the electricity distributors provided the energy consumption for each feeder, by residential and non-residential customers, and the proportion of faults that were phase to earth faults
- a VCR of $24.76 per kWh has been used for residential customer load and $45.00 per kWh for non-residential customer load.

The AER's Service Target Performance Incentive Scheme (STPIS) provides information on the value that customers place on the frequency of momentary interruptions relative to minutes off supply. The STPIS states that:

- the value that rural customers place on the duration of sustained interruptions relative to the frequency of sustained interruptions is 0.92[80] – this implies that for an interruption of average duration, 48 per cent of the VCR is attributable to the duration of the interruption and 52 per cent is attributable to the frequency of interruptions
- the value that customers place on momentary interruptions is 8 per cent of the value that they place on the frequency of sustained interruptions[81].

Momentary interruptions are, by definition, interruptions of short duration (less than one minute). The minutes off supply measures only include sustained interruptions which are longer than one minute. There is therefore no double counting of the benefits associated with minutes off supply and the frequency of momentary interruptions.

The benefits associated with a reduction in the number of momentary interruptions (B_M) for each feeder supplied by a ZSS is calculated as follows:

$$B_M = \frac{(E_R + E_{NR})}{Mins\ per\ year - Mins\ off\ supply} \times \frac{(VCR_R \times E_R + VCR_{NR} \times E_{NR})}{(E_R + E_{NR})} \times V_f \times V_m \times F_{\emptyset-e} \times \frac{N_f + 0.5 \times N_p}{N_s} Mins\ off\ supply$$

where:

E_R is the energy consumed by residential customers on the feeder

E_{NR} is the energy consumed by non-residential customers on the feeder

Mins per year is the total minutes in the year

Mins off supply is the current minutes off supply on the feeder

VCR_R is the VCR for residential customers

VCR_{NR} is the VCR for non-residential customers

$F_{\Phi-e}$ is the proportion of faults on the feeder that are phase to earth faults

V_f is the proportion of VCR attributable to the frequency of interruptions

V_m is the value of momentary interruptions relative to the frequency of sustained interruptions

N_f is the number of momentary interruptions (full feeder) on the feeder

N_p is the number of momentary interruptions (part feeder) on the feeder

N_s is the number of sustained interruptions on the feeder

The benefits associated with a reduction in the number of momentary interruptions are assumed to commence in the year following installation of the REFCL and continue

80 Australian Energy Regulator, *Electricity distribution network service providers, Service target performance incentive scheme,* November 2009, page 11

81 Australian Energy Regulator, *Electricity distribution network service providers, Service target performance incentive scheme,* November 2009, page 12

until the REFCL is installed under the base case. The benefits associated with a ZSS are the sum of the benefits associated with each feeder that is supplied by that ZSS.

The present value of a reduction in the number of momentary interruptions was calculated for each ZSS over a 40 year period with a discount rate of 4.0 per cent.

The present value of a reduction in the number of momentary interruptions was significantly less than the present value of a reduction in the minutes off supply.

Benefits associated with a reduction in minutes off supply and number of momentary interruptions

The estimated present value of the benefits associated with a reduction in the minutes off supply and a reduction in the number of momentary interruptions for each ZSS (excluding those in the base case) is set out in Table 23.

Table 23 **Estimated present value of benefits associated with a reduction in the minutes off supply and a reduction in the number of momentary interruptions with the installation of a REFCL for those ZSSs not in the base case**

Zone substation	Present value of reliability benefits (2015 dollars)
Ararat	$2,049,107
Ballarat	$8,735,517
Ballarat South	$5,226,437
Bairnsdale	$4,446,100
Bendigo TS	$836,533
Belgrave	$20,014,221
Bendigo	$5,083,775
Benalla	$12,235,816
Barnawatha	$1,740,917
Camperdown	$2,263,243
Colac	$2,371,360
Castlemaine	$2,348,266
Coolaroo	$101,724
Corio	$1,236,144
Charlton	$2,071,007
Eaglehawk	$1,496,799
Eltham	$4,841,129
Ferntree Gully	$4,404,976
Geelong	$2,215,094
Hamilton	$4,478,440
Kinglake	$2,100,268
Kalkallo	$2,265,038
Kilmore South (2nd transformer)	$1,165,325
Koroit	$3,727,973
Lilydale	$7,787,419
Lang Lang	$5,905,236
Merbein	$1,212,130
Moe	$10,672,832
Maryborough	$1,807,535
Mansfield	$3,696,486
Myrtleford	$1,315,187
Rubicon A	$1,686,143
Ringwood North	$5,801,925
Sale	$2,452,467
Seymour	$980,554
Stawell	$2,936,753
Terang	$4,092,390
Wonthaggi	$4,535,570
Winchelsea	$559,070
Wangaratta	$1,238,105
Wodonga and Tallangatta	$4,374,681
Waurn Ponds	$2,488,453
Total	**$160,998,147**

Note: Three ZSSs that are in the base case are not included in this table

Source: ACIL Allen

6.2.3 Net benefits – enhancing network protection for polyphase powerlines (option 1)

The net benefits associated with installing a REFCL at each ZSS were calculated as follows:

Net benefits (present value) = Benefits (present value)
less Costs (present value)

The net benefits, which were estimated inclusive and exclusive of the reliability benefits, are provided by ZSS in Table 24.

Table 24 **Estimated present value of the net benefits with the installation of a REFCL for those ZSSs not in the base case**

Zone substation	Present value of net benefit (2015 dollars)	Present value of net benefit (bushfire benefits only) (2015 dollars)
Ararat	$1,596,465	–$452,642
Ballarat	$10,844,230	$2,108,712
Ballarat South	$5,556,026	$329,589
Bairnsdale	$10,075,024	$5,628,924
Bendigo TS	$3,253,332	$2,416,799
Belgrave	$23,240,713	$3,226,492
Bendigo	$5,365,330	$281,555
Benalla	$25,063,618	$12,827,802
Barnawatha	$6,115,261	$4,374,344
Camperdown	$5,922,445	$3,659,203
Colac	$8,832,914	$6,461,554
Castlemaine	$6,098,921	$3,750,655
Coolaroo	–$2,057,066	–$2,158,790
Corio	$1,518,550	$282,407
Charlton	–$1,673,010	–$3,744,017
Eaglehawk	$4,155,470	$2,658,671
Eltham	$4,773,405	–$67,724
Ferntree Gully	$3,692,198	–$712,778
Geelong	$7,308,411	$5,093,317
Hamilton	$5,122,152	$643,712
Kinglake	$7,717,984	$5,617,716
Kalkallo	$4,775,700	$2,510,662
Kilmore South (2nd transformer)	$1,634,525	$469,199
Koroit	$5,599,945	$1,871,973
Lilydale	$13,050,356	$5,262,937
Lang Lang	$7,609,756	$1,704,520
Merbein	$2,339,453	$1,127,323
Moe	$12,476,281	$1,803,448
Maryborough	$5,242,947	$3,435,412
Mansfield	$4,565,776	$869,290
Myrtleford	$6,908,778	$5,593,591
Rubicon A	$4,646,134	$2,959,991
Ringwood North	$3,056,665	–$2,745,260
Sale	$2,584,759	$132,292
Seymour	$7,792,324	$6,811,770
Stawell	$2,601,538	–$335,215
Terang	$5,466,829	$1,374,439

Zone substation	Present value of net benefit (2015 dollars)	Present value of net benefit (bushfire benefits only) (2015 dollars)
Wonthaggi	$6,237,479	$1,701,908
Winchelsea	$3,473,161	$2,914,091
Wangaratta	$7,861,433	$6,623,328
Wodonga and Tallangatta	$6,399,268	$2,024,587
Waurn Ponds	$2,696,940	$208,487
Administrative and compliance costs	–$49,665	–$49,665
Total	**$259,492,756**	**$98,494,609**

Note: Three ZSSs that are in the base case are not included in this table

Source: ACIL Allen

Modelling the scenarios

The net benefits of each scenario have been assessed by considering the net benefits associated with each ZSS and adding the administrative and compliance costs associated with the scenario.

The estimated net benefits of each scenario are provided in Table 25 and Figure 12. Each of the three scenarios has a net benefit (in net present value terms), with the net incremental benefit increasing as the number of REFCLs installed increases.

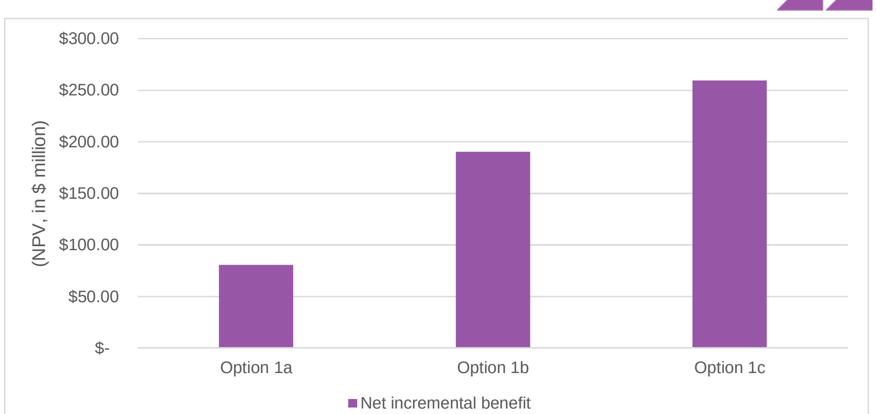
Table 25 also sets out the benefit cost ratio associated with each option. The benefit cost ratio is significantly greater than one for each scenario.

Table 25 **Estimated net incremental benefits of the scenarios to enhance network protection for polyphase powerlines**

Scenario	Net incremental benefits	Benefit cost ratio
	Net present value at 2015, in $million	
Scenario 1a – 15 REFCLs installed	$80.6	2.8
Scenario 1b – 32 REFCLs installed	$190.5	3.0
Scenario 1c – 45 REFCLs installed	$259.5	2.7

Source: ACIL Allen

Figure 12 **Estimated net incremental benefits of the scenarios to enhance network protection for polyphase powerlines**



Source: ACIL Allen

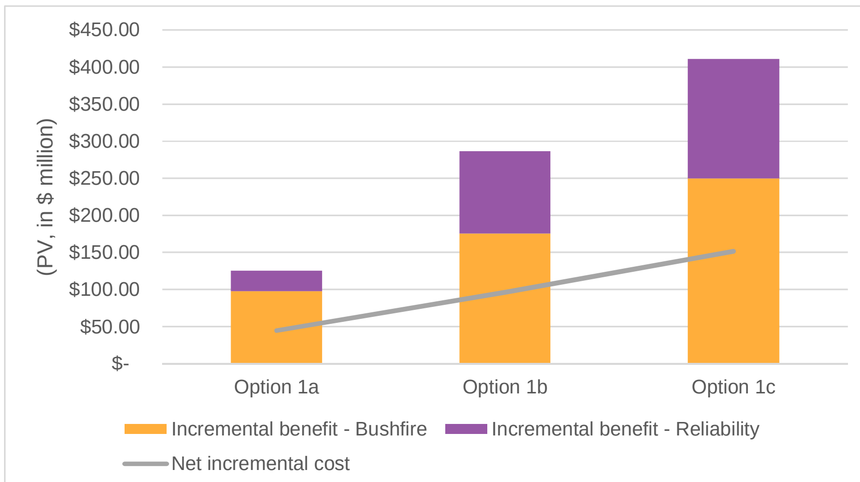
The estimated present value of the costs and the benefits (reduction in bushfire risk and improvement in reliability) is illustrated in Figure 13. Figure 13 indicates that:

— the present value of the costs increases as the number of REFCLs installed increases

— the present value of the benefits associated with a reduction in bushfire risk and with an improvement in reliability increases with each successive option

— there is a net benefit for each option when only bushfire benefits are considered – the assumption that has been made as to the reliability improvement benefits is therefore not material to the consideration of the preferred option.

Figure 13 **Estimated incremental costs and benefits of the scenarios to enhance network protection for polyphase powerlines**



Source: ACIL Allen

The estimated undiscounted costs for installing REFCLs in the highest consequence bushfire risk areas and the resulting reduction in the state's bushfire loss consequence are set out in Table 26. The undiscounted cost for a one per cent reduction in bushfire loss consequence increases with successive options as the number of REFCLs installed increases.

Table 26 **Estimated cost (undiscounted) for a one per cent reduction in the state's bushfire loss consequence**

	Option 1a	Option 1b	Option 1c
Undiscounted cost	$105.4 million	$215.5 million	$296.7 million
Reduction in state's bushfire loss consequence	18.9%	26.5%	32.7%
Undiscounted cost for a one per cent reduction in bushfire loss consequence	$5.6 million	$8.1 million	$9.1 million

Source: ACIL Allen

Sensitivity analysis

The estimated net incremental benefit associated with installing REFCLs for the four different powerline replacement options is set out in Table 27.

Table 27 **Estimated present value of the net incremental benefits associated with installing REFCLs, with different assumptions on powerline replacement (2015 dollars)**

	Option 1a	Option 1b	Option 1c
Committed powerline replacement	$80.6 million	$190.4 million	$259.5 million
Additional powerline replacement – high	$71.1 million	$169.1 million	$238.1 million
Additional powerline replacement – high and medium	$56.0 million	$150.9 million	$219.9 million
Additional powerline replacement – high, medium and low	$53.2 million	$141.9 million	$211.0 million

Source: ACIL Allen

Table 27 indicates that there is estimated to be a net incremental benefit associated with the installation of REFCLs under each of the powerline replacement options, however the net incremental benefit attributable to the REFCLs decreases with increasing powerline replacement. The benefit cost ratio is greater than two under each of these sensitivities.

As discussed in section 6.2.1, lower costs than submitted by AusNet Services and Powercor have been assumed in the analysis on the basis that only one third of lightning arresters proposed for replacement would be replaced. The estimated net incremental benefit associated with installing REFCLs and replacing all lightning arresters is set out in Table 28.

Table 28 **Estimated net incremental benefits of the scenarios to enhance network protection for polyphase powerlines with all lightning arresters replaced**

Scenario	Option 1a	Option 1b	Option 1c
Net incremental benefits (NPV at 2015, in $ million)			
Costs adjusted by ACIL Allen	$80.6	$190.4	$259.5
Costs as submitted by the electricity distributors	$62.9	$160.2	$216.2
Benefit cost ratio			
Costs adjusted by ACIL Allen	2.8	3.0	2.7
Costs as submitted by the electricity distributors	2.0	2.3	2.1

Source: ACIL Allen

While the net incremental benefits and benefit cost ratio are lower when the full costs as submitted by the electricity distributors are assumed, the net incremental benefits remain positive and the benefit cost ratio remains substantially greater than one.

6.3 Analysis of costs and benefits – enhance network protection for SWER powerlines (option 2)

The costs associated with the proposed regulations to enhance network protection for SWER powerlines (option 2) are discussed in section 6.3.1, the benefits are discussed in section 6.3.2, and the net benefits are discussed in section 6.3.3.

6.3.1 Analysis of costs – enhance network protection for SWER powerlines (option 2)

The costs associated with the proposed regulations to enhance network protection for SWER powerlines (option 2) can be divided into four categories:

- direct cost of installing new generation SWER ACRs
- avoided cost due to existing protection devices being replaced earlier than would otherwise occur
- avoided cost of manually resetting protection devices on SWER powerlines on fire ban days
- administrative and compliance costs.

It has been assumed that there is no incremental maintenance cost associated with the new generation SWER ACRs.

Each of the four categories of cost is discussed in the following sections.

Costs of installing SWER ACRs

Powercor advised that, to meet the Taskforce's recommendation on new generation SWER ACRs, it would need to install the following in lower consequence bushfire risk areas:

- 647 new generation SWER ACRs to replace older style SWER ACRs
- 417 new generation SWER ACRs to replace "slow blow" boric acid fuses on SWER powerlines.

Powercor advised that new generation SWER ACRs had already been installed on SWER powerlines in higher consequence bushfire risk areas.

Powercor estimated that the unit cost of a new generation SWER ACR is $50,000. The undiscounted cost associated with installing 1,064 new generation SWER ACRs is $53.2 million (in 2015 dollars).

Powercor estimated that approximately one fifth of the new generation SWER ACRs would be installed in each year of the 2016-20 period. It has been assumed that the new generation SWER ACRs would be installed on all feeders supplied by a ZSS in a year, and that the installations would be phased from the ZSSs with the highest fire loss consequence to the ZSSs with the lowest fire loss consequence. The full cost of the SWER ACRs would be incurred in the year of installation.

Avoided costs of replacing protection devices earlier

Powercor was requested to provide an estimate of when the existing protection device would be replaced if the new generation SWER ACR was not installed.

Powercor advised that the equipment would be replaced when they are identified as inoperable or when they fail, rather than in a specific year. For the purposes of the analysis, it is assumed that the existing protection device would have been replaced ten years after installation of the new generation SWER ACRs.

Avoided costs of not resetting protection devices manually

The Taskforce recommended that, "until the older style SWER ACRs are replaced, they should be manually changed in the highest fire loss consequence areas of the state during the worst bushfire period as declared by the Fire Services Commissioner"[82].

If the protection devices are replaced so that they can be remotely changed, the costs associated with manually changing the settings will be avoided.

Powercor advised that it takes a two man crew ten days to manually change the settings of older style SWER ACRs at the beginning of the declared period and again at the end of the declared period. The estimated cost per fire season is $61,800.

Administrative and compliance costs

The electricity distributors and ESV will incur additional costs under the proposed regulations due to the need to update existing Bushfire Mitigation Plans. Bushfire Mitigation Plans will need to be updated as the proposed regulations take effect to account for differences in operating procedures when new generation SWER ACRs are in place in all rural areas.

It is expected that Powercor will need to submit an amendment to its BMP if the proposed regulations are approved. Once the amended BMP has been approved the schedule for amending and renewing BMPs is assumed to be the same as in the base case.

The costs associated with developing, updating and approving BMPs are provided in Table 19. The estimated cost for Powercor to update its BMP is $5,015. As the amendment is relatively minor, it is assumed that the incremental cost for ESV to review Powercor's amended BMP will be substantially less than provided in Table 19, as only one BMP will be revised and Powercor's BMP will have already been amended to install new generation SWER ACRs in the highest consequence bushfire risk areas. It is estimated that the costs incurred by the ESV will be the same as the costs estimated for Powercor to amend its BMP. The total administrative and compliance costs associated with the proposed regulation are therefore $10,030.

Modelling the costs for installing new generation SWER ACRs

The present value of the costs associated with installing new generation SWER ACRs in the lower consequence bushfire risk areas has been estimated by modelling the costs for installing the new generation SWER ACRs less the avoided costs, and the administrative and compliance costs.

The costs have been modelled over a 20 year period, to 2035. This period was selected based on the estimated life of the new generation SWER ACR.

A discount rate of 4.0 per cent has been used, consistent with the *Victorian Guide to Regulation*.

The estimated present value of the costs for installing new generation SWER ACRs in lower consequence bushfire risk areas is set out in Table 29.

[82] Powerline Bushfire Safety Taskforce, Final Report, 30 September 2011, pages 112-113

Table 29 **Estimated present value of costs for installing new generation SWER ACRs**

	Present value of costs (2015 dollars)
New generation SWER ACRs	47,374,644
Less avoided costs	20,175,606
Administrative and compliance costs	10,030
Total net costs	**27,209,067**

Source: ACIL Allen

6.3.2 Analysis of benefits – enhance network protection for SWER powerlines (option 2)

The only benefit associated with the installation of new generation SWER ACRs that has been quantified for the purposes of this RIS is an improvement in bushfire risk.

It has been assumed that there will be no improvement in supply reliability. There are two potential impacts of the new generation SWER ACRs on supply reliability:

- the supply reliability may improve by reducing the time during which the protection settings will be changed over the fire danger period by being able to remotely reset the protection settings
- the supply reliability may deteriorate if the more sensitive protection settings on the new generation SWER ACRs detect more faults and interrupt supply more frequently.

It is assumed that these two impacts on supply reliability will cancel each other out.

Additionally, it is noted that the load supplied by SWER powerlines is low and so any impact on supply reliability will be relatively small.

Improvement in bushfire risk

The benefit associated with an improvement in bushfire risk with the installation of a new generation SWER ACR is a function of:

- the estimated cost of bushfires
- the fire loss consequence associated with the ZSS after the replacement of powerlines in the most dangerous areas of the state, as a proportion of the state's fire loss consequence prior to any treatments
- the estimated reduction in bushfire risk by installing a new generation SWER ACR.

As discussed in section 3.2.4, the annual cost of bushfires started by electricity assets is estimated to be $80 million.

The fire loss consequence associated with each ZSS was provided by the CSIRO. CSIRO estimated that the total state-wide bushfire risk reduction by installing new generation SWER ACRs in Powercor's lower consequence bushfire risk areas, following the replacement of powerlines under the PRF and the installation of REFCLs, is 2.1 per cent. This equates to a reduction in the bushfire risk at each ZSS of 4.0 per cent by installing new generation ACRs on the SWER feeders that are supplied by that ZSS.

The sequence with which bushfire reduction activities are undertaken is important in attributing a reduction in bushfire risk. The reduction in bushfire risk associated with installing SWER ACRs was estimated assuming that some bushfire reduction measures have already been undertaken since Black Saturday, and prior to the installation of REFCLs.

The improvement in bushfire risk is equal to the product of the estimated cost of bushfires, the fire loss consequence associated with the ZSS as a proportion of the state's fire loss consequence, and the estimated reduction in bushfire risk by installing new generation SWER ACRs.

The present value of the improvement in bushfire risk was calculated for each ZSS over a 20 year period with a discount rate of 4.0 per cent. The improvement in bushfire risk was assumed to occur in each year following the year in which the new generation SWER ACR was installed.

The present value of the benefits associated with an improvement in bushfire risk is estimated to be $22,243,959.

6.3.3 Net benefits – enhance network protection for SWER powerlines (option 2)

The net benefit and benefit cost ratio associated with the proposed regulations to enhance network protection for SWER powerlines is set out in Table 30.

Table 30 **Estimated net benefits associated with installing new generation SWER ACRs**

	2015 dollars	Benefit cost ratio
Present value of benefits	$22,243,959	
Present value of net costs	$27,209,067	
Present value of net benefits	**–$4,965,109**	**0.82**

Source: ACIL Allen

As the ratio of benefits to costs is less than one and a number of assumptions have been made in estimating the net benefits, the following assumptions have been varied to identify the sensitivity of the net benefits to these assumptions:

— the reduction in bushfire risk has been increased from 4.0 per cent to 5.0 per cent (scenario 2)

— the cost of new generation SWER ACRs has been decreased from $50,000 to $45,000 (scenario 3)

— the avoided cost of resetting older style SWER ACRs has been increased from $61,800 per fire season to $70,000 (scenario 4).

The results of the sensitivity analysis are set out in Table 31.

Table 31 **Sensitivity analysis of net benefits from installing new generation SWER ACRs (2015 dollars)**

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Reduction in bushfire risk at ZSS level	4.0%	5.0%	4.0%	4.0%
Cost of ACR	$50,000	$50,000	$45,000	$50,000
Cost of manual reset	$61,800	$61,800	$61,800	$70,000
PV of benefits	$22,243,959	$28,015,061	$22,243,959	$22,243,959
PV of net costs	$27,209,067	$27,209,067	$24,405,175	$27,097,627
PV of net benefits	**–$4,965,109**	**$805,994**	**–$2,161,217**	**–$4,853,668**
Benefit cost ratio	**0.82**	**1.03**	**0.91**	**0.82**

Source: ACIL Allen

Table 31 indicates that, if the reduction in bushfire risk is increased from 4.0 per cent to 5.0 per cent, there is a net benefit associated with the installation of new generation SWER ACRs. There is little change in the net cost if the cost of manually resetting ACRs is increased from $61,800 to $70,000. The net cost decreases if the cost of ACRs reduces from $50,000 to $45,000, but the benefit costs ratio is still less than one.

There are 45 ZSSs in Powercor's area that supply SWER powerlines and do not have the new generation SWER ACRs installed (scenario 1). There is a net benefit associated with installing new generation SWER ACRs on the SWER powerlines supplied by each of 18 ZSSs (scenario 5). There is a net benefit in aggregate associated with installing new generation SWER ACRs on the SWER powerlines associated with 43 of the 45 ZSSs (scenario 6).

The reduction in bushfire risk, costs and benefits associated with each of these scenarios is set out in Table 32. In addition, Table 32 includes a further scenario (scenario 7) under which new generation SWER ACRs are installed on SWER powerlines supplied by ZSSs at which a REFCL is proposed to be installed.

Table 32 **Sensitivity analysis of net benefits from installing new generation SWER ACRs (2015 dollars)**

	Scenario 1	Scenario 5	Scenario 6	Scenario 7
Number of ZSSs	45	18	43	21
Number of SWER ACRs	1,064	182	828	546
Undiscounted cost	$53,200,000	$9,100,000	$41,400,000	$27,300,000
Reduction in state-wide bushfire risk	2.10%	1.66%	2.02%	1.70%
Undiscounted cost of a one per cent reduction in bushfire risk	$25,287,738	$5,484,049	$20,462,081	$16,025,033
PV of benefits	$22,243,959	$17,811,053	$21,447,452	$18,154,646
PV of net costs	$27,209,067	$4,476,322	$20,271,945	$15,261,696
PV of net benefits	**–$4,965,109**	**$13,334,732**	**$1,175,507**	**$2,892,950**
Benefit cost ratio	**0.82**	**3.98**	**1.06**	**1.19**

Source: ACIL Allen

Table 32 indicates that the net benefits and benefit cost ratio increase if the number of new generation SWER ACRs installed is reduced. However, the reduction in state-wide bushfire risk is also reduced.

The benefit cost ratio is greater than one where new generation SWER ACRs are installed on SWER powerlines supplied by all but two of the 45 ZSSs.

One of the key assumptions in the cost benefit analysis is the cost of bushfires. The cost benefit analysis assumes an annual average cost of bushfires of $80 million, which is substantially less than the cost of a single major one in 25 year bushfire (more than $300 million). As discussed in section 3.2.3, the Royal Commission identified that the risks associated with bushfire are likely to increase with the impact of climate change.

If the annual average cost of bushfires in the future is $97.9 million rather than $80 million, as assumed, the benefits associated with installing a new generation SWER ACRs on SWER powerlines supplied by all 45 ZSSs will be the same as the costs.

6.4 Require powerlines in declared areas to be put underground or insulated (option 3)

The costs associated with the proposed regulations to require powerlines in declared areas to be put underground or insulated (option 3) are discussed in section 6.4.1, the benefits are discussed in section 6.4.2, and the net benefits are discussed in section 6.4.3.

6.4.1 Analysis of costs – require powerlines in declared areas to be put underground or insulated (option 3)

The costs associated with the proposed regulations to require powerlines in declared areas to be put underground or insulated (option 3), can be divided into four categories:

- direct cost of putting powerlines underground or insulating conductors
- direct cost for reconnecting customers to powerlines that are replaced
- avoided cost of replacing powerlines earlier than would otherwise occur
- administrative and compliance costs.

It has been assumed that the incremental maintenance cost associated with the new and replaced powerlines is immaterial for the purposes of this analysis.

Each of the four categories of cost is discussed in the following sections.

Costs of putting powerlines underground or insulating conductors

Given the uncertainty associated with estimating the unit cost for putting powerlines underground or insulating conductors, two scenarios have been considered – a low cost case and a high cost case.

The low cost case is based on insulating conductors using existing technology prior to 2020 and using a new technology (covered carbon core) from 2020. The high cost case is based on a mix of putting powerlines undergrounding and insulating conductors using existing technology.

The unit cost has been estimated based on:

- the costs revealed through the Government's Powerline Replacement Fund, as set out in Table 7
- the costs estimated by the Taskforce, as set out in Table 3 and Table 4
- the costs estimated for the new technology for insulated conductor (covered carbon core), as discussed in section 3.1.3.

The unit costs that have been used for the purposes of this analysis are as set out in Table 33.

Table 33 **Estimated unit cost of putting powerlines underground or insulating conductors**

Scenario	Type of powerlines	Unit cost (2015 dollars)
Low cost (prior to 2020)	Polyphase	$300,000 per km
	SWER	$257,000 per km
Low cost (post 2020)	Polyphase	$195,000 per km
	SWER	$145,000 per km
High cost	Polyphase	$400,000 per km
	SWER	$260,000 per km

Source: ACIL Allen based on costs revealed under the Government's Powerline Replacement Fund and the Taskforce's estimates

The feeders that are to be replaced are listed in Appendix D. The length of powerlines to be replaced has been provided by the Department based on modelling of the most dangerous areas of the state (the declared areas), and is set out in Table 34.

Table 34 **Length of powerlines to be replaced**

Type of powerlines	Length of powerlines to be replaced (km)
Polyphase	1,473.8
SWER	830.7
Total	**2,304.5**

Source: Departmental modelling

Direct costs for reconnecting customers to powerlines that are replaced

Where a powerline is replaced with a new technology, there will be a cost associated with reconnecting customers to that powerline. This cost is generally borne by the connecting customer.

Where a powerline is replaced with the same technology, it is assumed that there is no additional cost associated with reconnecting the customer.

Where a cost is incurred in reconnecting a customer to a powerline, it has been assumed that the cost will be $3,000 per customer to connect in the high cost scenario and $1,000 per customer to connect in the low cost scenario. In practice, the cost will vary significantly depending on the distance from the customer's premises to the powerline.

The number of customers to be connected or reconnected has been estimated based on the number of customers supplied by the feeder and the length of the powerline to be replaced as a proportion of the feeder length.

Avoided costs of replacing powerlines earlier

Where powerlines are replaced under option 3a, it is assumed that they would otherwise be replaced 25 years after the date of replacement. Where the powerlines are replaced under option 3b, it is assumed they would otherwise be replaced in the same year.

For all options, it is assumed that a bare wire powerline would be installed in the absence of a regulation.

The cost of a bare wire powerline has been estimated based on the analysis undertaken by the Taskforce for the Mt Macedon area, escalated to 2015 dollars, and is provided in Table 35.

Table 35 **Estimated unit cost of bare wire powerlines**

Type of powerline	Unit cost (2015 dollars)
Bare SWER powerlines	$132,000 per km
Bare polyphase powerlines	$160,000 per km

Source: ACIL Allen based on the Taskforce's estimates

Administrative and compliance costs

The electricity distributors and ESV will incur additional costs under the proposed regulations due to the need to update existing Bushfire Mitigation Plans. Bushfire Mitigation Plans will need to be updated as the proposed regulations take effect to account for differences in operating procedures when powerlines in declared areas that are replaced are put underground or insulated.

It is expected that AusNet Services and Powercor will need to submit an amendment to their BMP if the proposed regulations are approved. Once the amended BMPs have been approved, the schedule for amending and renewing BMPs is assumed to be the same as in the base case.

The costs associated with developing, updating and approving BMPs are provided in Table 19. The estimated cost for AusNet Services and Powercor to update their BMPs is $5,015 each, and the cost for ESV to review the amended BMPs is $34,621. The total administrative and compliance costs associated with the proposed regulation are therefore $44,651.

Modelling the costs for putting powerlines underground and insulating conductors

The present value of the costs associated with putting powerlines underground and insulating conductors in declared areas has been estimated by modelling the costs for replacing the powerlines less the avoided costs, the cost for connecting customers, and the administrative and compliance costs.

The costs have been modelled over a 50 year period, to 2065. This period was selected based on the estimated life of powerlines.

A discount rate of 4.0 per cent has been used, consistent with the *Victorian Guide to Regulation*.

For option 3a, it was assumed that an approximately equal length of powerlines was replaced in each year from 2016 to 2022. For option 3b, it was assumed that on average powerlines would be replaced in 25 years, so for modelling purposes, they were all assumed to be replaced in 2040.

The estimated present value of the costs for putting powerlines underground and insulating conductors in declared areas is set out in Table 36.

Table 36 **Estimated present value of costs for putting powerlines underground and insulating conductors**

Description			Present value of powerlines	Present value of avoided costs	Present value of cost to connect customers	Present value of net costs
Option	Replacement period	Scenario	(2015 dollars)	(2015 dollars)	(2015 dollars)	(2015 dollars)
3a	Replacement by 2023	Low cost	$481,007,048	–$111,058,341	$18,951,381	$388,900,088
		High cost	$696,168,911	–$111,058,341	$56,854,142	$641,964,713
3b	Replacement at end of life	Low cost	$154,257,985	–$137,315,873	$8,058,755	$25,000,867
		High cost	$304,620,552	–$137,315,873	$24,176,266	$191,480,944

Note: Powerline costs include the administrative and compliance costs
Source*:* ACIL Allen

The undiscounted cost associated with each of these scenarios is set out in Table 37.

Table 37 **Undiscounted cost for putting powerlines underground and insulating conductors**

Description			Undiscounted cost
Option	Replacement period	Scenario	(2015 dollars)
3a	Replacement by 2023	Low cost	$548,419,648
		High cost	$805,505,458
3b	Replacement at end of life	Low cost	$407,844,751
		High cost	$805,505,458

Source: ACIL Allen based on the Taskforce's estimates

6.4.2 Analysis of benefits – require powerlines in declared areas to be put underground or insulated (option 3)

The benefits associated with putting powerlines underground and insulating conductors, to reduce bushfire risk in declared areas, that have been quantified in the analysis are:

— an improvement in bushfire risk

— a reduction in the number of minutes that customers are off supply due to electricity interruptions

— a reduction in the number of momentary interruptions (those less than a minute in duration).

Improvement in bushfire risk

The benefit associated with an improvement in bushfire risk from putting powerlines in declared areas underground and insulating the conductors is a function of:

— the estimated cost of bushfires

- the fire loss consequence associated with the ZSS after the replacement of powerlines in the most dangerous areas of the state, as a proportion of the state's fire loss consequence prior to the implementation of any treatments[83]
- the estimated reduction in bushfire risk by replacing additional powerlines.

As discussed in section 3.2.4, the annual cost of bushfires started by electricity assets is estimated to be $80 million.

The fire loss consequence associated with the ZSSs relevant to this option was provided by CSIRO for different levels of powerline replacement:

- base case with powerline replacement that has occurred to date
- in the most dangerous areas of the state.

The estimated reduction in bushfire risk by replacing the powerlines was provided by CSIRO, for the relevant zone substation for each segment of powerline to be replaced under option 3.

The improvement in bushfire risk associated with each segment of powerline to be replaced was equal to the product of the estimated cost of bushfires and the estimated reduction in bushfire risk by replacing the powerlines.

The present value of the improvement in bushfire risk was calculated for each segment of powerline to be replaced over a 50 year period with a discount rate of 4.0 per cent. The improvement in bushfire risk was assumed to occur in each year following the year in which the powerline was replaced.

The present value of the improvement in bushfire risk for each scenario was the sum of the present value of the improvement in bushfire risk for each segment of powerline replaced.

The estimated present value of the benefits associated with a reduction in bushfire risk is set out in Table 38.

Table 38 **Estimated present value of benefits associated with an improvement in bushfire risk for putting powerlines underground and insulating conductors**

Description			Present value of bushfire benefits
Option	Replacement period	Scenario	(2015 dollars)
3a	Replacement by 2023	Low cost	$159,086,291
		High cost	$162,633,982
3b	Replacement at end of life	Low cost	$48,539,760
		High cost	$49,589,090

Source: ACIL Allen

Reduction in minutes off supply

The benefit associated with a reduction in the minutes off supply from putting powerlines underground and insulating conductors, to reduce bushfire risk in declared areas, is a function of:

- the energy consumption by customers that are supplied by each feeder
- the value that customers place on reliability

83 Treatments include the replacement of powerlines, replacement of SWER ACRs and two trial REFCLs.

— the estimated reduction in minutes off supply when a fault occurs
— the proportion of the feeder that is to be replaced.

As part of the data request, the electricity distributors provided the energy consumption for each feeder, by residential and non-residential customers.

As discussed previously, AEMO publishes the value that customers place on reliability (VCR), which is used throughout the National Electricity Market for planning and operational purposes. The most recently published VCRs that are applicable to Victoria are provided in Table 22.

As discussed in section 6.2.2, for the purposes of this analysis, we have used a VCR of $24.76 per kWh for residential customer load and $45.00 per kWh for non-residential customer load.

The estimated reduction in the minutes off supply by replacing powerlines was based on a 50 per cent reduction in the feeder's minutes off supply for the proportion of the feeder to be replaced. The 50 per cent reduction takes into account:

— there will be a reduction in the number of faults where the powerlines have been insulated (for example, light contact with vegetation and animals), but faults will still occur from large trees falling on the powerline or vehicles running into poles
— there will be a larger reduction in the number of faults where the powerlines have been put underground, but the time to repair faults in underground powerlines is longer than to repair overhead powerlines.

The benefits associated with a reduction in the minutes of supply (B_R) for each segment of powerline replaced is calculated as follows:

$$B_R = \frac{(E_R + E_{NR})}{Mins\ per\ year - Mins\ off\ supply} \times \frac{(VCR_R \times E_R + VCR_{NR} \times E_{NR})}{(E_R + E_{NR})} \times 0.5 \times \frac{l_s}{l_T} \times Mins\ off\ supply$$

where:

E_R is the energy consumed by residential customers on the feeder

E_{NR} is the energy consumed by non-residential customers on the feeder

Mins per year is the total minutes in the year

Mins off supply is the current minutes off supply on the feeder

VCR_R is the VCR for residential customers

VCR_{NR} is the VCR for non-residential customers

l_s is the length of the segment of feeder to be replaced

l_T is the total length of the feeder

The benefits associated with a reduction in the minutes off supply are assumed to commence in the year following replacement of the powerline.

The benefits associated with each scenario are the sum of the benefits associated with each segment of powerline to be replaced.

The present value of a reduction in minutes off supply was calculated for each option over a 50 year period with a discount rate of 4.0 per cent.

Reduction in the number of momentary interruptions

The benefit associated with a reduction in the number of momentary interruptions from putting powerlines underground and insulating conductors, to reduce bushfire risk in declared areas, is a function of:

- the energy consumption by customers that are supplied by each feeder connected to each ZSS
- the value that customers place on reliability
- the value that customers place on the frequency of momentary interruptions relative to minutes off supply
- the proportion of the feeder that is to be replaced.

As discussed above:

- the electricity distributors provided the energy consumption for each feeder, by residential and non-residential customers, and the proportion of faults that were phase to earth faults
- a VCR of $24.76 per kWh has been used for residential customer load and $45.00 per kWh for non-residential customer load.

As discussed in section 6.2.2:

- the value that rural customers place on the duration of sustained interruptions relative to the frequency of sustained interruptions is 0.92[84] – this implies that for an interruption of average duration, 48 per cent of the VCR is attributable to the duration of the interruption and 52 per cent is attributable to the frequency of interruptions
- the value that customers place on momentary interruptions is 8 per cent of the value that they place on the frequency of sustained interruptions[85].

Momentary interruptions are, by definition, interruptions of short duration (less than one minute). The minutes off supply measures only include sustained interruptions which are longer than one minute. There is therefore no double counting of the benefits associated with minutes off supply and the frequency of momentary interruptions.

The benefits associated with a reduction in the number of momentary interruptions (B_M) for each segment of powerline replaced is calculated as follows:

$$B_M = \frac{(E_R + E_{NR})}{Mins\ per\ year - Mins\ off\ supply} \times \frac{(VCR_R \times E_R + VCR_{NR} \times E_{NR})}{(E_R + E_{NR})} \times V_f \times V_m \times \frac{l_s}{l_T} \times \frac{N_f + 0.5 \times N_p}{N_s} Mins\ off\ supply$$

where:

E_R is the energy consumed by residential customers on the feeder

E_{NR} is the energy consumed by non-residential customers on the feeder

[84] Australian Energy Regulator, *Electricity distribution network service providers, Service target performance incentive scheme,* November 2009, page 11

[85] Australian Energy Regulator, *Electricity distribution network service providers, Service target performance incentive scheme,* November 2009, page 12

Mins per year is the total minutes in the year

Mins off supply is the current minutes off supply on the feeder

VCR_R is the VCR for residential customers

VCR_{NR} is the VCR for non-residential customers

l_s is the length of the segment of feeder to be replaced

l_T is the total length of the feeder

V_f is the proportion of VCR attributable to the frequency of interruptions

V_m is the value of momentary interruptions relative to the frequency of sustained interruptions

N_f is the number of momentary interruptions (full feeder) on the feeder

N_p is the number of momentary interruptions (part feeder) on the feeder

N_s is the number of sustained interruptions on the feeder

The benefits associated with a reduction in the number of momentary interruptions are assumed to commence in the year following replacement of the powerline.

The benefits associated each scenario are the sum of the benefits associated with each segment of powerline to be replaced.

The present value of a reduction in the number of momentary interruptions was calculated for each ZSS over a 50 year period with a discount rate of 4.0 per cent.

The present value of a reduction in the number of momentary interruptions was significantly less than the present value of a reduction in the minutes off supply.

Benefits associated with a reduction in minutes off supply and number of momentary interruptions

The estimated present value of the benefits associated with a reduction in the minutes off supply and a reduction in the number of momentary interruptions for each scenario is set out in Table 39. Table 39 indicates that the reliability benefits associated with replacing powerlines are relatively small, particularly under option 3b in which the reliability benefits do not commence until 2041. Accordingly, the assumptions that have been made in relation to the reduction in the minutes of supply and the reduction in the number of momentary interruptions are not material to the analysis.

Table 39 **Estimated present value of benefits associated with a reduction in the minutes off supply and a reduction in the number of momentary interruptions by putting powerlines underground and insulating conductors**

Description			Present value of reliability benefits
Option	Replacement period	Scenario	(2015 dollars)
3a	Replacement by 2023	Low cost	$1,356,328
		High cost	$1,356,328
3b	Replacement at end of life	Low cost	$428,444
		High cost	$428,444

Source: ACIL Allen

6.4.3 Net benefits – require powerlines in declared areas to be put underground or insulated (option 3)

The net benefit and benefit cost ratio associated with the proposed regulations to reduce bushfire risk in declared areas by putting powerlines underground and insulating conductors is set out in Table 40.

Table 40 **Estimated present value of the net benefits by putting powerlines underground and insulating conductors**

Description			Present value of net benefit	Benefit cost ratio
Option	Replacement period	Scenario	(2015 dollars)	
3a	Replacement by 2023	Low cost	–$228,457,469	0.41
		High cost	–$477,974,402	0.26
3b	Replacement at end of life	Low cost	$23,967,337	1.96
		High cost	–$141,463,410	0.26

Source: ACIL Allen

Table 40 indicates that there is a net benefit, and a benefits cost ratio greater than one, to replace powerlines at the end of their life with the new technology (covered carbon core conductor). There is a net cost and a benefit cost ratio less than one for the other scenarios considered for putting powerlines underground or insulating conductors in declared areas (accelerated replacement by 2023 and replacement at the end of life with existing technologies).

7 Preferred option

In this chapter, the preferred options to meet the objective of reducing the likelihood that electricity distribution powerlines start bushfires are discussed. The options, which were assessed in detail in chapter 6, are discussed in:

- section 7.1 – the proposed regulations to enhance the network protection for polyphase powerlines in the highest consequence bushfire risk areas (option 1)
- section 7.2 – the proposed regulations to enhance the network protection for SWER powerlines (option 2)
- section 7.3 – the proposed regulations to require powerlines in declared areas to be put underground or insulated (option 3).

7.1 Preferred option – enhance network protection for polyphase powerlines (option 1)

A cost benefit analysis was undertaken for three options to enhance the network protection for polyphase powerlines in the highest consequence bushfire risk areas:

- Option 1a – includes the 15 highest priority ZSSs, which are listed in Appendix B.1.
- Option 1b – includes the ZSSs in Option 1a and the next 17 highest priority ZSSs, which are listed in Appendix B.2.
- Option 1c – includes all the ZSSs that have been identified by the Department as being in the highest consequence bushfire risk areas. These 45 ZSSs are listed in Appendix B.3.

The results of the cost benefit analysis, which is provided in section 6.2.3, indicate that there is a net benefit associated with each of these scenarios when only bushfire benefits are considered. The net benefit increases further if the reliability benefits are also taken into consideration.

Table 26 sets out the undiscounted cost for a one per cent reduction in the state's bushfire risk associated with the three options. The incremental undiscounted cost for a one per cent reduction in the state's bushfire risk associated with each of the three options is provided in Table 41.

Table 41 **Estimated incremental cost (undiscounted) for a one per cent reduction in the state's bushfire loss consequence**

	Option 1a	Option 1b	Option 1c
Number of ZSSs	15	32	45
Undiscounted incremental cost	$105.3 million	$110.1 million	$81.2 million
Incremental reduction in state's bushfire loss consequence	18.9%	7.6%	6.2%
Undiscounted cost for a one per cent incremental reduction in bushfire loss consequence	$5.6 million	$14.4 million	$13.1 million

Source: ACIL Allen

Table 41 illustrates that the incremental reduction in the state's bushfire loss consequence is significant under option 1a (18.9 per cent), and decreases from option 1a to option 1b and from option 1b to option 1c. The incremental undiscounted cost for a one per cent incremental reduction in the state's bushfire loss consequence increases by more than two fold by moving from option 1a to option 1b and is similar moving from option 1b to option 1c.

The costs of REFCLs are paid for by the electricity customers in an electricity distribution area, while the beneficiaries of a reduction in bushfire risk are located more broadly across the state. The beneficiaries of the improvement in reliability are also the electricity customers in the electricity distribution area. Table 42 sets out the present value of the net benefits associated with installing REFCLs in the highest consequence bushfire risk areas by considering only the reliability benefits.

Table 42 **Estimated present value of the net benefits (reliability benefits only), by electricity distribution area**

	Option 1a	Option 1b	Option 1c
AusNet Services	$14.3 million	$56.8 million	$65.6 million
Powercor	–$31.8 million	–$41.9 million	–$53.8 million
Jemena			–$2.3 million
Total	**–$17.5 million**	**–$14.9 million**	**–$2.3 million**

Source: ACIL Allen

Table 42 indicates that, under all scenarios, there are positive net benefits from installing REFCLs in AusNet Services' area when only reliability benefits are considered, and net costs from installing REFCLs in Powercor's and Jemena's areas. The net costs (when only reliability benefits are considered) are the lowest in Powercor's area under option 1a.

The net reliability benefits resulting from the installation of REFCLs, as set out in Table 42, are largely based on the assumption that the minutes off supply from phase to earth faults will reduce by 30 per cent with the installation of a REFCL. Table 43 sets out the reduction in the minutes off supply that is required so that the reliability benefits associated with the installation of a REFCL are equal to the costs (in present value terms).

Table 43 **Reduction in minutes off supply required so that the present value of the net benefits (reliability benefits only) is breakeven, by electricity distribution area**

	Option 1a	Option 1b	Option 1c
AusNet Services	–14%	7%	10%
Powercor	90%	72%	60%
Jemena			>100%

Source: ACIL Allen

Table 43 indicates that the electricity customers in AusNet Services' area will experience a positive net reliability benefit from the installation of REFCLs in the accelerated timeframe, even if the minutes off supply is significantly less than the value assumed in the analysis.

A significantly larger improvement in the minutes off supply from the value assumed is required for the electricity customers in Powercor's area to experience a positive net reliability benefit from the installation of REFCLs in an accelerated timeframe. The one REFCL that is installed in Jemena's distribution area is installed in 2024 in the base case and in 2021 in the accelerated timeframe. As a result, it is not possible to get a net benefit from the reliability benefits alone within that three year period.

This would indicate that Powercor and Jemena would be highly unlikely to install REFCLs in their areas within an accelerated timeframe on the basis of reliability benefits alone.

The estimated maximum incremental impact of the installation of REFCLs in the highest consequence bushfire risk areas on customers' annual electricity bills is set out in Table 44.

The impact on customers' annual electricity bills is estimated by first considering the incremental revenue that would be earned by the electricity distributors to install the REFCLs. The incremental revenue comprises:

- the additional maintenance costs in each year
- the additional administrative and compliance costs associated with amending the Bushfire Mitigation Plans in the first year
- the depreciation of the additional assets, with the secondary equipment depreciated over 20 years and the remaining equipment associated with the REFCL depreciated over 50 years
- a return on the additional assets, using a rate of return of 6.0 per cent.

The avoided costs are not taken into consideration in this estimate as it is assumed that the maximum bill impact will occur prior to the avoidance of material costs associated with the replacement of assets. Similarly, a taxation allowance has not been included as this is a relatively small component of the revenue and depends on the business's overall tax position.

The potential reduction in revenue arising from improvements in reliability has not been considered. This revenue reduction will also be a relatively small component of the revenue and will offset the taxation component.

The electricity distributors determine whether the costs associated with the REFCLs are recovered from customers through the fixed component of the distribution tariff or the variable component of the distribution tariff.

For the purposes of this analysis, it is assumed that the additional revenue will be recovered equally from all customers based on energy consumption to determine a distribution tariff impact, and therefore a retail tariff impact. This is because the variable component of the distribution tariff is much larger than the fixed component. Additionally, if it was assumed that some or all of the costs were recovered through the fixed component of the distribution tariff, assumptions would need to be made as to how the costs would be allocated to different distribution tariffs. There is better data available on allocating costs to the variable component of distribution tariffs than to the fixed component of distribution tariffs.

The impact on a residential and small business customer has been estimated based on energy consumption of 5,000 kWh per year and 25,000 kWh per year, respectively.

The estimated maximum incremental impact of the installation of REFCLs in the highest consequence bushfire risk areas on customers' annual electricity bills excludes the impact of REFCLs that are expected to be installed under the base case. The maximum impact is estimated to occur in 2024, after the installation of all the additional REFCLs.

Table 44 **Estimated maximum impact of the proposed regulation on customers' annual electricity bills (2015 dollars)**

Distributor	Option	Increase in network tariff	Impact on residential customer	Impact on small business customer
		cents per kWh	$ per annum	$ per annum
AusNet Services	1a	0.04	$1.80	$9.01
	1b	0.11	$5.72	$28.62
	1c	0.15	$7.36	$36.79
Powercor	1a	0.03	$1.72	$8.61
	1b	0.06	$2.90	$14.49
	1c	0.09	$4.69	$23.46
Jemena	1c	0.00	$0.22	$1.08

Note: WACC assumed to 6.0% (pre tax real). Electricity delivered by the electricity distributors for 2016-20 is from their 2016-20 regulatory proposals. Electricity delivered is assumed to grow from 2020-24 with the same compound annual growth rate as from 2015-20. The retail electricity tariff is in the order of 30 cents per kWh (but is dependent on the customer's retailer and specific retail tariff).

Source: ACIL Allen

The maximum impact of the installation of REFCLs on customers' electricity bills is relatively modest with the maximum impact of any option less than 0.5 per cent.

The impact on competition of this price increase will be marginal, as the increases are modest and electricity costs tend to be a small proportion of a business's input costs. Energy intensive industries are generally connected directly to the transmission network, rather than the distribution network, and therefore do not pay distribution charges.

On balance, the preferred option is to amend the regulations to enhance the network protection for polyphase powerlines supplied by 45 ZSSs (option 1c) on the basis that:

- **there is a net benefit associated with all options**
- **there is a net benefit when considering only the bushfire benefits under all options**
- **the reduction in the state-wide bushfire risk increases as the number of REFCLs installed increases**
- **the undiscounted cost for an incremental reduction in bushfire risk is similar under options 1b and 1c**
- **the additional costs associated with option 1c are relatively modest.**

7.2 Preferred option – enhance network protection for SWER powerlines (option 2)

The results from a cost benefit analysis on the proposed regulation to enhance network protection for SWER powerlines are provided in section 6.3.3.

The cost benefit analysis indicated that there is a net cost associated with installing new generation SWER ACRs on all SWER powerlines (1,064 SWER ACRs on SWER powerlines supplied by 45 ZSSs), assuming an annual average bushfire cost of $80 million. If it is assumed that the average annual bushfire cost increases to $97.9 million with the impact of climate change, there is no net cost associated with installing new generation SWER ACRs on all SWER powerlines.

There is net benefit if the number of SWER ACRs installed is reduced so that they are only installed on SWER powerlines where there is a net benefit to do so, either at the ZSS level or in aggregate.

If SWER ACRs are installed on SWER powerlines supplied by the 17 ZSSs for which there is a net benefit, the benefit cost ratio is significantly greater than one (3.98) and the undiscounted cost for a one per cent reduction in the state-wide bushfire risk is $5.4 million. However, the reduction in state-wide bushfire risk reduces from 2.10 per cent (if all SWER ACRs are installed) to 1.66 per cent.

If SWER ACRs are installed on SWER powerlines supplied by the 43 ZSSs for which there is a net benefit in aggregate, the benefit cost ratio is just greater than one (1.06) and the undiscounted cost for a one per cent reduction in the state-wide bushfire risk is $20.5 million. However, the reduction in state-wide bushfire risk reduces from 2.10 per cent (if all SWER ACRs are installed) to 2.02 per cent. Under this scenario, new generation SWER ACRs would not be installed at Horsham and Hamilton, a ZSS for which it is proposed to install a REFCL.

REFCLs can only reduce the bushfire risk associated with polyphase lines. New generation SWER ACRs complement REFCLs as they can only reduce the bushfire risk associated with SWER powerlines. It would not be prudent to prioritise a ZSS for enhancement of the network protection for polyphase powerlines supplied by that ZSS but not to enhance the network protection for SWER powerlines supplied by that same ZSS.

If SWER ACRs are installed on SWER powerlines supplied by the 21 ZSSs for which it is proposed to install a REFCL, the benefit cost ratio is greater than one (1.19) and the undiscounted cost for a one per cent reduction in the state-wide bushfire risk is $16.0 million. The reduction in state-wide bushfire risk reduces from 2.10 per cent (if all SWER ACRs are installed) to 1.70 per cent.

The undiscounted cost to install new generation SWER ACRs on all SWER powerlines equates to $25.3 million for each one per cent reduction in the state's bushfire risk. This is more than the additional cost of $14.4 million for each one per cent reduction in the state's bushfire loss consequence to install an additional nine REFCLs under option 1b as compared to option 1a.

However, unless the number of SWER ACRs is reduced and excludes ZSSs at which a REFCL is to be installed, the undiscounted cost to reduce the state's bushfire risk is greater than the additional cost of $14.4 million for each one per cent reduction in the state's bushfire loss consequence to install an additional nine REFCLs under option 1b as compared to option 1a.

Powercor determines whether the costs associated with the new generation SWER ACRs are recovered from customers through the fixed component of the distribution tariff or the variable component of the distribution tariff. As discussed in section 7.1, for the purposes of this analysis, it is assumed that the additional revenue will be recovered equally from all customers based on energy consumption to determine a distribution and, therefore, a retail tariff impact.

The estimated maximum incremental impact on Powercor's customers' annual electricity bills of the installation of new generation SWER ACRs in Powercor's area is set out in Table 45. This excludes the estimated impact of new generation SWER ACRs already installed in the highest consequence bushfire risk areas. The maximum impact is estimated to occur in 2021, after the installation of all the additional new generation SWER ACRs.

Table 45 **Estimated maximum impact of the proposed regulation on customers' annual electricity bills (2015 dollars)**

Distributor	Increase in network tariff	Impact on residential customer	Impact on small business customer
	cents per kWh	$ per annum	$ per annum
Powercor	0.05	$2.29	$11.43

Note: Residential customer assumed to consume 5,000 kWh per annum; small business customer assumed to consume 25,000 kWh per annum. WACC assumed to 6.0% (pre tax real). Electricity delivered by Powercor for 2016-20 is from its 2016-20 regulatory proposal. Electricity delivered is assumed to grow from 2020-21 with the same compound annual growth rate as from 2015-20. The maximum estimated bill impact has been calculated on the basis of the costs of new generation SWER ACRs only; the avoided costs and other benefits have not been deducted. The retail electricity tariff is in the order of 30 cents per kWh.

Source: ACIL Allen

The maximum impact of the installation of new generation SWER ACRs on Powercor's customers' electricity bills is relatively modest with the maximum impact less than 0.2 per cent.

The impact on competition of this price increase will be immaterial, as the increase is immaterial and electricity costs tend to be a small proportion of a business's input costs. Energy intensive industries are generally connected directly to the transmission network, rather than the distribution network, and therefore do not pay distribution charges.

On balance, based on:

- **the high cost of a single major one in 25 year bushfire that is potentially avoided with the installation of new generation SWER ACRs (at least $300 million)**
- **the potential for the average annual bushfire cost (of around $80 million) to increase with the impact of climate change, which would increase the benefits associated with installing new generation SWER ACRs**
- **the relatively low unit cost of a new generation SWER ACR**
- **the modest cost to Powercor's consumers,**

the preferred option is to amend the regulations to enhance network protection on SWER powerlines, rather than not to require them or to limit their installation to specific ZSSs.

7.3 Preferred option – require powerlines in declared areas to be put underground or insulated (option 3)

The results from a cost benefit analysis on the proposed regulation to require powerlines in declared areas to be put underground or insulated are provided in section 6.4.3.

The cost benefit analysis indicates that there is a net benefit associated with replacing powerlines at the end of their life by insulating the conductors with the new covered carbon core conductor (option 3b – low cost scenario) and a net cost associated with the other scenarios:

- replacing powerlines within seven years (option 3a) – both low and high cost scenarios
- replacing powerlines at the end of their life (option 3b) – high cost scenario.

The reduction in state-wide bushfire risk under each scenario, and the undiscounted cost for a one per cent reduction in bushfire risk is set out in Table 46.

Table 46 **Estimated reduction in statewide bushfire risk and cost of reduction in risk**

Distributor			Reduction in state-wide bushfire risk	Undiscounted cost for a one per cent reduction in bushfire risk
Option	Replacement period	Scenario		(2015 dollars)
3a	Replacement by 2023	Low cost	10.4%	$53.0 million
		High cost	10.6%	$76.2 million
3b	Replacement at end of life	Low cost	10.4%	$39.4 million
		High cost	10.6%	$76.2 million

Source: ACIL Allen

While the options to replace powerlines in declared areas reduce the state-wide bushfire risk substantially, the cost to do so is substantial. The undiscounted cost for a one per cent reduction in the state-wide bushfire risk is substantially higher than enhancing the network protection for polyphase or SWER powerlines.

The costs associated with the Government's PRF are paid for by the Government. The costs associated with a regulatory obligation on electricity distributors to replace powerlines will be paid for by electricity customers. Table 47 sets out the estimated maximum impact on customers' retail electricity bills resulting from replacing powerlines in declared areas with the low cost technology within seven years.

The electricity distributors determine whether the costs associated with the powerline replacement are recovered from customers through the fixed component of the distribution tariff or the variable component of the distribution tariff. As discussed in section 7.1, for the purposes of this analysis, it is assumed that the additional revenue will be recovered equally from all customers based on energy consumption to determine a distribution and, therefore, a retail tariff impact.

Table 47 **Estimated maximum impact of the proposed regulation on customers' annual electricity bills (2015 dollars)**

Distributor	Increase in network tariff	Impact on residential customer	Impact on small business customer
	cents per kWh	$ per annum	$ per annum
AusNet Services			
Low cost scenario	0.30	$15.00	$74.99
High cost scenario	0.45	$22.62	$113.10
Powercor			
Low cost scenario	0.15	$7.46	$37.30
High cost scenario	0.21	$10.38	$51.89

Note: Residential customer assumed to consume 5,000 kWh per annum; small business customer assumed to consume 25,000 kWh per annum. WACC assumed to 6.0% (pre tax real). Electricity delivered by the electricity distributors for 2016-20 is from their 2016-20 regulatory proposals. Electricity delivered is assumed to grow from 2020-24 with the same compound annual growth rate as from 2015-20. The maximum estimated bill impact has been calculated on the basis of powerline costs only; the avoided costs and other benefits have not been deducted. The retail electricity tariff is in the order of 30 cents per kWh.

Source: ACIL Allen

The maximum impact on customers' retail electricity bills of a regulation to replace powerlines in declared areas with the low cost technology within seven years is estimated to be around 1.0 per cent, with the maximum impact in 2023.

The impact on customers' retail electricity bills of a regulation to require powerlines in declared areas to be replaced at the end of their life with the new insulated technology has not been estimated given the level of uncertainty in the assumptions required, particularly the actual phasing of powerline replacements. However, the maximum impact would be less than if powerlines are required to be replaced within seven years; the impacts as presented in Table 47 could therefore be considered a worst case. The maximum impact is likely to occur around 2040.

The impact on competition of this price increase will be marginal, as the increase is modest and electricity costs tend to be a small proportion of a business's input costs. Energy intensive industries are generally connected directly to the transmission network, rather than the distribution network, and therefore do not pay distribution charges.

On balance, the preferred option is to amend the regulations to require powerlines in declared areas to be insulated when they are replaced. It is currently estimated that there is a net benefit to do so using new technology, which is likely to be available when powerlines need to be replaced, and the impact on electricity customers' retail electricity bills is reasonable. It is considered prudent to proceed with this option given that it targets only the most dangerous areas of the state, results in a substantial reduction in the state's bushfire risk, and potentially avoids the very significant cost associated with a single major one in 25 year bushfire (at least $300 million).

8 Implementation plan

The *Victorian Guide to Regulation* requires that all RISs include an implementation plan to ensure the successful implementation of the regulations. Implementation plans should consider:

- communication of the new regulations to regulated entities
- how to transition to the new regime
- how to achieve compliance
- who will be responsible for administering and monitoring the regulations.

Communication

ESV and the PBSP have been in regular contact with the electricity distribution businesses that will be affected by the regulations to communicate the proposed regulations and seek feedback on implementation issues. Much of this has been done through the Distribution Business Reference Group that is convened by the PBSP.

The reference group will continue to be used as a means to communicate the final requirements of the regulations, as well as to monitor implementation, including progress and any unexpected challenges and delays to implementation.

Implementation

The electricity distributors will be responsible for implementing the regulation, the implementation of which will be staged over the life of the regulations.

Fifteen REFCLs will need to be installed by 2018, a further 17 REFCLs will need to be installed by 2020 with the balance (13) installed by 1 January 2023, prior to the sunsetting of the regulations.

Electricity distributors will be able to draw on the experience of the testing that is currently being undertaken at Kilmore South ZSS. In addition they will be able to share their experience with rolling out the installation of REFCLs, through the reference group.

There are a number of significant risks associated with the installation of REFCLs within this timeframe. The successful implementation of this regulation will rely on the development and implementation of a risk management plan by the reference group.

The new generation SWER ACRs will need to be installed by Powercor in the lower consequence bushfire risk areas by 2020. As Powercor has already installed new generation SWER ACRs in the higher consequence bushfire risk areas, there is a low risk associated with the implementation of this proposed regulation.

Powerlines in declared areas will be required to be put underground or insulated as and when they are replaced. As the electricity distributors have already replaced powerlines in the most dangerous areas of the state, there is a low risk associated with replacing the powerlines with the current technologies (undergrounding and insulated ABC).

It is assumed that the new technology (carbon core) will be available from 2020. Trials are currently being conducted on this technology. The reference group will need to continue to monitor the trial, identify the risks associated with the successful trialling of the technology and to address these risks as they are revealed.

Monitoring and compliance

ESV, as the body responsible for the regulations, will be responsible for monitoring implementation of the regulations. ESV will need to gather data on the following to determine whether the regulations are being implemented as intended:

- progress of REFCL installation – monitor annually
- the performance of each of the REFCL installations meets the standard in the regulations
- availability of the REFCL
- progress of new generation SWER ACR installation – monitor annually
- progress of powerline replacement – monitor annually
- number of bushfires started by powerlines:
  - in the most dangerous areas of the state where powerlines have been replaced
  - in the highest consequence bushfire risk areas where REFCLs have been installed
  - in areas supplied by SWER powerlines.

Sanctions

Section 98 of the *Electricity Safety Act 1998* 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) the bushfire danger arising from the supply network.

The *Electricity Safety Act 1998* provides for penalties for failure to comply of 300 penalty units for natural persons and 1500 penalty units for bodies corporate.

9 Evaluation strategy

To ensure regulations remain relevant and keep up with social and technological developments, it is important to conduct an evaluation at regular intervals. The *Victorian Guide to Regulation* requires ex-post evaluations to be conducted of all regulations to enhance the effectiveness and efficiency of regulations in meeting government objectives. In addition, for high impact regulations a mid-term evaluation is also necessary. To ensure appropriate evaluation of regulations, an evaluation strategy must be included in a RIS.

9.1 Key evaluation questions

The evaluation strategy should address the effectiveness of the regulation in meeting the objectives, as well as the efficiency. The following questions need to be addressed in the evaluation:

— Have the regulations been effective in reducing the likelihood of powerlines starting bushfires?

— Do the regulations constrain the costs of doing so to the most efficient level possible?

— Do the regulations maximise potential reliability improvements arising as an ancillary benefit of the regulations?

9.1.1 To what extent have the regulations reduced the likelihood of powerlines starting bushfires?

The imposition of heightened performance standards is intended to prevent harm by directly incentivising a large capital investment program by electricity distributors. This action is preventative in nature rather than remedial. Consequently the success of the regulations will be gauged by the use of *lead* indicators (measures which precede the event in question, but which have a causal link to that event).

There are three such measures proposed. These are listed in *proximity* order, that is, how far in advance of the event in question (bushfire starting) they take place:

- electricity distributors' commitments to deploy a quantum and type of asset in a given place, by a given time
- audits evidencing the extent to which these commitments have been met
- the number of fires actually started by powerlines.

These are detailed below with respect to which party is responsible for gathering the data, the source of data, the frequency of reporting, and the form in which it is reported.

Scheduled asset deployment

Under the *Electricity Safety (Bushfire Mitigation) Regulations 2015*, electricity distributors must submit a Bushfire Mitigation Plan (BMP) to Energy Safe Victoria (ESV) every five years. ESV can direct that the plan be updated at any point where there is a need to do so. The plans must detail how particular safety objectives will be achieved. With respect to the deployment of REFCLs, SWER ACRs and heightened powerline construction standards, the businesses will be required to commit to a particular quantum of asset deployment, indicating location and timing of completion.

BMPs are publicly available documents from individual businesses' websites.

Audits of actual asset deployment

Energy Safe Victoria will conduct audits of the commitments made in BMPs on an annual basis. The performance of the businesses is then contained in ESV's annual safety performance report, which is publicly available from the ESV website.

Fire starts

The *National Electricity (Victoria) Act 2005* establishes the powers for the operation of the 2010 *F-factor Order-in-Council*. The Order requires electricity distributors to report, on an annual basis, to the AER on the number fires that have been started by their networks. The Order then empowers the AER to reward or penalise businesses for fire start performance which deviates above or below their historic level of fire starts (the F-factor).

The AER publishes fire start data, and makes an F-factor determination, on an annual basis. This provides a sound measure of the ultimate impact of the proposed regulations.

9.1.2 How successfully have costs to consumers been constrained?

This outcome will be measured in the following ways:

Revenue determinations

The AER will make a determination to establish the quantum of costs electricity distributors may recover from customers in respect of the proposed regulations. This will comprise, in the first instance, a five-yearly revenue determination. As required, the AER will make subsequent cost pass through determinations for specific events linked to the regulations.

Consistent with the AER's primary function, these determinations will establish the efficient level of costs forecast to be incurred by the businesses to comply with the new requirements. The determinations are informed by submissions by the electricity distributors, as well as other interested parties.

Departmental review

The Department of Economic Development, Jobs, Transport and Resources (the Department) will continue to administer the PRF, obtaining pertinent information as to the actual costs of replacing bare overhead wire. The Department will also continue to commission research into technologies relevant to compliance with the regulations, and to conduct grant programs with a view to discovering new, more cost-effective means of achieving bushfire risk reduction.

These discoveries will inform Departmental submissions to the AER's revenue and cost pass through determinations. They will also be shared with the ESV and the electricity distributors.

9.1.3 Maximise reliability improvements

The deployment of REFCLs, and to a lesser extent the replacement of bare-wire powerlines with covered or underground cable, is expected to significantly improve the reliability of electricity supply to customers. The extent of this expected benefit is documented in this RIS.

The economic regulatory framework administered by the AER is designed to ensure that consumers pay an efficient amount for a given level of supply reliability. This is achieved through the AER's administration of the Service Target Performance Incentive Scheme (STPIS).

In brief, the STPIS establishes a baseline of reliability for each electricity distribution business, based on the historic performance of that electricity distribution network. Improvements over the baseline attract a financial reward; worsening of reliability attracts a financial penalty.

Customer minutes off supply

Customer reliability is measured by reference to *customer minutes off supply*. Electricity distribution businesses are required to report this information to the AER. The AER obtains this information annually in order to make STPIS determinations. The information is made publicly available from the AER's website.

Reporting format

The above measures will be reported on an annual basis in the Powerline Bushfire Safety Program (PBSP) Annual Report.

9.2 Evaluation audiences

The identified audiences for the evaluation strategy are provided in Table 48.

Table 48 **Evaluation audiences**

Evaluation audience	What do they want to know about the Regulations?	Why is it important that they know this information?
Primary (they will make a decision based on this information)		
Minister for Energy and Resources; Department of Economic Development	Extent to which regulations are lowering bushfire risk Extent to which costs have been constrained Extent to which customer reliability benefits are being realised	To determine whether future changes are required to the regulations
Australian Energy Regulator, Energy Safe Victoria, Electricity Distributors	The extent to which more cost-effective technologies have become available to meet the new regulatory requirements	To make accurate determinations of future costs which electricity distributors may recover from consumers
Secondary (for information only)		
Inspector General for Emergency Management	The extent to which bushfire risk is being reduced	To monitor delivery of the intentions of the Royal Commission
Electricity consumers in AusNet Services and Powercor distribution areas	The extent to which costs have been constrained The extent to which reliability benefits have been realised	These customers will pay for the network improvements, and will directly realise reliability benefits
Members of the public in high bushfire risk areas	The extent to which bushfire risk is being reduced	These customers are potentially at risk from future bushfires

9.3 Evaluation strategy summary

The evaluation strategy is summarised in Table 49.

Table 49 **Evaluation strategy summary**

Objective	Method	Data Source	Party responsible for reporting	Frequency	Publicly reported?
Reduce likelihood of powerlines starting bushfires	Businesses' commitments to asset deployment	Bushfire Mitigation Plans (BMPs)	Distribution businesses	Minimum every five years – detailing annual asset deployment	Yes
	Audit of deployment of assets cited in regulations	Safety Performance Reports	Energy Safe Victoria	Annual	Yes
	Measure the number of bushfires started by powerlines by time and location	F-factor Determination	Australian Energy Regulator	Annual	Yes
Constrain costs to the most efficient level possible	Revenue and cost pass through determinations	Submissions from interested parties including electricity distributors; and Victorian Government	Australian Energy Regulator	Every five years or more frequently (cost pass-through determinations)	Yes
	Review technologies available to meet standards, and their costs	Commissioned research, grants programs	Department of Economic Development, Jobs, Transport and Resources	Ad hoc	No
Maximise reliability benefits for customers	Customer minutes off supply	Regulatory Information Notices (RINs) issued further to the Service Target Performance Incentive Scheme (STPIS)	Australian Energy Regulator	Annual	Yes

10 Consultation undertaken

Consultation was undertaken with the parties listed in Table 50, specifically in relation to this RIS.

Table 50 **List of consultations**

Name	Company	Date consulted
Greg Williams David Matassoni	Powercor AusNet Services	24 March 2015
Mercedes Lentz	Consumer Utilities Advocacy Centre	25 March 2015
David Matassoni Phillip Bryant	AusNet Services	9 April 2015
Tony Marxsen	Marxsen Consulting	20 April 2015
Paul Fearon Robert Skene	Energy Safe Victoria	20 April 2015
Greg Williams G Parkinson	Powercor	22 April 2015
David Speairs Peter Wong Craig Savage	Jemena Jemena United Energy	22 April 2015
Anthony Bell Paul Dunn Anthony Seipolt	Australian Energy Regulator	28 April 2015
Grahame McClure Ed Viel Robert Riley Phillip Bryant Peter Wong Fakhrediin Mafaakher Brodie Stephenson Dene Ward Wayne McDonald David Wilkinson Robert Simpkin Mark Doherty Frank Crisci Steve McDonald Tony Walker Robert Skene Paul Dunn Evan Lutton Anthony Seipolt Tony Marxsen Gary Towns Alex Baitch	AusNet Services AusNet Services AusNet Services AusNet Services Jemena Jemena Powercor Powercor Powercor United Energy United Energy SA Power Networks SA Power Networks Orion, NZ Connetics, NZ Energy Safe Victoria Australian Energy Regulator Australian Energy Regulator Australian Energy Regulator Marxsen Consulting Facio Pty Ltd BES (Aust) Pty Ltd	26 May 2015 – workshop on REFCLs
Anthony Bell Paul Dunn Chris Pattas Anthony Seipolt	Australian Energy Regulator	27 May 2015
Paul Fearon Robert Skene	Energy Safe Victoria	28 May 2015

Name	Company	Date consulted
Roger Riley	AusNet Services	28 May 2015
David Matassoni	AusNet Services	
Philip Bryant	AusNet Services	
Dene Ward	Powercor	
Craig Savage	United Energy	

In addition, the Powerline Bushfire Safety Program within the Department periodically meets with the parties listed in Table 51, during which the development of the proposed regulations has been discussed.

Table 51 **List of consultations**

Forum	Organisations represented	Frequency of meetings
Powerline Bushfire Safety Program, Program Control Board	Department of Economic Development, Jobs, Transport and Resources Department of Premier and Cabinet Energy Safe Victoria	At least once every 6 weeks
Powerline Bushfire Safety Program, Distribution Reference Group	Department of Economic Development, Jobs, Transport and Resources Energy Safe Victoria AusNet Services Jemena Powercor United Energy	Once a month
Bilateral meetings	Emergency Management Commissioner	Once every 2 months
Bilateral meetings	CSIRO	Weekly

Energy Safe Victoria and the electricity distributors have been actively involved with the development of the proposed regulations. They generally support the proposed regulations and the analysis in the RIS. The three areas of concern that have been raised are:

1. **Timeframe** – the electricity distributors are concerned that the timeframe for installing REFCLs is too ambitious (45 REFCLs to be installed by the end of 2022), particularly given that Powercor has not yet installed any REFCLs in its electricity distribution area and AusNet Services' trials are ongoing. As discussed in section 3.3, the rationale for the proposed regulations is that the electricity distributors would not undertake the activity on a timely basis in the absence of regulations. The electricity distributors' concerns on the timeframe emphasise the need for regulations.
2. **Costs associated with installing REFCLs** – the cost benefit analysis assumes that the costs that will be incurred by the electricity distributors in installing REFCLs will be less than the costs submitted by them. The analysis assumes that only one third of lightning arresters will be replaced, rather than all lightning arresters, as proposed by the electricity distributors. A sensitivity analysis has therefore been undertaken to identify the sensitivity of the analysis to this assumption (refer Table 28). The sensitivity analysis identified that there continues to be a net benefit from the installation of REFCLs, even if it is assumed that the costs are as submitted by the electricity distributors.
3. **Reliability benefits associated with installing REFCLs** – the electricity distributors are concerned that the reliability benefits that have been assumed from the installation of REFCLs will not be realised, or that the installation of REFCLs may result in disruption to or the reduced reliability of supply. However, even if this is the case, the bushfire benefits alone justify their installation (see Figure 13).

Appendix A Prescribed particulars for Bushfire Mitigation Plans

Regulation 7 of the Electricity Safety (Bushfire Mitigation) Regulations 2013 prescribes that a Bushfire Mitigation Plan must contain the following:

4. For the purposes of section 113A(2)(b) of the Act, the following are the prescribed particulars—
   a) the name, address and telephone number of the major electricity company;
   b) the position, address and telephone number of the person who was responsible for the preparation of the plan;
   c) the position, address and telephone number of the persons who are responsible for carrying out the plan;
   d) the telephone number of the major electricity company's control room so that persons in the room can be contacted in an emergency that requires action by the major electricity company to mitigate the danger of bushfire;
   e) the bushfire mitigation policy of the major electricity company to minimise the risk of fire ignition from its supply network;
   f) the objectives of the plan to achieve the mitigation of fire danger arising from the major electricity company's supply network;
   g) a description, map or plan of the land to which the bushfire mitigation plan applies;
   h) the preventative strategies and programs to be adopted by the major electricity company to minimise the risk of the major electricity company's supply networks starting fires;
   i) a plan for inspection that ensures that—
      i) the parts of the major electricity company's supply network in hazardous bushfire risk areas are inspected at intervals not exceeding 37 months from the date of the previous inspection; and
      ii) the parts of the major electricity company's supply network in other areas are inspected at specified intervals not exceeding 61 months from the date of the previous inspection;
   j) details of the processes and procedures for ensuring that each person who is assigned to carry out inspections referred to in paragraph (i) and of private electric lines has satisfactorily completed a training course approved by Energy Safe Victoria and is competent to carry out such inspections;
   k) details of the processes and procedures for ensuring that persons (other than persons referred to in paragraph (j)) who carry out or will carry out functions under the plan are competent to do so;
   l) the operation and maintenance plans for the major electricity company's supply network—
      i) in the event of a fire; and
      ii) during a total fire ban day; and
      iii) during a fire danger period;
   m) the investigations, analysis and methodology to be adopted by the major electricity company for the mitigation of the risk of fire ignition from its supply network;
   n) details of the processes and procedures by which the major electricity company will—
      i) monitor the implementation of the bushfire mitigation plan; and
      ii) audit the implementation of the plan; and
      iii) identify any deficiencies in the plan or the plan's implementation; and

iv) change the plan and the plan's implementation to rectify any deficiencies identified under subparagraph (iii); and

v) monitor the effectiveness of inspections carried out under the plan; and

vi) audit the effectiveness of inspections carried out under the plan;

o) the policy of the major electricity company in relation to the assistance to be provided to fire control authorities in the investigation of fires near the major electricity company's supply network;

p) details of processes and procedures for enhancing public awareness of—

i) the responsibilities of owners of private electric lines that are above the surface of the land in relation to maintenance and mitigation of bushfire danger;

ii) the obligation of the major electricity company to inspect private electric lines that are above the surface of the land within its distribution area;

q) a description of the measures to be used to assess the performance of the major electricity company under the plan.

5. In subregulation (1)(i) supply network does not include a terminal station, a zone substation or any part of the major electricity company's underground supply network that is below the surface of the land.

Appendix B Definition of the highest consequence bushfire risk areas

The zone substations that are in the highest consequence bushfire risk areas are listed in:

- Appendix B.1 for option 1a
- Appendix B.2 for option 1b
- Appendix B.3 for option 1c.

B.1 Zone substations included in the definition of the highest consequence bushfire risk area for option 1a

The 15 zone substations that are in the highest consequence bushfire risk area under option 1a are:

- Bairnsdale
- Ballarat South
- Bendigo Terminal
- Camperdown
- Castlemaine
- Colac
- Eaglehawk
- Kinglake
- Maryborough
- Rubicon A
- Seymour
- Wangaratta
- Winchelsea
- Woodend
- Woori Yallock.

B.2 Zone substations included in the definition of the highest consequence bushfire risk area for option 1b

The 32 zone substations that are in the highest consequence bushfire risk area under option 1b are:

- Bairnsdale
- Ballarat
- Ballarat South
- Barnawatha
- Belgrave
- Bendigo Terminal
- Camperdown

- Castlemaine
- Charlton
- Colac
- Eaglehawk
- Eltham
- Ferntree Gully
- Geelong
- Gisborne
- Kalkallo
- Kilmore South (2nd transformer)
- Kinglake
- Lilydale
- Mansfield
- Maryborough
- Moe
- Myrtleford
- Ringwood North
- Rubicon A
- Seymour
- Wangaratta
- Waurn Ponds
- Winchelsea
- Wodonga and Tallangatta
- Woodend
- Woori Yallock.

B.3 Zone substations included in the definition of the highest consequence bushfire risk area for option 1c

The 45 zone substations that are in the highest consequence bushfire risk area under option 1c are:

- Ararat
- Bairnsdale
- Ballarat
- Ballarat South
- Barnawatha
- Belgrave
- Benalla
- Bendigo
- Bendigo Terminal
- Camperdown
- Castlemaine

- Charlton
- Colac
- Coolaroo
- Corio
- Eaglehawk
- Eltham
- Ferntree Gully
- Geelong
- Gisborne
- Hamilton
- Kalkallo
- Kilmore South (2nd transformer)
- Kinglake
- Koroit
- Lang Lang
- Lilydale
- Mansfield
- Maryborough
- Merbein
- Moe
- Myrtleford
- Ringwood North
- Rubicon A
- Sale
- Seymour
- Stawell
- Terang
- Wangaratta
- Waurn Ponds
- Winchelsea
- Wodonga and Tallangatta
- Wonthaggi
- Woodend
- Woori Yallock.

Appendix C Proposed regulations

Appendix D Feeders to be replaced under option 3

The feeders to be replaced under option 3 are set out in the following table.

Table D1 **Feeders to be replaced under option 3**

Area	Feeder
Dandenong Ranges	BGE11
Dandenong Ranges	BGE12
Dandenong Ranges	BGE21
Dandenong Ranges	BGE22
Dandenong Ranges	BGE23
Dandenong Ranges	BGE24
Dandenong Ranges	BRA14
Indigo - Chiltern	BWA22
Dandenong Ranges	BWR13
Dandenong Ranges	BWR34
Colac Otway Ranges	CLC005
Surf Coast - Otway Ranges	CLC007
Mount Alexander - Muckleford Nature Reserve	CMN002
Mount Alexander – Maldon	CMN003
Mount Alexander – Maldon	CMN004
Mount Alexander - Muckleford Nature Reserve	CMN004
Mount Alexander – Maldon	CMN005
Dandenong Ranges	CYN21
Dandenong Ranges	CYN33
Dandenong Ranges	FGY14
Dandenong Ranges	FGY23
Dandenong Ranges	FGY32
Dandenong Ranges	FGY33
Dandenong Ranges	FGY34
Murrindindi - King Lake	KLK1
Dandenong Ranges	LDL13
Murrindindi - King Lake	LDL14
Dandenong Ranges	LDL21
Murrindindi - King Lake	LDL23
Yarra Ranges - Healesville	LDL23
Dandenong Ranges	MDG1
Nillumbik - Warrandyte	RWN24
Nillumbik - Warrandyte	RWN31
Surf Coast - Otway Ranges	WIN011
Colac Otway Ranges	WIN011
Surf Coast - Otway Ranges	WIN012
Colac Otway Ranges	WIN012
Surf Coast - Otway Ranges	WIN013
Macedon Ranges - Kyneton	WND011
Macedon Ranges - Kyneton	WND014
Macedon Ranges - Kyneton	WND021
Macedon Ranges - Kyneton	WND023
Macedon Ranges - Kyneton	WND024
Surf Coast - Otway Ranges	WPD013
Colac Otway Ranges	WPD014
Colac Otway Ranges	WPD021

Area	Feeder
Warburton	WYK11
Warburton	WYK23
Murrindindi - King Lake	WYK24
Yarra Ranges - Healesville	WYK24
Warburton	WYK24
Hepburn - Clunes	BAN006
Ballarat - Creswick	BAN007
Hepburn - Newstead	BAN008
Hepburn – Clunes	BAN009
Ballarat – Creswick	BAN009
Pyrenees - Snake Valley / Smythesdale	BAS011
Pyrenees - Snake Valley / Smythesdale	BAS021
Greater Bendigo - Bendigo	BET001
Greater Bendigo - Bendigo	BET004
Greater Bendigo - Bendigo	BET006
Greater Bendigo - Bendigo	BETSCTN
Greater Bendigo - Bendigo	EHK024
Greater Bendigo - Bendigo	EHK031
Greater Bendigo - Bendigo	EHK032
Murrindindi - Flowerdale/Hazeldene	KLK1
Mitchell - Kilmore	KLO14
Mitchell - Lancefield	KMS1
Mitchell - Kilmore	KMS1
Mitchell - Lancefield	KMS21
Murrindindi - Flowerdale/Hazeldene	MDI1
Mount Alexander - Newstead	MRO007
Hepburn - Newstead Extension	MRO007
Murrindindi - Narbethong	MVE01
Mitchell - Seymour	SMR1
Mitchell - Kilmore	SMR3
Mitchell - Seymour	SMR3
Mitchell - Seymour	SMR4
Mitchell - Seymour	SMR5
Murrindindi - Flowerdale/Hazeldene	SMR5
Mitchell - Lancefield	WND012
Mitchell - Lancefield	WND013
East Gippsland - Swifts Creek	BDL8
East Gippsland - Swifts Creek	BDL8G
Alpine - Myrtleford	BRT22
Indigo - Rutherglen	BWA22
Indigo - Rutherglen	BWA23
Corangamite - South of Lake	CDN002
Loddon - Serpentine	CHA006
Corangamite - South of Lake	CLC004
Colac-Otway - Gellibrand	CLC006
Loddon - Serpentine	EHK024
Baw Baw - Erica North	MOE14
Baw Baw - Erica South	MOE14
Baw Baw - Erica North	MOE21
Baw Baw - Erica South	MOE21
Mansfield - Jamieson	MSD1
Alpine - Myrtleford	MYT2

Area	Feeder
Indigo - Yackandandah	MYT2
Alpine - Myrtleford	MYT8
Mitchell - Broadford	SMR3
Indigo - Rutherglen	WN3
Indigo - Yackandandah	WOTS11

Source: Departmental analysis

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