Bushfire performance of networks: improving the win/win game

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PRECIS

For thousands of years, nature and Australians shaped and managed the landscape by bushfire. In the 1790s Western Sydney local Dharuk tribe, helping Pemulwuy's Eora, threatened to drive John Hunter's boat people from their Hawkesbury and the Sydneytown colony to starvation by bushfiring the summer heat ripening wheat crops planted in their destroyed sustainable floodplain yam patches.[1] Modern day Australian community amenity is to varying degrees dependent upon electricity supply availability as much as on food, and risk management is increasingly in an environmental context.

- Integrated expert bushfire risk management prevention is better than post bushfire restoration cure. Yet when cure is needed, continuously improving prevention can be part of the cure in network restoration.

- Managing to minimise Australian regional and urban bushfire risk to power system assets is a strategic mix of preventative and post fire emergency and restoration project management.

- The distribution power system needs to go where its customers go, wherever they ask for supply and pay for it, and in a big and diverse country there are quite a wide range of customer-chosen locations and matching strategic mixes to the local conditions.

- The main point of the paper is to demonstrate the post Ash Wednesday 1983 improvements in integrated network design construction and maintenance management strategies used in the Upper Hunter to minimise bushfire risk to power lines, to maximise power supply continuity to customers arising from bushfire damage.

- An early ERA Report 5291, in 1962,after reviewing fires experience across the British Commonwealth, noted cropfires/grassfires/bushfires 'allowed to burn through or under powerlines can cause electrical fault caused by flashover from conductor to earth or between phase conductors, when air space near conductors are exposed to hot rising gases or flames from the fire'. This pre-green era report's recommendations encouraged easement space fuel reduction as the cheapest remedy, still echoed in Vegetation Electrical Overhead Line Clearing space diagrams guides and/or regulations before and after, that are not species specific with several risk distance allowances left for local conditions. (Its now known more clearly to be flashover by increased air gap conduction arising from heat or combustion causing ionised gases and air. Similar to gas torch flame hazard covered in most Electrical Safety Rules.)

- This and more environmentally acceptable control enhancement risk mitigation combination options now exist in community cooperation, selective asset design,

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[1] 'Six Australian Battlefields', Al Grassby & Marji Hill.

construction, maintenance, and emergency contingency plans, and feedback. 'Unpriced Values' need be communicated for stakeholder consensus (John Sinden) and safety consultation auditability (NSW OH&S Regulation 2001). Another Australian author on relevant Choice Modelling for estimating non-market values is Prof Jeff Bennett, ANU.

- The CSIRO's Fire Triangle (Heat, Fuel, Oxygen) is risk managed with application of the key fourth ingredient of 'Timing' for working mostly preventively on 'Fuel' and to a lesser extent on 'Heat'. Timing is both by electrical asset design, construction and maintenance with 'embodied hardwired protection technology', SCADA and proactive System Control and Emergency Field Operations Response Teams

- Risk Management is a subject in itself, but an approach example for setting a risk target is by the ALARP Principle (As Low As Practicable) as referred to in APESMA MBA Risk Management Course. Legal cases are slowly determining what is 'reasonably practicable' for ALARP to mean that 'the degree of risk can be balanced against time, trouble, cost and physical difficulty of implementing further risk reduction measures'. The underlying value judgements, as often for environmental issues, often involve care with balancing issues far beyond conventional cost benefit analysis.

- Bush Fire Risk Management in NSW in bushfire prone areas will soon be more systemised and audited by the Commissioner of Rural Fire Services under a bill now passed by both Houses of the Parliament and assented 10 July 2002. (Rural Fires and Environmental Assessment Legislation Act 2002, No 67). This is a valuable risk mechanism for mobilising collective knowledge especially timely if the 'be lean and agile like a small company' knowledge communication practice of Jack Welsh's huge General Electric is applied — 'clean, simple, effective'.

- Sourcing, assessing and using local knowledge/experience of fire conditions allows feedback continuously helping improve risk management. As Jack Welsh says it should at the speed of sound — voices — where once they were muffled and garbled by a gauntlet of approvals and the oppressive ministrations of staff reviews'.

- The diligence and skills of overhead line inspection teams and line asset restoration teams, and their feedback for researchers, design teams and strategists for continuous review and improvements can not be overstated as a critical success factor, eg trial use of modular steel poles for restoration.

- Running publicity campaigns to alert community, landowners, customers for informed tree selection and tree pruning care when near powerlines for bushfire risk management, including private powerlines is a key risk management control for easement 'encroachments' and street air space encroachment.

MATCHING THE AUSTRALIAN FIRE CYCLES

Bushfire Risk Mitigation by Network design, matched construction, and ongoing maintenance is the best form of risk cover. Although it is also important to have skilled experts timely available to review the local scene in context and community consensus, both for periodic bushfire hazard prevention strategy and for improvements learned from actual Bushfire cause/burn pattern evidence gathering while scene is 'still hot'. The latter is made difficult by the need to manage urgent restoration of supply to customers as safely and as quickly as possible often in physically hazardous and emotionally stressful circumstances.

There are different bushfire intensities and risk levels eg, as defined on NPWS web site.[2] The worst is 'wildfire', and is usually in summer (hot) high wind (oxygen) with high fuel.

The CSIRO website defines the fire hazard by the 'Fire Triangle':

> For a fire to thrive and spread it requires three things:
>
> 1. Fuel for the fire to burn
> 2. Air for the fire to breathe
> 3. Heat for the fire to continue burning
>
> Removal of any one of the sides of the Fire Triangle will extinguish the fire.

The CSIRO's Fire Triangle (Heat, Fuel, Oxygen) is risk managed with application of the key fourth ingredient of 'Timing' for working mostly preventively on 'Fuel' and to a lesser extent on 'Heat'. Timing is by long leadtime works by electrical asset network standards, design, construction and maintenance teams, by 'online' 'embodied hard-wired protection technology', with increasingly sophisticated SCADA and 24 hour proactive System Control and Emergency Field Operations Response Teams with contingency planning.

Available air or oxygen is enhanced by wind velocity.

Bushfire Risk Management for power network assets is mainly preventative removal of fuel and heat from proximity of the power network asset, and when after post-fire arrival into proximity of the asset, its mainly the removal of heat and/or oxygen if practicable.

Many power network assets that are themselves 'combustible' can be victims of fires of whatever cause if the fire conditions of heat and oxygen suffice.

I will assert that most bushfire causes are now non-electrical grid ones. Statistics to check that assertion need be regularly assessed as a risk review tool. The CSIRO Bushfire Research website is a good place to start. Also challenge data collectors — the statistical 'Default Cause' for 'too hard' should be 'unknown' not 'electrical causes',…then more science can be applied.

The impact of summer storm lightning strikes for fire ignition can be significant risk.[3]

The early ERA Report 5291, in 1962, noted cropfires/grassfires/bushfires allowed to burn through or under powerlines can cause electrical fault caused by flashover from conductor to earth or between phase conductors, when air space near conductors are exposed to hot rising gases or flames from the fire. This pre-environmentalism era report's recommendations encouraged easement fuel reduction as the cheapest remedy. Other and some more environmentally acceptable control options exist. Its now known to be flashover by increased air gap conduction in heat or combustion ionised gases and air.

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[2] www.npws.nsw.gov.au
[3] Scientific American Magazine, November 1989, page 26

Its also important for fire fighter safety or electricity worker safety to recognise that fires burning under or into live powerlines in relatively fuel-cleared corridor easements, when position is used for defensive fire fighting can electrically arc or flashover causing electrical step and touch hazard to firefighters. Damaged or burning power line assets are similarly electrically hazardous until isolated, proven de-energised and safety earthed. Informative Publications on risk managing the issues include the ESAA's Emergency Services Electricity Safety Blue Book, NSW Rural Fire Service Training, and NSW Forestry Circular No08/2001, 28/01/01 Interim Guidelines 'Fire Control near Powerlines'.

The Win-Win need for co-operation, timely and good communications between Network's System Control Room, Field Operations and the Fire Controllers is crucial for preventatives, and if its when fire then quick site access, making safe, and saving assets is the local perspective while the NEM and local Network System Control room's 'big picture' is to keep the whole grid or most of it stable and on — challenging if with many fire problem sites simultaneously causing arcing as fire fronts move under lines.

The supply availability performance of the power network asset then is largely dependent on minimising the risk of power network asset damage from bushfire and/or maximising the speed with which repair can restore it to service. This is particularly important for maintaining replacement water supply via pumping, sewerage and telecommunications to sustain communities fighting bushfires for long periods, even 24 hours a day, for weeks at a time.

The Australian Volunteer and willingness to help mates in trouble is a real community strategic resource, but skilled planning for fatigue management is key to effectiveness. Worksite Safety Risk Assessment method training and drill and is particularly relevant to keep workers safety focus proactive.[4] In spite of 'safe case' documentation auditable drills, the safest worker is one who remains resilient and self-aware.[5]

THE UPPER HUNTER SCENE

The Upper Hunter (Hunter Branch) which covers 75% of the EnergyAustralia distribution franchise area, like much of Australia, experiences a regular bushfire hazard cycle that mostly coincides with the el Nino cycle's drought impacts, although many summer fire seasons can have periods of hot dry risk times. The area varies from alpine forest, rain forest, dry sclerophyll forest fire-modified, scrubland, to natural and modified woodland grasslands, gazing, irrigated lucerne, vineyards, cultivation, coal mines, industrial and urban areas, dams and swamps. Large natural parkland areas include portions of Wollemi, Yengo and Mount Royal/Barrington, Towarri, Goulburn River National Parks and state forests and reserves.

The area is known as a scenic tourism and recreational region, diversified for wine, horses, export coal mining, industry, power generation, forestry and agriculture as well as for conservation.

Environmental sensitivity is a contemporary expectation and an often mandatory requirement in network design, construction and maintenance strategies, it often relates to vegetation

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[4] Refer to NSW WorkCover website.
[5] 'There's more to work safety than not getting hurt' by David Uren, *The Weekend Australian*, 29 April 2000, page 46.

proximity. This is important in placement of new power line assets and in managing the vegetation maintenance clearances to existing power lines and to substations for minimising risk of damage to network assets.

> Fires are not just limited to severe drought years or el Nino seasons as many people believe. Last year, in the height of a la Nina season (where above average rainfall is expected), the north coast of NSW had its worst fire season since 1994.[6]

NSW Forestry has over 190,000 hectares of eucalypt forest in Hunter Region.

The individual el Nino event's potential fire severity is modified by rural economic cycles, especially. The beef cycle, in respect to livestock stocking rates which can reduce grass fuel load on the mixed grazing and timbered areas that make up a large share of the overall area. Less dry vegetation per metre means less hazard for fire ignition and transmission from any electric arc sparks, or other non-electrical causes. Drought droving grazes the 'long paddock' too, reducing fuel for cigarette, car exhaust, and roadside pyromaniacs, fire initiation.

The Australian Bureau of Meteorology's publications/website show the el Nino cycle climate history drought severity maps and mentions memorable large bushfire events amongst other extreme events like floods in last 100 years.

Much bushfire mitigation activity by both community and utilities arose from the 1983 Ash Wednesday Bushfires in Victoria in which former SECV power lines and dropout fuses scenarios were cited as some probable causes of fire initiations in Royal Commission.

The Upper Hunter Bushfire Risk area includes almost the whole Upper Hunter region excluding some major wet irrigation area/vineyards, the ground cleared parts of open cut mine areas and the heavily urban areas wherein grass fuel, urban decorative trees, and power line conductor clearances/proximity are usually aesthetically and beneficially managed by landowners, Shire Council's and network contractor tree pruners. Rural sites are similarly managed even if only after prompting by the utility or the Local Bushfire Control.

Vegetation growth/fuel level build-up can occur in la Nina (wet cycle) years, and in wet spring growth.

During the dry extreme 40 degree C plus hot dry summer bushfire periods, the electrical network assets are at risk of damage by bushfires. This often can have non-electrical system causes, which can include microburst (mini-tornado or willie willie) wind damage, windstorm damage, human fire bugs or vandalism, accidental welding sparks, sparks from matches, cigarettes or camp fires, dry lightning strikes, car accidents, unleaded fuel vehicle hot exhausts in long grass, spontaneous combustion of combustible dusts such as coal or wheat flour by electrostatics or survey laser beam, of 'composting' coal-laden mine spoil, of swamps, of decaying farm products such as wet grain, wet hay, 'wet' animal waste stacks or authorised controlled burn-backs, animal/bird damage, smoulder from repetitive sparking of electric livestock fences, or open cut mine explosion detonations, military firing ranges, or post-initial bushfire passage remanent burning logs or tree roots fire reignition, hot vehicle brake pads, live mains arcing to/from high load vehicles driven or elevated inside electrical safety clearances.

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[6] Paul de Mar, NSW Forestry (2001).

It is notable that electrical grid power availability/continuity/restoration is often critical for timely rural customer and suburban customer water pumping for wetting down for bushfire prevention and fire damage mitigation in often sustained and repeated attack of fire front hazard with windage and defensive burnback firefighting. Access to restore power from network system assets for water availability is often essential to allow customer's local continued fire control, even though the Fire Control Officers are increasingly aware of their OH&S responsibilities and may be reluctant to grant access to electricity workers back in areas recently destabilised by fire damage. Respect for Fire Control Officers wishes in fires is often mandatory, as it is for Mine Statutory Officers for Mine Leases or Police scenarios.

Wood poles and crossarms are combustible given the appropriate levels of heat and oxygen and time to initiate combustion. The heat is usually related initially to proximity of fuel. (A grass fire or canopy fire burning past a wood pole can ignite the wood causing a sustained smoulder or wood pole fire long 'after' the fire front has passed by).

A modern hazard for some CCA-treated wood power poles is a reported relatively enhanced 'afterburn' effect, which can help CCA treated wood poles to continue to burnout long after the fire front passes. The researchers have developed various proprietary CCA adaptions to try to reduce the afterburn effect of CCA. The CCA water-soluble chemical leaching from the pole could in some options change afterburn effects over time (eg the leaching of Boron).

The creosote treated poles tend to have lesser afterburn. This afterburn problem if its applicable, is best remedied by prompt site access to line patrol and to put out pole fires after fire passes by, or prior removal of nearby vegetation fuel, or the use of non-wood poles such as concrete or steel poles or concrete/steel hybrid combinations (eg Stobie pole of South Australia). Steel Nailed wood poles or concrete/steel/wood hybrids are still combustible in wood component.

A few hot wildfire pole survivor specimens shown to me (1) spun concrete by Rocla (but not in EnergyAustralia network) concrete had minor concrete surface pitting, and (2) galvanised steel by INGAL had the galvanising discoloured with heat to a carbon grey in localised sections. Heat conduction in steel can utilise heat capacity of large poles for short intense heat impact and for strength issues.

Of greater risk significance are the conductors — the loss of long aerial conductor spans by bushfire burning-out their pole supports, viz wood crossarm or wood pole burn-out, can mean a long delay to restoration of electricity supply of several weeks if on rural radial systems without access to distributed or mobile step-up generation. Bare aerial conductor damage by observation, is normally minimal unless the aerial conductor is left close to sustained fuel, such as fallen on/near the ground for some time.

Wood poletop fires arising from storm-damaged/lightning cracked insulators, and/or moistened aerially deposited pollution tracking across surfaces of wood pole and wood crossarm designs can be reduced by live line cleaning, or design dressings for equipotential strapping, or equi-potential painting or stress — relieving gang nailing near stress points such as HV crossarm bolt holes. Aerial Pollution that causes this stress can be bushfire aerial carbonised debris, salt, coal dust, aerial fertiliser, etc and the problem is aggravated by long dry periods of deposition followed by only light misty rain or fog moistening.

THE PAST

Following the Victorian Barber Report (1977) and Victorian Ash Wednesday, 1983, for a while, Australian power utilities were the fashion or natural target of litigation if any bushfire damage occurred. More science and factual analysis were essential to both define and manage the issue, and to identify fraudulent claims and misdiagnosis from real cases.

The effects of conductor clashing arcing risk for fire ignition was well reported upon by A/Professor AD Stokes, University of Sydney, for the Electricity Supply Industry (see reference 1). The reported findings put the sparking induced risk of fire initiation scenarios into better clarity for risk management.

A/Professor AD Stokes' study of 'Electrical Pruning' of vegetation by live mains at subtransmission and distribution voltage levels facilitated knowledge in the Upper Hunter network to better understand risk issues for managing conductor clashing with vegetation.

The pragmatism of Stokes is better understood after reading Cooper's text for general Principles. ***Sparks do not always lead to ignition, unless several pre conditions arise***.

Bushfires and related liability claims against the electricity utility historically arose in hot dry summers in 1984–85 and 1990–91. Many were found not to be electricity utility network initiated. Some were and valuable lessons learned. However in many, the network assets were damage victims of the bushfires.

Between 1984–85 and 2001–2002 in Upper Hunter, a lot of risk management network investment was done to further identify and reduce bushfire initiation risk and network damage risk from bushfires.

This includes:

- By better and annual seasonal aerial inspections, (ie pre-bushfire season helipatrol line inspection of all bushfire prone areas not recently ground patrolled to locate broken crossarms or deteriorated poles, broken insulators, broken insulator ties, trees in mains, birds nests of wire near live conductors/transformers, etc).

- More local fire control preventative committee liaison and feedback, encouraging local rural fire controllers and brigades to help part-time city neighbours recognise their private line and vegetation hazards minimisation responsibilities.

- Strategic overhead line easement corridor vegetation trimming, even minching and trittering where environmentally acceptable. (Vegetation Safety Clearances are to Network Standard NS 179 and that is related to the Vegetation Management Guideline.

- Wider fire radiation separation distance for mowing strip perimeters maintained around substations.[7]

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[7] see ESAA "Fires in Substations Guide" C(b)29 1982, and more recent Building Code data, especially "Planning for Bushfire Protection" by NSW Rural Fire Service with Planning NSW, December 2001.

- Better worker vegetation directional pruning techniques to reduce ‘watershoot’ regrowth provide better species-specific tree shaping, and tree-care feedback.[8] Tree experts have developed an industry focused TAFE course.

- More vegetation clearing where permissible to environmental concerns especially inspecting and encouraging landowners to organise to clear their vegetation from their own powerlines, easement fuel reduction including some trittering and minching for reducing stumps and branch fragments for a complete mulching tilthe to promote low growth species.

- Tree Hormone Growth Retardant injections were looked at in the 1990s.

- Encouraging landowner tree replacement with more appropriate species or tree positions.[9]

- Utilising greater knowledge of native tree species and symbiotic micro-niche environments such as the boosted growth rate of a creek bank — located casuarina if with nitrogen fixing root-association Kentia bacteria. Environmental knowledge expansion has been significant in the recent decade.

- Retrofitting of sparkless DOLF’s, of better pressure relieved surge diverters, to minimise electric sparks initiation, especially in storms.

  (Surge diverters of the explosion relief type, now many with polymeric weathersheds, have been extensively developed and deployed since 1983 Ash Wednesday. This reduces probability of surge diverter explosion. The selecting and deploying of larger drop-out fuse ratings to reduce nuisance fatigue tripping after or during lightning storms has reduced reliability risk and arcing risk, which was also reduced by adopting better ‘sparkless’ design to AS 1055.)

- From Prof Darveniza et al research in Queensland, better surge diverter multi-shot type testing matches to better understood strike reality and reduces the risk of transformer failure by lightning over voltage. Also his team has shown 50% risk is by LV backflash and is reduced by surge diverters on low voltage terminals. That can ease transformer damage and bushfire risk scenarios. (Transformer tank rupture is a rare event although storm fault internal damage on distribution pole transformers is more common.)

- Inspection-prioritised replacement of old copper mains and rusty steel mains, (in service age is the not only determinant, as conductor corrosion rate is affected by local impacts of aerial pollutants such as mine coal dusts, salts, acid soil cultivation or road dust, aerial crop dusting, acid rain, AND the passage of grass/forest fires can produce acid smoke/rain too).

- Adding more Low Voltage spacers fitted to long bare conductor LV aerial spans and/or insulated LV ABC replacement to eliminate conductor clashing arcing risk.

- Pre-bushfire summer season helipatrol line skilled visual inspection of all bushfire prone areas not recently ground patrolled to locate any defects such as broken crossarms or

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[8] Phillip Hadlington, Judith Johnston “Australian Trees – their care and repair”.
[9] See EnergyAustralia Vegetation Management Guideline.

deteriorated poles, broken or cracked insulators, stretched or broken insulator conductor ties, trees in mains, birds nests of wire near live conductors/transformers, corroded conductors or conductor fittings, etc). Both flying or grounded Inspectors need good concentration and clear recording documentation and/or a digital camera and even GPS helps.

- Reliability Centred Maintenance-based systematic maintenance underpins the preventative's. Also consider exceptions, such as known extreme storms events, load cycling events or fault repeat frequency-diagnostic based line patrols using infra-red or Thermovision to detect hot spots in conductor connections before thermal runaway. AM radio can often detect cracked insulators, and a pick can sound towers for loose bolts.

- Aging assets follow a 'Bathtub Curve' fault statistic pattern for Mean Time between Failures. Rising fault rates highlight assets for increased patrols and risk review.

- Animal behaviour patterns are consistent but changing. Revisiting hazard re-occurrence. (Some native birds from Wedgetail Eagles to Magpies can sometimes make nests with wire that can either be blown into power system assets or be built on them).local fault histories provide evidence of animal or bird impact hazards or wind-blown wire birds nests if not obvious at time of design, eg migratory bird or bat roosts or flight paths — increased auto reclosing/interruption to supply is likely , but some risk of arcing causing sparks. For example after discovery, often increased conductor spacing can be sufficient remedy, although insulated conductors, spacers, insulator guards or line marker balls can suffice to reduce. Small birds, frogs are kept away from 11kV transformer bushings by plastic shrouds. Metallic possum guards and ABC rest guards stop cats, koala's, goanna's and possums climbing substation poles.

- Protecting line pole stay from rubbing hazards by itchy cattle and horses. (NB Fleas and lice are most active after cold snaps trigger egg hatching.) Bollard pole stays or fence rail proximity keep animals back leverage away from the stay wire.

- ***However timely annual pre-fire season line inspection is still best fire season defence.***

- Vigilance to Network Standards, Traffic Police/RTA approval procedures and public awareness campaigns to discourage or prevent arcing impact with live aerial mains from some illegal high load vehicles (such as road carried yachts) or mine plant accidents, travelling irrigator, crop harvester, cotton or sugar bin, auger, crane or even vineyard cropduster planes. Today terapoli or tiger-tails are fitted as a visible insulation and warning on many urban construction sites near live mains, and bright coloured UFO marker balls are fitted to warn drivers or flyers of critical frequented aerial spans. (Since early 1990s high span aerial conductors when erected to 90m above ground level clearance are fitted with bright coloured UFO marker balls to an Australian Standard. Similarly near designated airstrips bright coloured UFO marker balls are fitted to warn flyers of aerial spans). (Mines are working to AS3007.5 for mine plant needing higher ground clearances and in frequented haulage routes warning safety chains with rattlepipes and/or coloured UFO marker balls). The impact of rubber-tyred vehicles to live HV mains can cause conductor clashing, arcing, electrocution and rubber tyre conduction induced combustion heating and overpressure explosion — this is a particular problem for mine plant with large oxygen-containing tyres as the explosion can occur many hours after.

- Identifying local knowledge of conditions causing exceptional vegetation growth spurts, that exceed normal trimming cycle revisit expectations that can lead to vegetation reaching closer proximity near live mains and become a clashing conductor arcing risk. For example, a particular Casuarina (River Oak) was alleged to have grown at three times the expected rate limit for the species, when its roots were in a symbiotic relationship with a nitrogen-fixing Bacteria, Kentia, and on a creek bank.

- Watching for plantation forestry trimming or thinning of tree stands that can for many months wind destabilise remaining tree stands near powerlines until root systems adjust.

- Identifying high load vehicles travel paths for risk of legal ground clearance conductor impact clashing both along road and across easements, and improving traffic police approval system coordinations and utility coordination with load planners for high load movements. This is particularly important for busy main roads, boat ramps for yachts and in mine industry related tall plant movements especially beyond AS3007.5 mine clearances applicability. (Rubber-tyred vehicles making contact with live mains can explode tyres from fault current heating causing combustion and resulting overpressure).

- In late 1990s the use of LV ABC has grown, and some covered high voltage conductors (CCT) has been used in urban decorative tree areas, and tall native timbered corridors. A Written and presented small amount of HV ABC has been used in sensitive urban areas in decorative and native tree streets. However the other fire damage to HV ABC conductors insulation reported in wildfires in some places suggests this is not always a quickly restorable network design after sustaining fire damage.

- Continuously improving emergency on-call electricity worker team training, PPE, plant/vehicles and onsite communications to System Control and back-up teams, as well as auditable Management Contingency Plans to ISO9001, ISO14001 and AS/NZ 4801:2000. It helps to establish a management system culture for regular auditability and teaming , and the Sydney 2000 Olympics experience plus accreditations hard won to ISO9001, ISO14001 and AS/NZ 4801:2000 do help Enerserve.

- Do your teams know to ring ‘000’ to report fires? Reduce Time Delay — contingency plan, update and drill.

- New NSW OH&S 2001 Regulation and OH&S Act 2000 make site safety management more auditable with consultative safety pre job assessment.

- More use of AAC and AAAC conductors.

EXPERIENCE AND FEEDBACK

Experience has shown for prevention that annual pre-fire season ‘helipatrols’ of overhead lines annually since 1986, and ground line patrols were needed where low flying can’t be done safely, have helped avoid many potential hazards by prevention at appropriate time.

Extensive job planning, public alert advertising of helipatrol flying periods, telephone communications for public concerns, careful consensus for workers in preflight HAZOP briefings, feedback toolbox talks, debriefs, auditable HAC sheets, regular volunteer crew changeovers for fatigue management, general safety site management is practiced, and was generally done to EANSW EC 10 Guideline, which is now updated by ISSC 10 Guideline, 2001. OH&S Regulation 2001 requires auditable consultation in the safety hazard assessment and risk controls.

Local helipatrol experience has also shown usefulness of aerial patrol photography to record the line defects as discovered as it helps convey detail for expediting matched preparations for prioritised preventative repair/maintenance. Helipatrols are no joy flight low flying lines at about 80kph with frequent turns rises and hoverings to do more closer visuals of suspect defects.

Helipatrols using motivated and locally experienced line inspectors in frequent flight crew changeovers which helps flying fatigue prevention, and local ownership of the problem — linepersons focused by flight inspection can help local maintenance line crews, noting that remedy in hazard priority can be achieved by using local HV live line teams or emergency outages for dead work then, even as the helipatrol flights continue on.

After large bushfires and especially those sustained for days, the aerial assessment of damage area extent and its fire burn pattern is essential for assessing likely fire origin, and actual priority and extent of network repairs. Planning restoration of extensively damaged areas is best done after timely inspection reports from the air, especially if ground access is denied by continuing fire hazard. Regrowth of burnt native vegetation and grasses can be rapid, hiding fire cause clues. Fire history is invaluable for future replacement design optimisation.

Fire cause investigations expertise helps identify evidence quicker. The knowledge gained of fire causes /initiation methodology builds understanding for developing better prevention and economy — such as electrical pruning near distribution lines, and applying directional pruning to guide tree regrowth away from the electricity mains.

Cases include one presumed initiated by a casuarina tree sapling's exceptionally fast growth into LV private bare mains with strong wind causing conductor clashing arcing sparks over dry grass fuel, and wind driven fire spread).

This led to increased concern for homestead surrounds with decorative trees/shrubs left untrimmed, especially by absentee landowners, near their private bare low voltage service mains.

Since 1986, the management strategy included:

- pre fire season vegetation management
- inspection — targeted rusted steel conductor replacement program
- annual pre-season bushfire area helipatrols of overhead lines
- some use of CCT aerial conductor insulation near aesthetic valued trees for HV mains
- extensive use of LV ABC mains
- retrofitting of more sparkless DOLFs
- using improved polymeric pressure relieved surge diverters
- improved directional pruning methods
- training in safety and environmental awareness

- close local contact and feedback with local fire committee briefings.

After the utility teams are permitted to enter the post-bushfire burnt area, electricity supply restoration can often be achieved quickly in hours for most blacked-out area residents who are often still facing bushfires burning near there. Stopping further fire damage to network assets, eg from afterburn in burnt wood poles or impact of falling still burning or destabilised trees is a key factor.

WHAT CAN BE DONE TO MINIMISE NETWORK ASSET DAMAGE?

Undergrounding?

Yes please, but at what cost, and how many decades?

It is appropriate in some places, but it is often an expensive option. Especially expensive in already built-up urban areas and in rocky soil profile areas. Undergrounding distribution networks is not always totally fire proof as it usually is involving some aboveground structures — pillars SL columns, and substation kiosks. Also after bushfires pass, tree roots can burn for weeks underground (so long as oxygen is present), and fire destabilised trees and structures can fall to uproot underground cables.

To underground the subtransmission system, a serious look at modern HVDC technology may be appropriate for economy, system stability, and easier retrofits. 80kVdc bi-polar Directlink is a trial merchant link in northern NSW.

The advent of fuel cells and distributed micro-generation may change the distribution and subtransmission asset mix on thirty year to eighty year service life assets.

More fire — resisting overhead lines?

Since 1980s, many major new subtransmission lines have been built in concrete, or steel support structures mostly with OHEW and on non-effectively earthed systems. These structures are comparatively fire resistant, although some fire heat stress pitting and cracking of concrete poles or loss of galvanising thickness on steel is a manageable maintenance issue.

The metal melt/strength changes with temperatures are key risk design issues for wildfire extremes to balance with delayed access to put out wood pole fires.

The key to prompt overhead line restoration after fire is keeping the aerial conductors intact and aloft.

In 2002, a trial of steel poles was initiated for 22kV system bush fire damage replacements in a remote NPWS national park wilderness locality, and done with an appropriate OH&S consultative workplace safe work/toolbox review. Pole footings are direct butt burial with dry concrete backfill for quick install and pH buffering corrosion. Butt earthing of a 300mm diameter galvanised steel tube is relatively easy. Epoxy paint coating in the oxygenated soil zone is one adaption from URD streetlight column practice for added corrosion protection.

These INGAL 12.8m/8kN modular steel poles were also used for an earlier trial in a 25MVA 66/11kV zone substation as new 11kV busbar and transformer cable support structures in a fast two-day/night 11kV transformer cable augmentation/retrofit in1999. They were light to handle and install in tight clearances, and easy to drill and dress.

Field staff erection crew feedback after handling the steel poles has been positive.

Special mention is made of a 1991 — built SRA (RIC) Riverton Engineering galvanised steel pole 66kV/11kV power line in the Brisbane Water locality, where pole(s) sustained canopy fire damage in a 1994 bushfire and survived with minor fire discolouration of galvanised coating. A field inspection of this impressive 66kV RIC steel pole line in Brisbane Water NP was kindly permitted by RIC for the steel pole supplier INGAL to demonstrate field service fire resilience, 8 years on, to us).

It is prudent to check new materials for heat tolerance and fire resistance. Avoid thermal runaway and/or fire ignition by matching heat/time exposure at least for typical bushfire severity.

It is noted that in these wilderness bush firestorm scenarios the urban area focused 11kV CCT and ABC insulated aerial conductors insulation could have been fire damage casualties like the wood crossarms, and the shorter span stringing limitations of these insulated conductor systems would, in a rural system, expose the system to having more wooden pole supports per line kilometre to be burned and maintained. (Insulation charring is a deterioration issue for insulated aerial conductors exposed to canopy firestorm).

Bushfire resilience of power system assets can be reviewed too if locational circumstances change, eg. removal of shielding tree windbreaks, or less fire-resistant trees planted nearby.

The pole spacings or span length for insulated HV ABC aerial conductors is ideal for urban applications, but is much shorter than for rural bare conductors, and that is a problem away from the constraint for services at urban area block boundary spacings (compare 50–60m with 150–200m spans). That means adding many more support poles per kilometre for converting bare to insulated conductors in retrofits in rural regions, and bushfire damage risk to more pole assets).

In the review of Bushfire Hazard Control, the need for local knowledge and for local cooperation/liaison with local Bushfire Controllers and Brigades can not be over stated. An expert understanding of local vegetation species growth, habit, optimal pruning and their local climate responses is desirable for better vegetation risk management. Topography and prevailing seasonal winds and storm paths are also important for risk management. Debriefing is invaluable.

Fire damaged trees/fire-thinned forests, can mean remaining trees are destabilised for strong winds fall into lines for a period of time after the fire. System reliability is under risk of wind follow-up falls.

Fire resistant wind breaks can shelter assets from wind and fire.

Tree trunk/stump/root smokers can restart old bush fires if repeat conditions arise, including burning on remanent lower storey fuel left unburnt by fast canopy fire storm front. It is important to patrol and put out CCA treated poles and wood crossarms too. Remember burning CCA treated wood produces toxic fumes and should be handled and disposed of to appropriate procedures. The ash is also toxic after wood is burnt.

Although full width line easement clearing is often environmentally undesirable generally, it could be environmentally beneficial in some localities to maintain a mulched tilthe for smaller wild flowers and shrubs survival, for small animals habitat survival and as fire breaks to limit fire path expansion. Its also desirable risk managing to reduce vegetation fuel load near powerline support structures especially if they are of wood. One of the longest duration repairs to restore supply is a long span of conductor in difficult terrain — even with helicopters for stringing — it is quicker if support structures survive to keep conductors higher above the burning fuel.

Improving electrical fault finding technology such as line fault indicators, and more sophisticated on-line condition monitoring schemes and remote communication reporting (SCADA–linked) fault locating and remote operating schemes, also help mitigate power line hazard risks by quicker fault location detection and/or by remote-controlled power source isolation. Some sophisticated new trial systems may, when trialed, provide asset fault-site location accuracy for ionised air pre-arcing and/or arcing fault flashover sites, such as arising from lightning strike, insulation failure, poletop leakage fire or ionised gases from burning by bushfire passage past/under/through the powerline/substation. Such fire locational information could ideally be useful to Local Fire Controllers. Tapered concrete poles are now regularly seen in urban and rural/regional subtransmission lines at voltages of 33, 66, or 132kV, where line pole service lives of 60 to 80 years are desirable. For economy some shorter life mine customers insist on radial 66kV wood pole lines, in some cases lines sections being relocated in months or a couple of years.

Fire controllers already use lighting strike location systems (eg Kattron) as possible new bushfire location identifiers. This is often electrically unsophisticated being taken from web on ESI free public websites. Closer liaison for asset siting, GIS maps and ESI interpretation could be useful for diagnosis. For example 4kA lightning strikes cause little damage on a 5kA surge diverter rated system, whereas one 100kA direct strike could melt 11kV rural conductors and coincide with feeder protection/alarms time log.

Where possible, pole and lines should be designed to be away from risk eg. fire trap gullies, exposed ridgelines and places with high fire frequency history.

Steel poles are lighter than equivalent wood poles, can be shipped in sections, and can be more easily installed by helicopters into difficult access terrain. There is also a Washington Standard for frangible steel power poles for traffic route safety improvement. Concrete poles are heavier than wood pole equivalents (about double).

An EnergyAustralia trial remote site 132kV two-pole galvanised steel retrofit structure, supplied by ONESTEEL, Newcastle, was installed in a bushfire-prone area in 2001–2002, to support a long span. (60 year service life design).

The use of moulded and/or spun concrete poles in distribution MV lines is not new, but is usually constrained by EPR issues to be in CMEN systems or remoter low fault level systems Please note most rural regional distribution system HV fault levels are generally comparatively low when compared to urban systems, ie lower arc current energy. An 11kV remote rural system three phase fault level and earth fault level as low as 20–30kVA is not uncommon so that protection grading is a balanced compromise. Better arcing harmonic relays are a possible more selective earth fault scheme if ‘tuned’.

Where some overhead line damage as-inspected is caused by tree canopy fire storms, (see photo) the results were severe structural wood loss in poletops and wood crossarm damage and carbonation. Although often pole stumps, porcelain insulators and ACSR conductors/ties were found intact (especially on critical long span burnt support poles for fast restoration). This is a local clue that the wildfire intensity was of short duration and that favours steel more than wood.

To reduce fire damage re-occurrence of pole line damage by forest canopy fire firestorms, a trial use of 60 year service life designed thick galvanised steel modular distribution poles and galvanised steel crossarms/porcelain insulators was undertaken in 2002 to better 'fire-proof' the replacement assets in locations of recently burnt-out poles on a 22kV rural system.

This trial of modular conductive steel pole was possible only after a careful risk management review of corrosion control, EPR/electrical step and touch hazard and control. At 6 yearly inspection cycle (4 for wood), steel poles require less maintenance, inspection and treatment than wood for NPV (nett present value).

A review of cost/benefits of retrofitting for a CMEN system to improve EPR for conductive pole interpoling could be a future option.

Facilitating faster and safer access to site of fire damage

- Helipatrols with visual and/or thermovision can locate pole fires.
- To ensure wood poles burning from bushfire ignition are more quickly extinguished, live line washing and or the services of helicopter water bombers like 'Elvis' may be needed if Area Fire Controllers must deny ESI ground quick access.
- Alternatively electricity workers, if on ground access, need to satisfy Fire Controllers risk control requirement such as GRN radio channels to match fire control; ESI workers do basic fire safety induction training; have PPE required and safe vehicles suited to site fire risks and take 4WD backhoes to clear fallen trees and rocks to ensure team's escape routes.[10]

SUMMING UP

- Power utility network assets design, construction, and maintenance methodologies support the community in its bushfire defences by safely, environmentally, economically and timely risk minimising the network asset damage risks to cause bushfire or to be destroyed from a bushfire, thus minimising supply outage risk and restoration time when fires threaten or pass through, and maintaining continuous improvement systems to do it better.
- 'Better awareness, more stringent regulation and more efficient suppression during fire danger periods have dramatically reduced the number of fires burning in the countryside on days of less than extreme fire danger. There is, however, little evidence to suggest that the number of ignitions that occur on the extreme days has decreased. The possibility

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[10] Refer to second attachment from Forestry website – www.forest.nsw.gov.au.

always exists of accidents in the course of normal activities starting fires that, under less severe conditions, either would not start or would be easily controlled. Also there appears to be a greater incidence of deliberate incendiarism than was the case in the past. Whatever the cause the result is the same, and individuals throughout rural Australia should take basic sensible precautions to protect their major assets — their homestead and stock from wildfire'.[11]

- 'Removal of any one of the sides of the Fire Triangle will extinguish the fire.'[12]
- Bushfire Risk Management for power network assets is mainly preventative removal of fuel and heat, and if/when bushfire passes the removal of further heat to save or restore the network asset, is time critical but safety for accessing site in times of bushfire is also critical. Steel and concrete poles offer some bushfire resilience over wood poles if prompt access is not possible.
- There is always need for continuous process improvement. (ISO 9001, ISO 14001 and AS4801).

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Enerserve Engineering's Hunter team, esp. SafeEarth needs a mention in trial risk review.

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Thanks to Tim Schilling at Rocla for permission to use concrete pole wildfire bushfire survivor photographs and comments and to M Cleary of Onesteel for 132kV steel pole trial, with Enerserve's Stephen Connor.

[11] Quoted from CSIRO Fire Fact of the Month website, June 2002.
[12] Quoted from CSIRO Fire Fact of the Month website, June 2002.

ATTACHMENT 1
INFORMATION FOR STEEL IN FOCUS MAGAZINE, PROVIDED TO GREG SHOEMARK OF THE PROJECT GROUP, FOR BHP, 12 JUNE 2002

Utilising steel poles to mitigate bushfire loss

EnergyAustralia is trialing Ingal's modular galvanised steel poles on its high voltage 22kV infrastructure in the remote Putty area of NSW.

The poles have been installed to replace a number of wooden poles carrying high voltage electricity which had succumbed to the Christmas bushfires. The tops and cross-arms of the wooden poles were burnt out, but the porcelain insulators, bolts, tie-wires and conductors appeared visually undamaged.

As the area, which is managed by the National Parks and Wildlife Service is remote, access to the electricity infrastructure is difficult. EnergyAustralia therefore sought an alternative solution to heavy, long wooden poles which can be very difficult to transport in bushland areas.

EnergyAustralia has chosen to trial Ingal's lightweight, modular galvanised steel poles, which also have galvanised steel cross-arms, and 33kV glass/porcelain insulators fitted for lightning impulse compensation.

For further information, contact Project Manager, David Eccles, (02) 6542 9002.

Installing the new steel poles, adjacent to a burnt out wooden pole

AN EXAMPLE OF PREVENTION RISK MANAGEMENT: A QUOTE EXTRACT FROM A NSW FORESTRY BULLETIN MEDIA WEBSITE — 'BUSH TELEGRAPH NOV-JAN 2001'

'Preparation is the key to Bushfire Management'

'Fire is the biggest threat to the state's forests and it poses a serious danger to the people who fight it. While there is more to firefighting than racing off in tankers to douse flames with water, it's this aspect that most often grabs media attention. Sarah Chester reports that most of the hard work in fire management occurs well before newspaper headlines of the first summer outbreaks.

With the fire season upon us, State Forests fire manager, Paul de Mar, said that the past few months have been spent rigorously preparing for whatever the season may bring.

'Fires are not just limited to severe drought years or El Nino seasons as many people believe. Last year, in the height of a La Nina season (where above average rainfall is expected), the north coast of NSW had its worst fire season since 1994,' he said.

'In NSW, three summers in every four will expose our forests to moderate or high-fire threats, with a 'major' season occurring once a decade, and a disastrous season about once every 30 years.'

State Forests puts more than two-thirds of its fire risk management effort and expenditure into fire prevention and preparation.

This means going into each bushfire season with:

- strategically located hazard reduced areas;
- a well maintained network of roads and firebreaks in plantations;
- a team of well-trained fire spotters ready to man the extensive fire tower network;
- a well maintained radio communication network;
- extra fire crews trained prior to the season;
- up-to-date and tested fire suppression plans in place;
- and a team of highly experienced fire crews and managers ready to operate State Forests' extensive fleet of modern and well maintained fire suppression resources when the fires start.

State Forests' fire suppression principle is simple: early detection and response. The bigger the fire becomes, the more difficult, dangerous and costly it is to put out. 'Our local firefighters respond to fires with a rapid and sustained attack, backed up when necessary by local volunteer bushfire brigades,' Paul said. 'If necessary, we move in resources from other regions.'

In addition to the usual preparations this year, State Forests has increased its emphasis on training and safety.

‘As with every year, our crews are hoping this is not the ‘disastrous’ one-in-30-year season, but we’re prepared just in case,’ Paul said. He said that throughout the fire season, which may run through to the end of March or mid-April in the south of the state, the organisation needed to be on constant alert.

‘It’s a long season and keeping ahead of the game can prove challenging,’ Paul said.

‘But if we get our hazard reduction burns right and preparation in order, it can be hugely satisfying to be able protect such a valuable resource.’

Sarah Chester
Public Affairs, Albury

Hunter native forest region

- 190,000 hectares of eucalypt forests in the Hunter Valley, NSW.

Prevention emphasis:

- 10,000–15,000 ha of strategically located hazard reduction burns each year
- 4 fire spotting towers
- 6 large fire tankers
- 15 fast striker units
- 4 bulldozers/graders.

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