Engineering Bushfire Resilience

A Best Practice Approach to Electricity Transmission Infrastructure Development

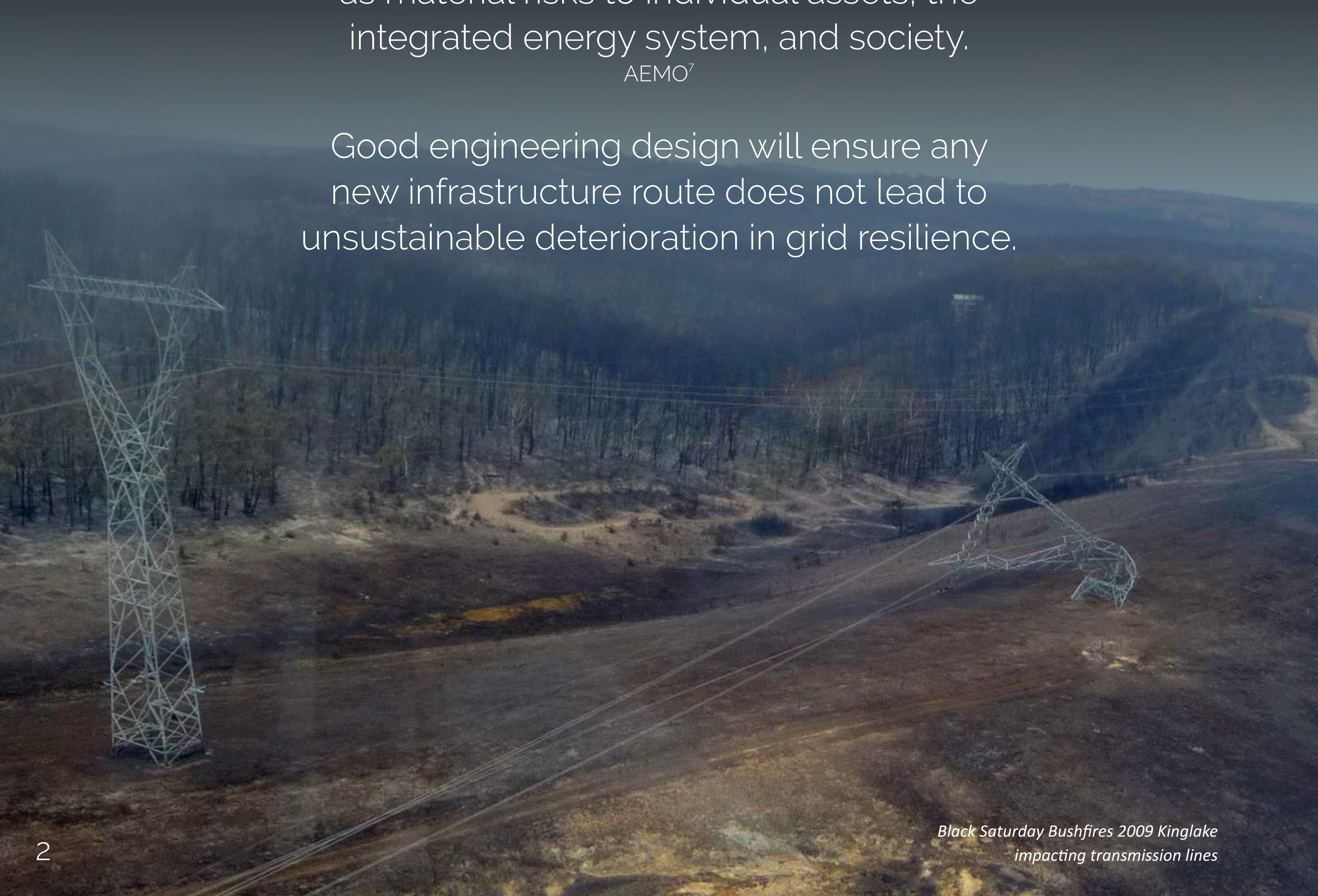
August 2021

Energy Grid ALLIANCE

Increasingly, energy system vulnerabilities to heightened climate impacts, particularly extreme weather and bushfire, are recognised as material risks to individual assets, the integrated energy system, and society.

AEMO[7]

Good engineering design will ensure any new infrastructure route does not lead to unsustainable deterioration in grid resilience.



Black Saturday Bushfires 2009 Kinglake impacting transmission lines

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Executive Summary

Natural hazard events have significant cost implications for network businesses and the economy more broadly. Maintaining power supply is linked to the ability of communities to absorb and recover from these types of events. Findings from a study commissioned by the Australian Business Round Table for Disaster Resilience and Safer Communities indicate that natural disaster events cost the economy on average $13 billion every year,[4] highlighting the need for proactive resilience measures.

In 2020 Victorian's saw an unprecedented number of cost pass through applications being made by electricity network businesses to recover costs sustained to network infrastructure from natural hazard events including bushfires[1] , severe storms[2] and winds[3] from extreme conditions experienced across Australia in 2019 and early 2020.

The capacity for electricity networks to prepare, absorb and recover from natural hazard events is referred to as resilience; the ability to continually supply energy during and after an incident.

Investing in reliability does not always deliver resilience, but investing in resilience is demonstrated to deliver significant improvements in both resilience and reliability, resulting in beneficial performance outcomes for customers using cost-effective and efficient network investment approaches.[14]

As most of Australia's transmission infrastructure was built decades ago, resilience and risk mitigation policies tend to assume a reactive approach to protecting existing essential infrastructure. As we transition to renewable energy and construction of new large-scale electricity transmission networks, all stakeholders have an opportunity and responsibility to proactively engineer resilience by avoiding areas of high risk in the first place.

In the case of the Western Victoria Transmission Network Project (WVTNP), the first of the next generation of transmission investment, it is concerning the preferred final transmission corridor has been routed through one of Victoria's highest risk bushfire prone regions. Best practice bushfire-resilience approaches are **not** being applied in this case. A resilient approach would have proactively determined this corridor would lead to unsustainable deterioration in grid resilience given the inherent bushfire risks. This lack of proactive resilience engineering contravenes years of informed research, consultation and government-led resilience reform.

Introduction and Context

Victoria is one of the most bushfire-prone areas in the world. The state's extreme weather events are becoming more frequent and intense, which is leading to more severe bushfires that burn more land. The recent 2019–20 bushfire season had a devastating impact on human life, wildlife, flora and infrastructure, and adversely affected Victoria's economy. It is not possible to eliminate the threat of bushfires. However, the government plays a key role in reducing the risks they pose to people, property and the environment.[5]

The health, safety and prosperity of the Victorian community are reliant on essential services supported by certain infrastructure. Emergency events – whether natural or human-induced – pose a risk of disrupting the ability of critical infrastructure providers to deliver essential services to the community. Furthermore, the complex, interconnected and often interdependent nature of critical infrastructure in modern society increases the risk of a disaster-causing systemic failure.[6]

Increasingly, energy system vulnerabilities to heightened climate impacts, particularly extreme weather, are recognised as material risks to individual assets, the integrated energy system, and society.

Scientists warn that extreme weather will increase in both frequency and severity as climate change accelerates. The Australian Energy Market Operator (AEMO) is acutely aware of this[7], warning climate change poses "*material risks to individual assets, the integrated energy system, and society*".

A Grattan Institute energy expert and bushfire mitigation specialist, Tony Wood, says "*the government should move to bury power lines underground where possible in the storm and fire-prone area*". Tony has called for "*a serious assessment of whether electricity wires should go underground in communities vulnerable to storms and fire*".[8]

While the reference here is to power lines, the same risk mitigation measures should be applied to electricity transmission lines too.

"We're building community resilience and safety as we face the impact of climate change and see hotter summers with longer bushfire seasons."
Quote attributable to Minister for Energy, Environment and Climate Change Lily D'Ambrosio

The 2019-20 summer was particularly challenging for Australia's physical gas and electricity infrastructure, with notable increases in heat and fire impacts consistent with climate change projections. These impacts highlight the need to integrate resilience measures into the planning, routing, design and assessment of transmission projects and upgrades. The vulnerability of key transmission lines and other major energy infrastructure to fire impacts and extreme weather events needs to be addressed.

Routing critical transmission infrastructure away from bushfire prone areas or underground, would enable our energy networks to better withstand extreme weather events and build increased network resilience.

Increasing frequency of dangerous fire weather poses a threat to most assets, with a particularly high operational risk to transmission lines due to heat and smoke. It is also an important consideration in transmission line route selection and design.

According to AEMO[7], "***good engineering design will ensure that any new infrastructure does not lead to unsustainable deterioration in grid resilience. Building additional transmission lines along a bushfire prone transmission corridor would be an example of resilience deterioration***."

Black Saturday Bushfires 2009 Kinglake impacting transmission lines

Deteriorated Grid Resilience

The recent bushfires, and subsequent strong winds and heavy rain events across Australia's east coast hit the electricity network hard. Critical infrastructure was affected, including poles and wires, regional substations and state interconnectors, which led to blackouts for tens of thousands of homes. Rural towns and those living on the edge of the grid were most affected where there is currently a lack of network contingency or back-up supply.

However, lengthy network recovery times, intermittent surges in wholesale power prices and thousands remaining without power weeks later, highlighted a lack of overall system resilience.

During the fires, AEMO acknowledged weaknesses across the National Energy Market (NEM)[9], calling it a '*wake-up call for further investment*' and a clear need for more government support.[15]

While energy generators and operators have developed their own business continuity and emergency plans, AEMO is looking to establish a 'best practice' approach to improving resilience across the energy supply chain[7]. This includes looking to international case studies and lessons learnt, such as the recent Californian bushfires.

Weather-related cost pass through applications

There has been a growing increase in the cost pass through applications being submitted for damage sustained from natural hazards. Summarised below are a list of cost pass through applications made by networks in the period 2015-2020.

Applications are expected to increase in line with predictions of increased severe weather events.

Application Date	Network Operator	Nature of Event	Cost Impact
31 August 2020	Endeavour	Bushfire	$31.27m
31 July 2020	Ausgrid[2]	Storm	$37.6m
10 July 2020	AusNet[3]	Wind	$25.07m
14 May 2020	AusNet[1]	Bushfire	$21.50m
21 August 2015	Ausgrid	Storm	$43.2m

Natural disasters impact infrastructure, essential services and communities and can cost billions of dollars. In a paper prepared by Deloitte Access Economics[9] for the Australian Business Round Table for Disaster Resilience and Safer Communities, it was estimated that natural disasters cost Australians over $13 billion every year. As the frequency and intensity of natural disaster event increases, these costs are expected to escalate over the coming years.

Current regulatory arrangements place greater emphasis on managing network resilience through **recovery measures, such as via holding insurance or the cost pass through mechanism**. These arrangements do not adequately support or incentivise other measures that look at mitigating the impacts of, or absorbing the impacts from, natural hazard events. This is a concern given the increased frequency in which natural hazardous events are occurring and the growing trend for insurance providers to withdraw coverage for natural hazardous events. This trend, if not addressed, is likely to create an over reliance on the pass through mechanism which in the long-term may not be the most efficient mechanism for mitigating against these types of risks[10].

Reliance on this mechanism is likely to lead to deteriorate grid resilience as it reduces the incentive of network planners and operators to invest in resilience as a priority.

Transmission lines through bushfire prone region

Energy System Vulnerabilities to Bushfire

Increasing frequency of dangerous fire weather poses a threat to most assets, with a particularly high operational risk to transmission lines due to heat and smoke. Bushfire risk to critical energy assets is an important consideration in transmission line route selection and design. Routing critical transmission infrastructure away from bushfire prone areas or underground, will enable our energy networks to better withstand extreme weather events and build increased network resilience into Victoria's energy grid.

To help defend Victoria's economy, communities and environment against extreme weather events and future-proof critical energy infrastructure, the Victorian Government, policymakers and network operators need to adopt best planning practices and design resilience into the grid by avoiding or undergrounding bushfire prone regions and heavily forested corridors.

Engineering resilience into the grid by adopting the least-regret approach and avoiding bushfire prone areas should realistically achieve a drastic reduction in risk to critical energy infrastructure and pass thorugh costs to energy consumers. Resilience is also an important consideration in transmission line route selection and design.

Overhead transmission network assets can sometimes be damaged during bushfires. It is more common, however, that lines are reclassified during bushfires to reduce the security risks arising from arcing due to heat and smoke. Failures and line reclassification reduce throughput, increasing costs and the risk of consumer outage. The impact of destructive events is addressed through system security and risk management margins. There is growing evidence these margins may need to be reconsidered for future extreme events.[7]

Considering the long terms economic and social costs, caused by increasing extreme weather events, the risk in building overhead transmission infrastructure through bushfire prone regions is that investments will not be optimally designed for the needs for resilience to bushfires or future climate change. This inherent limitation may not be fully appreciated until the future climate is experienced, by then it will be too late.

AEMO has sought to include cost-effective resilient characteristics in the development of the solution design and technology that form the optimal development path.

In the 2020 ISP, AEMO claim to have applied the principles of good engineering design in its approach to resilience in transmission planning through two criteria[7]:

- **Do no harm** – ensuring that any new infrastructure does not lead to unsustainable deterioration in grid resilience.
- **Opportunistic** – where there is an opportunity to increase resilience at minimal cost to consumers, the more resilient option will be taken. This helps inform the decision-making process but is not a key driver of investment.

While Energy Grid Alliance are concerned these principles have not been applied as routing transmission lines along a bushfire prone transmission corridor would be an example of resilience deterioration.

National Energy Rules clause 4.8.1

In accordance with NER clause 4.8.1[11] registered participants must promptly advise AEMO or a relevant System Operator of any circumstance which could be expected to adversely affect the secure operation of the power system or any equipment owned or under the control of the registered participant or a network service provider. A System Operator must, to the extent the System Operator is aware, keep AEMO fully and timely informed as to:

- Any present or anticipated risks to power system security such as bushfires.

As identified in the following case studies, the impact of bushfire events does not appear to have been thoroughly captured, or reported through project risk analysis.

By capturing extreme impacts more thoroughly, modelling may indicate an increased need for alternate routing practices to engineer a more robust and resilient network.

Increased Frequency of Bushfire Events

Extreme fire weather has increased in recent decades, especially in southern and eastern Australia, and this has been associated with an increase in the length of the fire season. Most climate change projections indicate that weather conducive to bushfires will become more frequent and more intense.

During summer 2019-20, there was an observed increase in the number of unplanned transmission network outages in all National Energy Market (NEM) regions compared to the previous summer. The largest increase was in New South Wales, mainly due to the impact of bushfires.[12]

The increase in unplanned outages in New South Wales was mainly due to bushfires impacting the transmission network between November 2019 and January 2020. A large proportion of bushfire-related unplanned outages occurred between 21 December 2019 and 4 January 2020. In particular, events resulting in LOR declarations included:

- **On 30 December**, there was an unplanned outage due to bushfires which significantly reduced the New South Wales to Victoria interconnector transfer limit and resulted in an actual Lack of Reserve Level 1 (LOR1) condition in Victoria.
- **On 4 January**, Victoria and New South Wales separated due to bushfire-related unplanned outages. During this event, reserves in New South Wales decreased quickly and an actual Lack of Reserve Level 2 (LOR2) was declared.

LOR1: This is the least severe level of alert.
In simple terms, it means that if the largest 'credible contingency' were to occur in the region, then AEMO expects that the region would be in LOR2 territory.

LOR2: This is the middle level of alert. It can also work in real time, or forecast.
In simple terms, it means that if the largest 'credible contingency' were to occur in the region, then AEMO expects that the region would be in LOR3 territory (i.e. Load Shedding).

In 2020, bushfires damaged vegetation types not previously expected, further indicating that climate change is changing the quantity and spread of vegetation more susceptible to bushfires. Given the compounding changes in vegetation and fire weather, experts in the climate science field predict a **spread in the areas at high risk**, and an **increase in fire frequency and intensity**.[12]

These factors pose great challenges for energy networks.

Anatomy of Bushfires in Australia

Bushfires in Australia spread as a thin front of flame, with flames usually about as thick as they are high. Forest fires normally travel at one to three km/hr, have flames 10-20 metres high and thick, and will pass a spot in 30-60 seconds. Severe forest fires travel at up to 12 km/hr, with flames 100-150 metres high and thick. Grass fires generally travel about 3 – 10 km/hr, but speeds of around 25 km/hr have been recorded.[13]

Fire weather, characterised by strong gusty winds, low humidity and high temperatures, results in bushfires, another natural hazard that has a major effect on electricity networks. Bushfires not only burn through above-ground network assets, but electricity networks are potentially a source of ignition for bushfires, particularly on extreme fire weather days *(Miller et al. 2017)*.

The costs and impacts of bushfires are increasing, and fires are becoming harder to manage as communities expand beyond the urban fringe and into bush. Not only does this place property in an environment where fire is a significant risk, but it also means that network infrastructure supporting properties requiring power is built in treed environments.

Typically, governments and critical infrastructure providers focus on responding to an incident after it has occurred, trying to manage the event and its aftermath. International agencies *(e.g. UNISDR, Sendai Framework)* encourage an approach that supports risk reduction and preparedness.

There is evidence to show *(NIBS 2017)* that every dollar spent reducing risk prior to an event replaces the four dollars that would need to be spent on recovery and response.

Importance of Whole-system Thinking

Recent extreme bushfires highlight the importance of whole-system thinking. Leah Howell, Energy Specialist, has commented that additional state-to-state connections and creating a more 'enmeshed' transmission infrastructure, as well as strategically located energy storage, more distributed renewable generation sources, and microgrids would all enhance the ability of the system to continue to function during these events.

Other measures such as back-up renewable generation at the fringe of grid, **burying lines where possible**, and utilising technology to isolate parts of grid/shut down areas at risk while keeping others running could all contribute to the wider system resilience. Some of these measures are set out in the resilience primer on Electric utilities: an industry guide to enhancing resilience.[16]

When designing new transmission lines, designers consider paths that minimise the risks associated with bushfires by avoiding vegetated areas where possible or, if not, then reducing fuel load under lines. They also diversify the risk associated with bushfires by building geographically diverse line paths, aiming to minimise the probability of losing multiple transmission lines to the same event. Understanding the future risk of bushfire as this varies regionally may inform the routing of transmission lines. If future bushfire risk is lower along a potential path, this could improve the investment case.[17]

While the number of bushfires ignited by overhead transmission lines is low, once started they have the potential to burn large areas. In 2018, a Camp Fire, started by a transmission line fault, devastated a huge swathe of California, claiming 85 lives. Estimation shows that wildfire damages in 2018 totalled $148.5 (126.1–192.9) billion (roughly 1.5% of California's annual gross domestic product), with $27.7 billion (19%) in capital losses, $32.2 billion (22%) in health costs and $88.6 billion (59%) in indirect losses (all values in US$).[24]

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 due to bushfire has the potential to impact far more customers than an interruption on a distribution powerline.

It is for this very reason that engineering increased resilience to the impacts of future fire weather is critical.

> Building transmission lines along a bushfire prone transmission corridor would be an example of resilience deterioration[7]
>
> *AEMO*

Transmission lines through bushfire prone region

Critical Infrastructure - Preparing for the Future

The *Royal Commission into National Natural Disaster Arrangements*[22] was established on 20 February 2020 in response to the extreme bushfire season of 2019-2020 which resulted in devastating loss of life, property and wildlife, and environmental destruction across the nation. As the events of the 2019-2020 bushfire season show, what was unprecedented is now our future.

The enquiry states that achieving an effective national approach to natural disasters requires a clear, robust and accountable system capable of both providing a comprehensive understanding of, and responding to, the aggregated risks associated with mitigation, preparation for, response to and recovery from natural disasters.

Interdependencies of Essential Services

A disruption to one essential service can trigger failures in dependent services. Electricity is central to the delivery of all essential services; communications, water and wastewater, natural gas, transport, petroleum, banking and finance. Damage to transmission infrastructure can cause outages of essential services including cellular phone sites which impacts the ability of governments, related agencies and the community to coordinate and respond to bushfires.

Australia's electricity transmission network is an interconnected system that runs from northern Australia to Tasmania, including SA. It is 'oblivious to the State borders'. The impact of extreme fire weather can impact interconnectors between states.

To ensure a resilient system, all levels of government — Australian, state, territory and local — have responsibilities for engineering critical infrastructure resilience to bushfires, natural disasters and extreme weather events.

Transmission lines through bushfire prone region

Responsibility and Accountability

According to the inquiry, resilience to natural disasters, including with respect to critical infrastructure and essential services, is a shared responsibility. Governments, critical infrastructure operators, individuals and communities all have a role to play in understanding the risks of disruptions to critical infrastructure, ensuring that others are aware of these risks as appropriate, and managing the consequences of outages.

Local governments are well placed to identify critical infrastructure on which their communities rely. They are also well placed to identify local risks, such as bushfire prone regions, that should be avoided when planning new network infrastructure.

State and territory governments have an important role in setting legal and regulatory requirements for critical infrastructure and coordinating resilience measures across their jurisdictions.

The Australian Government also has an important role in protecting critical infrastructure from national security risks.

Network planners and operators have responsibility for the planning, day-to-day management of the network and infrastructure assets, including continued supply of the service and restoring service following outages. This responsibility also involves identifying and assessing risks to assets and networks, and making appropriate plans to avoid these risks. If avoidance is not possible, then early action is required to mitigate them.

Individuals and communities have a responsibility to understand that natural disasters can lead to disruptions, and prepare for those circumstances. They also have a responsibility to inform network planners and government agencies of local risks, such as bushfire prone regions, that should be avoided when planning new network infrastructure.

When understanding and assessing risks we should not expect critical infrastructure to be completely resistant to damage, or for essential services to be immune to disruption. We can however, better understand the increased risk of extreme fire weather as a result of a changing climate, and use this understanding to engineer a more resilient network.

As most of Australia's transmission infrastructure was built decades ago, resilience and risk mitigation policies assume a reactive approach to protecting essential infrastructure. As we transition to renewable energy and with this, construction of new large-scale electricity transmission networks, we have the opportunity and responsibility to proactively engineer resilience by avoiding areas of high risk in the first place.

Bushfire Mitigation Plans

Electricity network operators in Australia are required under the Electricity Safety Act (1998) to provide a *Bushfire Mitigation Plan*[23] (5-yearly), including requirements set out in the Electricity Safety (Bushfire Mitigation) Regulations (2013), for approval by Energy Safe Victoria (ESV).

This Plan is required to detail how they will manage electricity transmission networks to mitigate bushfire risk and fulfil their commitment and obligation to provide energy consumers with a reliable and safe electricity supply.

Typically, key objectives of Bushfire Mitigation Plan are to:

- Describe the strategies and programs implemented to mitigate the risk of fire ignition from supply network assets
- Describe the processes and procedures for monitoring the implementation and effectiveness of the bushfire mitigation strategies and programs
- Describe the corrective action processes and procedures for ensuring effectiveness of the bushfire mitigation program
- Describe the processes and procedures that apply to operation and maintenance of the supply network in high bushfire risk areas during the fire season period and total fire ban days
- Nominate persons responsible for preparation and implementation of the Plan and their contact details
- Provide contact details in the event of an emergency, and
- Demonstrate compliance with the Electricity Safety (Bushfire Mitigation) Regulations 2013.

The primary focus of Bushfire Mitigation Plans is to minimise the risk of bushfire ignition and maintaining regular supply. According to AusNet Services[28], design, operation and maintenance regimes include the size and strength of the asset, the size of the easement, strict vegetation management, management plans, stringent regulations, the superior level of protection systems, the increased safety factors built into design, and the technology deployed to inspect and maintain the network.

Energy Networks Australia[29] have indicated there are significant benefits from removing network infrastructure from higher risk areas in the form of reduction in bushfire risk and enhanced network resilience.

Proactive Risk Avoidance

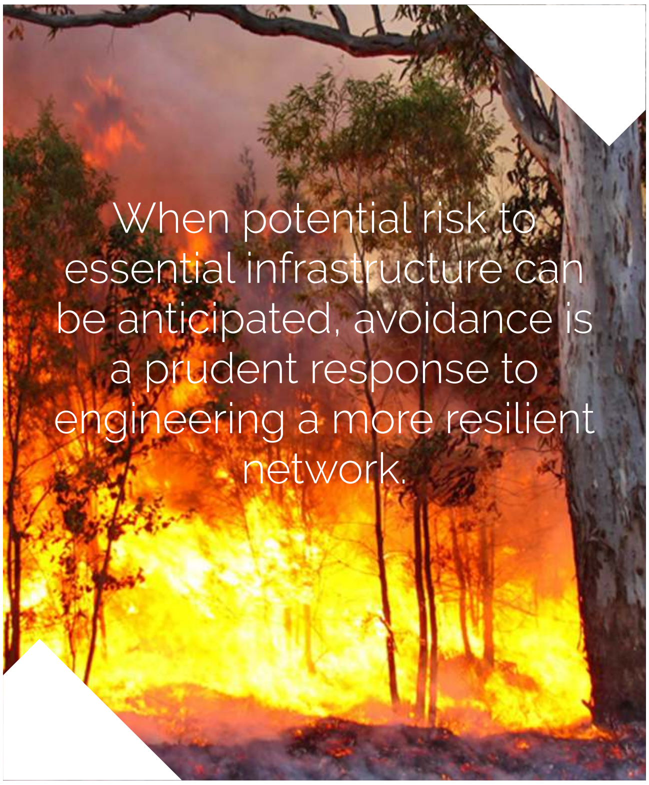
Bushfire Mitigation Plans relate to the 'operation' of existing networks. They do not address avoidance or mitigation measures when planning new electricity transmission routes.

It appears there is a lack of 'bushfire resilience policy' relating to engineering and routing of new transmission networks. This lack of, or limited, policy results in network planners and operators inadvertently adopting historical, legacy and reactive mitigation plans, believing they are acting in the best interest of energy consumers.

As network planners and policymakers develop a blueprint for the whole-of-system plan that maximises consumer benefits through a transition period of great complexity and uncertainty, it is crucial policies are developed that emphasise the critical importance of avoiding resilience deterioration to essential infrastructure.

When potential risk to essential infrastructure can be anticipated, such as routing transmission lines through bushfire prone areas, prevention through elimination of this risk is the first priority.

According to Emergency Management Victoria (EMV)[25], if there is a risk and the risk can be eliminated, strategies should be implemented for a safer, more sustainable community. As the residual risk reduces through mitigation, less effort need be invested in preparedness or response.



Case Study:
Western Victoria Transmission Network Project (WVTNP)

A proposed high-voltage overhead transmission network project that is receiving noteworthy objection and push-back from local communities is the proposed Western Victoria Transmission Network Project (WVTNP).

According to Forest Fire Management Victoria, the eastern half of the Grampians region is where the greatest bushfire risk sits, particularly for settlements in and around the **Wombat State Forest** and **Lerderderg State Park**, such as **Daylesford, Trentham and Darley**.[18]

Under severe weather conditions the bushfire risk to the area surrounding the Lerderderg State Park and Wombat State Forest could be extreme. The landscape surrounding the township of Darley provides the potential for very long fire runs from the north and west, over some areas of steep or very steep terrain. This landscape has the potential to generate extreme fire behaviour.

In 1983, on Ash Wednesday, a fire claimed seven people's lives in the Macedon, East Trentham area. The fire reached a final size of 29,500 hectares, destroying 157 homes and 628 other buildings. Whilst fires of this magnitude have not occurred in this area since, the potential consequence of large fires in this area remains extremely high.

The risk to human life and deterioration in grid resilience directly contravenes strategic planning and bushfire mitigation objectives which are to minimise the impact of major bushfires on human life, communities, essential infrastructure, economy and the environment. Human life should and will be afforded priority over all other considerations.

Overhead transmission infrastructure, proposed through bushfire prone areas and nearby township settlements, is highly inappropriate and represents one of the worst locations in the state for this project to be routed.

The Planning and Environment Act requires Responsible Authorities to administer and enforce the planning scheme.

This includes bushfire protection measures required to **strengthen the resilience of settlements and communities to bushfire through risk-based planning that prioritises the protection of human life.**[6]

The WVTNP proposes the development of a new transmission line starting at Bulgana, near Stawell in Victoria's west, and covering approximately 190km to the north-western Melbourne suburb of Sydenham.

The WVTNP is critical infrastructure required to unlock the renewable energy potential of western Victoria as a key Renewable Energy Zone and will help to deliver clean and affordable energy to Victorians. The project will also drive economic growth and bring new job opportunities to the region.

The project will include:
- a new terminal station to the north of Ballarat
- new 220 kilovolt (kV) double circuit overhead transmission lines from the new terminal station to Bulgana (via Waubra)
- new 500kV double circuit overhead transmission lines from Sydenham to the new terminal station
- several minor upgrades, including to existing electricity infrastructure.

Western (V3) Stage 1 | Category 2 refers to constructing a new 500kV double circuit overhead transmission line from North Ballarat to Bulgana. This represents an alternative to the proposed WVTNP.

Planning assessments underway as part of WVTNP need to be amended to include 500kV to Bulgana.

Case Study:
WVTNP Proposed Corridor - Highest Risk Bushfire Region

According to Forest Fire Management Victoria, Darley is in the **Highest Risk** category for the region. Coimadai, further to the north is in the High Risk category.

Overhead transmission infrastructure, proposed to the north of Darley, is highly inappropriate for this area and represents one of the worst locations in the state for critical infrastructure assets to be routed.

Overhead transmission infrastructure amplifies the risk of fire ignition and increases bushfire risk to one of the highest risk towns in the region.

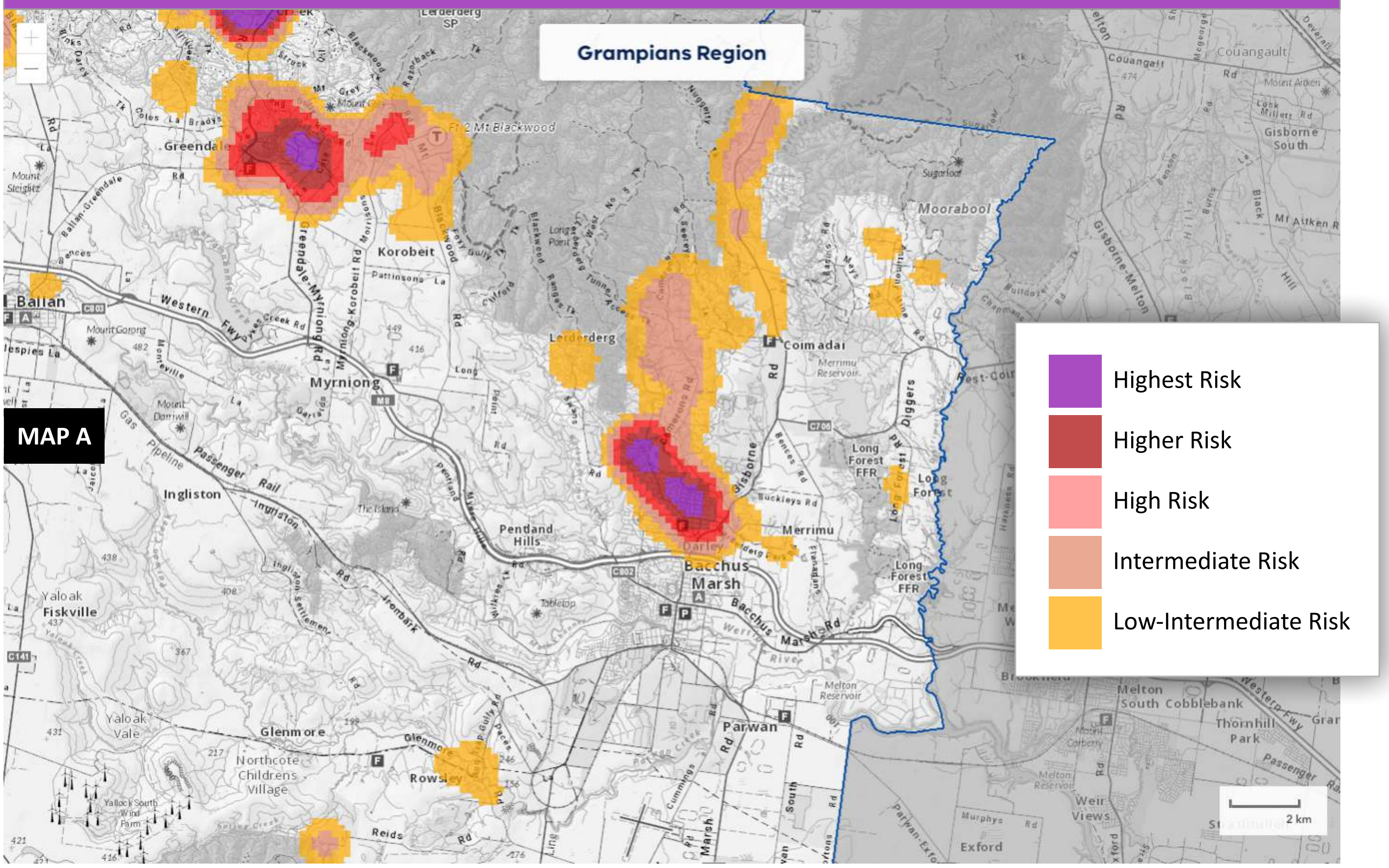
Proposed transmission infrastructure in highest risk bushfire prone area

Forest Fire Management Victoria (FFMVic) seasonal objectives identifies one of the following priorities for delivery: **Reducing risk to Victorian communities, priority assets and critical infrastructure, and ecosystem health and resilience.**[19]

As AEMO have rightly stated "**Building transmission lines along a bushfire prone transmission corridor would be an example of resilience deterioration**".[7]

The Climate science field predict a **spread in the areas at high risk**, and an **increase in fire frequency and intensity**.[12]

Map A[20] demonstrates potential risk of house loss in the Grampians region. It compares where houses could be destroyed by bushfire across the region. Different shades represent different levels of risk. As the shades progress from yellow through red to purple, more and more houses are potentially destroyed. The purple areas have the highest risk of house loss. More houses could potentially be destroyed by bushfire in these areas than in any other areas in this region.



(Map: Bushfire Planning - Fire Forest Management Victoria - Grampians Region[20])

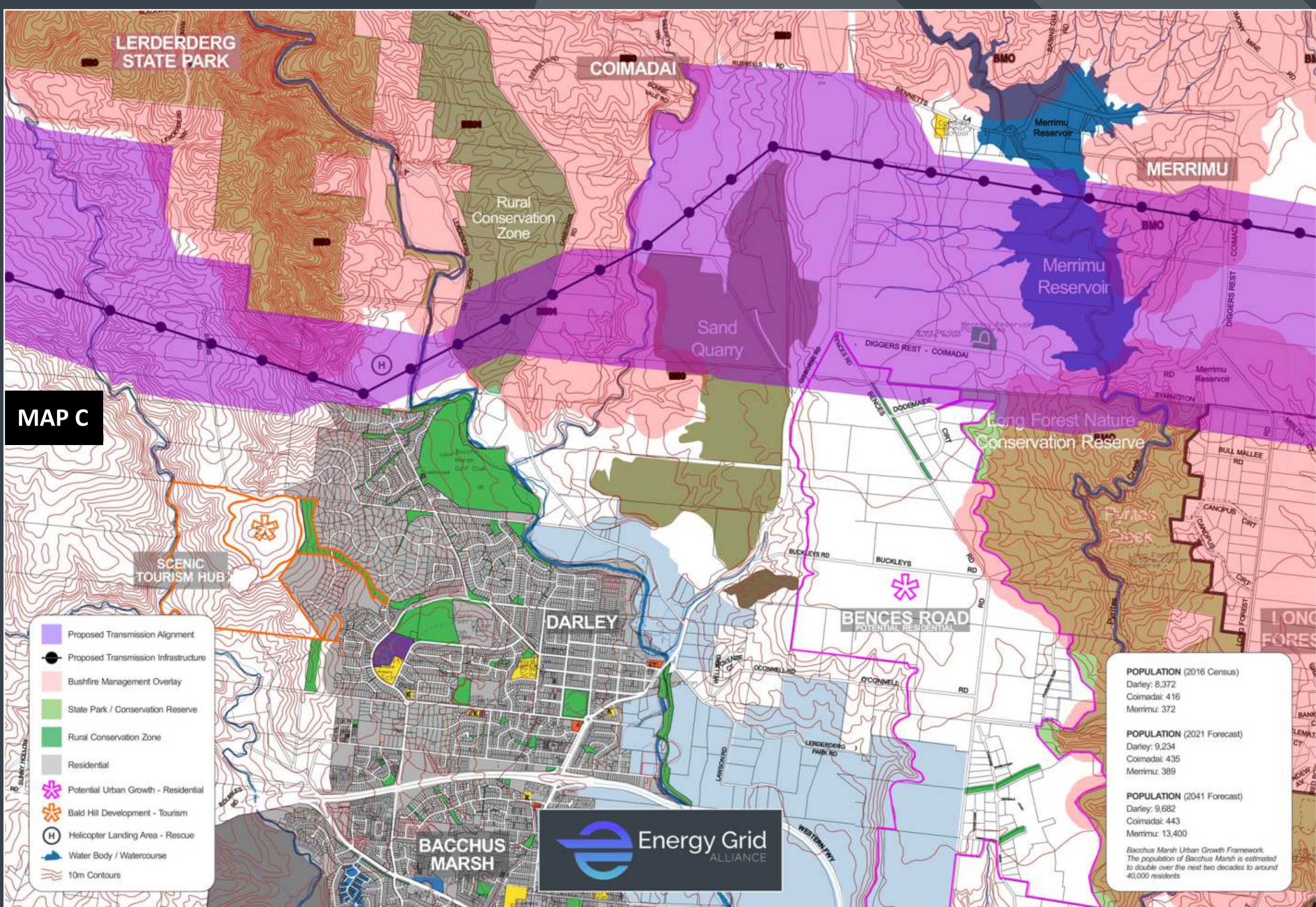
Case Study:
WVTNP Proposed Corridor Maps

Purple shading on **Maps B and C** represent what AusNet Services (the proponent for the WVTNP) believe to be the least constrained corridor. Energy Grid Alliance is concerned the principles of good resilience engineering design have not been applied to this project. If they had, routing through bushfire prone areas would have been avoided. It's concerning to note the *Transmission Corridor Fact Sheet (June 2021)*[26], which highlights considerations and key constraints for determining the final 'least constrained' corridor, makes no reference to consideration of bushfire risk, in one of the highest risk regions in Victoria.

Western Victoria Transmission Network Project (WVTNP) Proposed Final Single Transmission Corridor

Map Source: AusNet Services

Proposed WVTNP Final Single Transmission Corridor - DARLEY, COIMADAI, MERRIMU



Map Source: Energy Grid Alliance

Case Study:
WVTNP Proposed Corridor - How Bushfires Behave

In worst-case bushfire weather, north-westerly winds bring hot, dry air from central Australia to raise Victoria's temperature above 40°. Then, cold fronts, often with little rain, swing the wind to the south-west, initially at strong to gale force. These conditions can create bushfires with powerful convection columns. Ember storms, wind-blown debris, downbursts, fire tornadoes and explosive flares of igniting eucalyptus vapour are common[27]. This was the weather on 16 February 1983 (Ash Wednesday) and 7 February 2009 (Black Saturday).

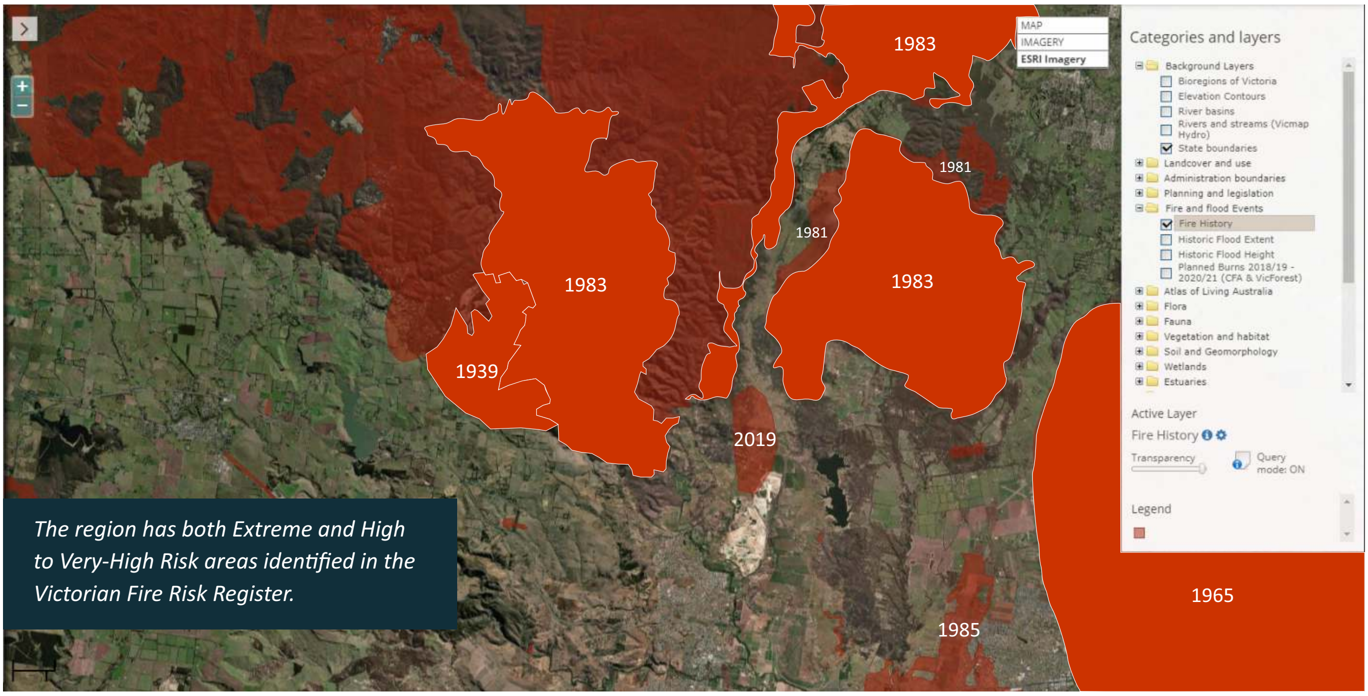
In the West Central[27] region, many regional cities, towns and communities in the landscape are surrounded by forest and scrub. Bendigo, Maryborough, Dunolly, Chewton, Fryerstown, Hepburn Springs, Daylesford, Trentham, Blackwood, Darley, Coimadai, Long Forest, Macedon and Ballarat are particularly vulnerable to bushfires: they are south-east of large areas of forest and bushfires in these areas can be quickly blown into populated areas by strong north-westerlies.

There is potential for intense bushfires in the forests on the upper slopes of the Lerderderg Gorge and Cobaw Ranges on the afternoons of hot and windy days, after several very hot days, in the middle of summer, or after a long drought.[27]

There have been many destructive bushfires in the West Central landscape. The potential for similar bushfires exists, and will continue to exist into the future.

Network planners should recognise this and proactively plan to avoid routing transmission lines through areas of highest risk to avoid network resilience deterioration and increase safety and resilience of communities.

> *"Community safety is our top priority – we're putting people first by reducing the risk of bushfires."*
> Quote attributable to Minister for Energy, Environment and Climate Change Lily D'Ambrosio



The region has both Extreme and High to Very-High Risk areas identified in the Victorian Fire Risk Register.

Destructive bushfires/grass fires

Bushfires and fuel reduction burns

Year of bushfire shown

(Map: Fire History - WNVTP Northern Corridor Lerderderg State Park and Wombat State Forest)

Summary of Recommendations

The following recommendations relate to planning and development of new overhead transmission infrastructure.

#	Resilience Recommendations
1	When potential risk to transmission infrastructure can be anticipated, such as routing lines through bushfire prone areas, prevention through elimination of this risk will be the priority. If there is a risk and the risk can be eliminated, strategies will be implemented for a safer, more resilient system.
2	That good engineering design will ensure that a new transmission line route does not lead to unsustainable deterioration in grid resilience. Where there is an opportunity to increase resilience, the more resilient option will be taken.
3	That building new or additional transmission lines along a bushfire prone transmission corridor will be avoided. If avoidance is not possible, lines will be buried to improve network resilience.
4	That new approaches to stakeholder involvement will be developed to support better design, planning and implementation of resilient networks. It is vital to have a framework in place that supports the energy, telecommunications and dependent sectors working collaboratively when planning new networks for resilience to natural disasters such as bushfires.
5	That governments, network planners, transmission infrastructure operators, communities and individuals will meaningfully consult on network planning to identify key risk areas to infrastructure when faced with extreme weather events. The outcome of consultation will be to build, maintain and improve network resilience.
6	That framework will be developed to encourage an approach that supports proactive risk reduction and preparedness during transmission route planning rather than a focus on responding to and managing an incident after it has occurred. As the residual risk reduces through proactive avoidance, less effort need be invested in a reactive response.
7	That historical data be harnessed to enhance forecasting and modelling of future fire weather events to better understand the risk and impacts associated with potential transmission corridors during network planning.
8	That community resilience, safety and protection of human life be afforded priority over all other considerations, including network route selection.

All stakeholders have an opportunity and responsibility to proactively engineer resilience by avoiding areas of high risk in the first place.

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Routing critical transmission infrastructure away from bushfire prone areas or underground, would enable our energy networks to better withstand extreme weather events and build increased network resilience.

Photo: Jo-Anne McArthur

Energy Grid
ALLIANCE

Energy Grid Alliance was established with the purpose of engaging with energy transmission companies, industry regulators, market operators, relevant peak bodies, government and communities to establish best planning practices for new energy transmission infrastructure and to advocate the importance of working with communities to acquire and maintain social license.

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