Attachment 1.13

R2A: Asset/System Failure Safety Risk Assessment

January 2015

Ausgrid revised regulatory proposal attachment

DUE DILIGENCE ENGINEERS

AUSGRID

ASSET / SYSTEM FAILURE SAFETY RISK ASSESSMENT

JANUARY 2015

DOCUMENT CONTROL

This document has been prepared to the particular instructions of our client or responsible R2A director. It should only be used for the purpose for which it has been commissioned.

Risk is peculiar to time and place. So unless specifically indicated to the contrary, this report only applies to the particular situation or scenario that is the subject of this commission.

PROJECT DETAILS

Client:	Ausgrid
Project Name:	Asset / System Failure Safety Risk Assessment
Client Reference:	Networks NSW RFQE2
R2A Reference:	490-01

REVISION SCHEDULE

VERSION	DATE	DESCRIPTION	PREPARED BY:	REVIEWED BY:	ISSUE AUTHORISED BY:
1.0	15/01/15	First Release	RMR	GEF/SCR	RMR

DISTRIBUTION

	DISTRIBUTION	NUMBER	COMMENTS
i	Client	1	Nicole Albert
Ii	R2A	1	Client File
	Total	2	

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EXECUTIVE SUMMARY

Ausgrid as a PCBU (person conducting a business or undertaking) has a duty under the provisions of the Work Health and Safety Act 2011 to ensure that, for all foreseeable hazards associated with the operation of the Ausgrid network, all practicable precautions are in place, so far as is reasonably practicable (SFAIRP).

To meet this duty, Ausgrid has implemented a recognised good practice FMECA/RCM (failure mode effects and criticality analysis/reliability centered maintenance) process which optimises lifecycle costs of plant and equipment including safety performance based on the field experience of knowledgeable on-the-ground Ausgrid staff. This methodology underpinned Ausgrid's submission to the Australian Energy Regulator (AER), particularly for network operating expenditure requirements.

The AER's draft revenue determination proposes a 42% reduction in Capex and 39% in Opex over the 5 year determination period. This would require an abrupt decrease of around 2,400 employees (out of 5,388 full-time equivalent employees) resulting in a substantial decrease in asset inspection frequencies (typically from 5 to 8 years). This will have a significant effect on the safety performance of Ausgrid's Network Operation.

If Ausgrid were to operate within the constraints of the AER's draft determination, then in the short term, the number of safety incidents, especially to employees, is expected to spike due to the change in safety culture associated with this scale of staff loss. In the longer term, this analysis indicates that for the foreseeable threats to members of the public considered in this review, an increase of around 3.4 per annum in the fatality rate from network hazards would most likely occur. In addition, the likelihood of the Ausgrid network starting a catastrophic bushfire (meaning 100 fatalities and 1,000 houses lost) more than doubles as a result of increased equipment failures due to longer inspection cycles. This assumes that existing precautions (especially vegetation clearance and asset condition inspection effectiveness) remain unchanged by the proposed revenue reductions. The AER appears to accept that there will be an increase in unexpected events resulting from this draft determination[1]:

Where an unexpected event leads to an overspend of the capex amount approved in this determination as part of total revenue, a service provider will be only required to bear 30% of this cost if the expenditure is found to be prudent and efficient. For these reasons, in the event that the approved total revenue underestimates the total capex required, we do not consider that this should lead to undue safety or reliability issues.

The AER draft determination is, in effect, directing Ausgrid to disregard Ausgrid's own determination of what Ausgrid believes is necessary to demonstrate SFAIRP under the provisions of the Work Health and Safety Act 2011.

[1] AER Ausgrid draft decision. Attachment 6: Capital expenditure. P 6-18

1. EXPERT WITNESS STATEMENT

1.1 QUALIFICATIONS AND EXPERTISE

1.1.1 My name is Richard Manthey Robinson.

1.1.2 I am a Director and the Chairman of R2A Due Diligence Engineers, Melbourne. I undertake due diligence engineering reviews for a wide range of industries with a specific focus on safety.

1.1.3 I advocate the precautionary approach to risk management that is enshrined in the model Work Health and Safety Act (2011) since it supports the common law decisions of the High Court of Australia with regard to due diligence as a defence against negligence, an approach I have used since the early 90s.

1.1.4 I was the expert Risk Management Member of the Victorian Powerline Bushfire Safety Taskforce (2012-13) arising from the Victorian Royal Commission into the Black Saturday Bushfires.

The Taskforce adopted the approach I recommended which specifically included the precautionary approach to risk management consistent with the model WHS legislation. Appendix E, *Threat-Barrier Analysis*, was the particular responsibility of R2A and developed by the two R2A directors, Gaye Francis and I and was the basis of Cabinet's decision, in policy terms, as to the optimal precautionary spend to prevent fires from faults on the (rural) electrical distribution network (primarily 22kV and SWER).

1.1.5 Other representative relevant experience includes:

- Member of the Independent Blasting Audit Team into fatalities in all of the then Western Mining Corporation's mines in Western Australia (1999-2000).
- Member Ministerial Eildon Dam Review Panel, DSE Victoria (2004).
- Powerlink, Substation Earthing Due Diligence Review, Qld (2013).
- United Energy & Multinet Gas, Formal Safety Assessment of Electric Network, Victoria (2013).
- Transpower, Pole 3 Commissioning Due Diligence Review, New Zealand (2012).
- Essential Energy. NBN Cabling Height Due Diligence Review, NSW (2012).
- Endeavour Energy (via Sparke Helmore Lawyers) Live High Voltage Working Due Diligence Review, NSW (2011).
- Transpower, South Island Blackstart Procedure Review, New Zealand (2011).
- MWH Global, Warragamba Dam Drum Gate FMECA, NSW (2010).
- Energy Safe Victoria. Abnormal Voltage Rises on Water Meters Review.
- Rail Corporation of NSW. Electrical Network Risk Analysis.

- Western Power Corporation, Mobile Substations - High Level Due Diligence Study
- Western Power Corporation, (via William Ellison Barristers) - Overhead Service Wire & Twisties Electrical Fire and Shock Hazard
- Energy Australia, Low Voltage Energised Line Working, NSW
- Energy Australia, Review of Bushfire Risk Model, NSW
- ETSA, SWER Workshops, South Australia.
- Transgrid, Pole Maintenance Workshops, NSW.
- Transmission Asset and Maintenance Workshops, ETSA South Australia.
- Transmission Line Risk Management Information Systems and Implementation for the whole of Tasmania (1995-2000) for Transend, formerly the Hydro Electric Corporation.
- Pacific Power, advice on a risk based allocation process to break-up the 132kV assets between distributors and Transgrid (mid 90s).

1.1.6 I am currently the presenter of one and two day short courses for Engineering Education Australia, *Engineering Due Diligence, Defensible Management Techniques* as well as the *Safety Due Diligence and Project Due Diligence modules* for the Construction series, and a part-time Lecturer, *Introduction to Risk and Due Diligence* postgraduate unit at the Swinburne University of Technology.

1.1.7 I have degrees in Mechanical Engineering from Monash University and in Philosophy (History and Philosophy of Science) from the University of Melbourne.

1.1.8 I am the principal author of *Risk & Reliability: Engineering Due Diligence*. 9th Edition (updated 2014) (the R2A Text). The 10th edition is to be released in January 2015. I was a major contributor to the Engineers Australia *Safety Case Guideline*, third edition: *Clarifying the safety case concept to engineer due diligence under the provisions of the model Work Health & Safety Act 2011*, published in November 2014.

Other recent relevant papers include:

Implications for Fire Engineering Design of the Australian Model WHS Legislation (November 2014). 10th International Conference on Performance-Based Codes and Fire Safety Designs Methods. Society of Fire Protection Engineers. Gold Coast, Australia.

Near Enough Not Safe Enough (2014). *Richard Robinson and Gaye Francis*. SIRF Conference 2014. Gold Coast.

SFAIRP vs ALARP (May 2014). *Richard Robinson and Gaye Francis*. CORE 2014. Adelaide.

Implications for Designers of the Engineers Australia Safety Case Guideline (3rd Edition) (2013). Gaye Francis and Richard Robinson. Proceedings of the IDC “Earthing, Bonding & Surge Protection Forum” – IDC Technologies, Brisbane.

Power Safety Due Diligence. Gaye E Francis and Richard M Robinson (2011). Proceedings of the IDC “Power System Protection & Earthing Forum“. Perth. 23-24 November 2011.

1.1.9 I am a Fellow of Engineers Australia, Member of the Society of Fire Protection Engineers of the USA, an Honorary Fellow of the Australasian Marine Pilots Institute (AMPI), a Life Member of the Risk Engineering Society of Engineers Australia (2013) for my contribution to the 3rd Edition of the Engineers Australia *Safety Case Guideline*, and a Member of the Royal Society of Victoria.

1.2 EXPERT’S CERTIFICATE

I, Richard Manthey Robinson

Of: Level 1, 55 Hardware Lane, Melbourne VICTORIA 3000

state:

I have specialised knowledge in the field of Due Diligence Engineering and the application of the precautionary approach to the management of safety risk as set out above.

The opinions set out in my report, which is attached, are wholly or substantially based on my specialised knowledge.

I acknowledge that I have read, understand and complied with the Federal Court of Australia’s Practice Note CM7, Expert Witnesses in proceedings in the Federal Court of Australia.

I have made all the inquiries that I believe are desirable and appropriate and that no matters of significance that I regard as relevant have, to my knowledge, been withheld.

Richard Manthey Robinson — Thursday 15th January 2015

2. PURPOSE

The purpose of the asset / system failure safety risk assessment is to examine and assess any foreseeable safety risks that may arise, or would be likely to arise if Ausgrid, over the period 1 July 2014 to 30 June 2019, only spent the proposed allowances for operating and capital expenditure set out in the AER's draft revenue determination. The findings will be used to consider whether Ausgrid will be able to meet their PCBU WHS obligations based on the proposed operating and capital expenditure allowance in the draft determination.

3. BACKGROUND

3.1 AUSGRID

Ausgrid's electricity network covers approximately 22,275 square kilometres from Waterfall in the south of Sydney, to Auburn in Sydney's western suburbs and north to Barry in the Upper Hunter. Customers include residential and large and small businesses, as well as major industry including mining, shipping, tourism, manufacturing and agriculture.

Ausgrid's Network area[2]

In 2013/14[3], Ausgrid's network supplied more than 25,523 GWh of electricity to more than 1.64 million network customers – about half the electricity customers in NSW. It had 5,388 full-time equivalent employees and generated energy revenue of

[2] From: https://www.ausgrid.com.au/network_area viewed 13dec14
[3] Ausgrid Annual Report 2013/14. P 4.

$2.8 billion. Total company assets were $16.2 billion with shareholders equity of $4.4 billion. Ausgrid's distribution network includes:

- a subtransmission system of 33kV, 66kV and 132kV assets
- a high - voltage distribution system of 5kV and 11kV assets
- low - voltage distribution system of 240V and 415V assets.

Networks NSW (NNSW) refers to a cooperative operating model across Ausgrid, Endeavour Energy and Essential Energy. The objective of NNSW is to contain the future costs of building, maintaining and operating the electricity network in a safe, reliable and sustainable manner.

3.2 AER DETERMINATION BACKGROUND

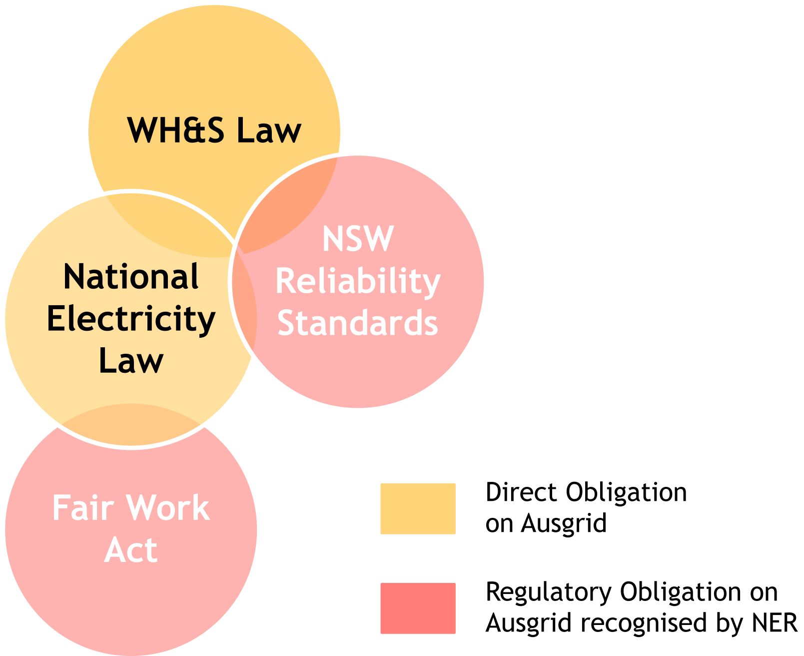
The AER regulates the revenues of the distribution network service providers in eastern and southern Australia under the National Electricity Law (NEL) and National Electricity Rules (NER). The AER is required to determine the revenue allowance for the distribution network service providers under the National Electricity Rules (NER). The regulatory period for NSW is 5 years, from 1 July 2014 to 30 June 2019.

The AER's draft determinations for the 5-year period were published on 27 November 2014. The proposed Capex and Opex expenditure for Ausgrid is shown in the table below.

$ million 2013/14	Submission by Ausgrid	Draft by AER	$ difference	% difference
CAPEX	$4,421	$2,546	-$1,875	-42%
OPEX	$2,888	$1,759	-$1,129	-39%
Total	**$7,309**	**$4,305**	**-$3,004**	**-41%**

3.3 LEGAL CONTEXT

The legislative framework in which Ausgrid operates is shown in the following diagram[4].



The overarching legislation in relation to safety is the Work Health and Safety (WHS) Act 2011. Under the Act, Ausgrid is a PCBU (person conducting a business or undertaking). Under this Act, the primary duty holder has an obligation to ensure so far as is reasonably practicable (SFAIRP), the health and safety of workers (inclusive of contractors) while they are at work in the business or undertaking and that the health and safety of other persons (members of the public) is not put at risk from work carried out as part of the conduct of the business or undertaking (maintaining the safety of the Network Asset / System).

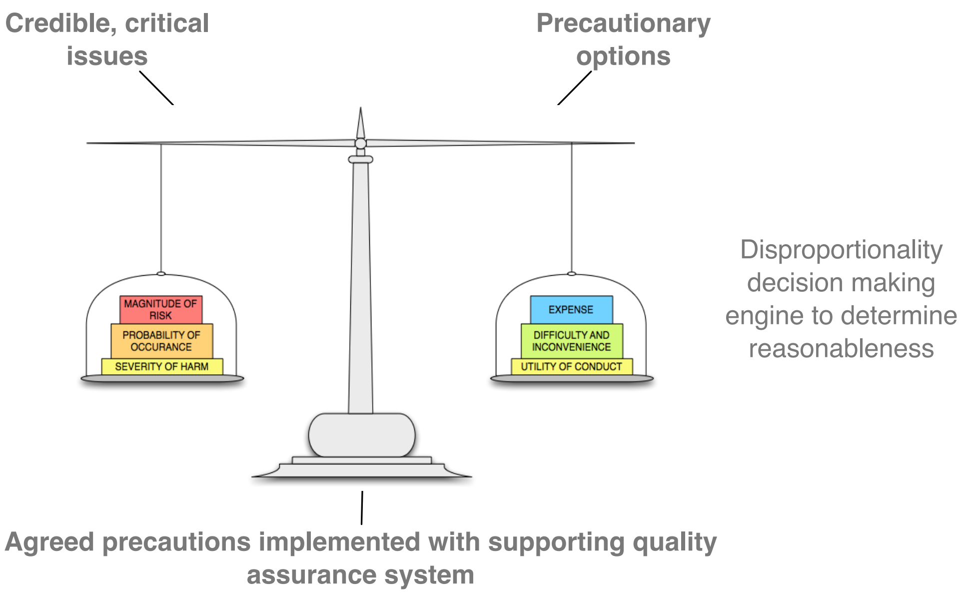
A PCBU needs to consider what is able to be done in relation to the identified risk and then the extent to which those identified control measures are reasonable in the circumstances. However, cost of itself is unlikely to be a sufficient justification for choosing a lower order safety control measure (or for not implementing a safety control measure) unless the cost is *grossly disproportionate to the risk*.

Officers of the PCBU must exercise due diligence to ensure that the PCBU complies with its duty or obligation under the WHS Act.

[4] Adapted from Networks NSW Presentation to AER Pre-determination Conference. 8 December 2014. Mr Vince Graham, CEO, Networks NSW.

4. METHOD

The review has been completed within a precautionary due diligence framework consistent with the provisions of the NSW WHS legislation following the R2A model described below and in further detail in the R2A Text[5]. This approach has been used in a number of studies. It was expressly used in the report[6] of the Powerline Bushfire Safety Taskforce, arising from the Royal Commission into the Black Saturday fires in Victoria all of whose recommendations were adopted by Cabinet.



R2A 'Y' Model

As shown in the R2A 'Y' model above, the process has three primary steps.

a. Credible critical issues. This is a check to ensure all credible critical safety issues have been identified. In essence this asks the question: *What exposed groups are we trying to protect and to what credible threats are they exposed?* For this study, the purpose is to identify the most significant fatality contributors.

b. Precautionary options. This step identifies all of the practicable precautionary options for the hazard and documents them in the form of threat barrier diagrams. These are particularly useful in showing barriers (precautions and mitigations) that have an effect on multiple threats. A sample generic threat barrier diagram is shown below. For this study the purpose is to identify the precautions presently applied to the credible critical issues.

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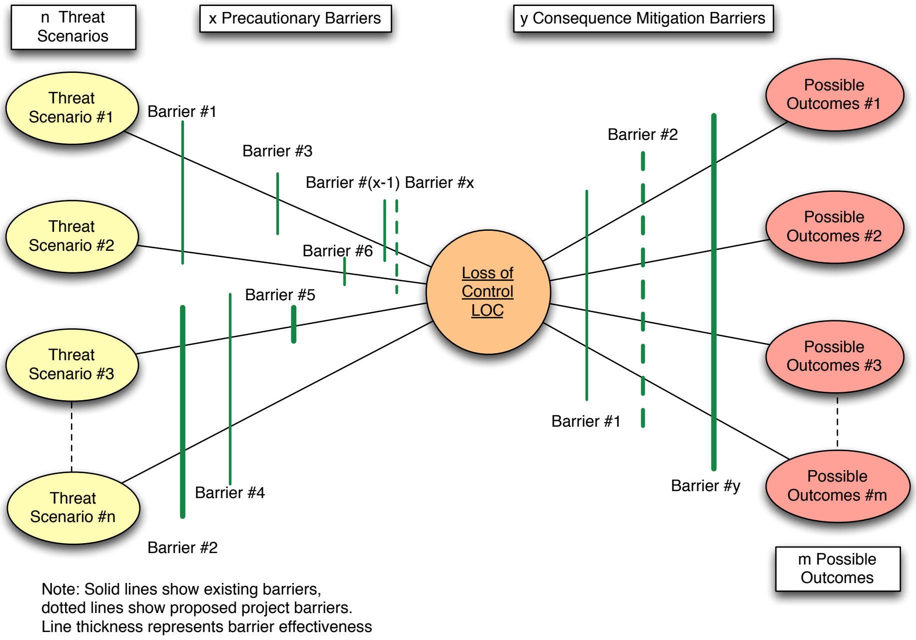
[5] Robinson & Francis et al 2014. *Risk and Reliability: Engineering Due Diligence*. 9th Edition, Updated 2014. This outlines numerous studies using this process in Chapter 24.
[6] Powerline Bushfire Safety Taskforce. *Final Report*. 30 September 2011. Particularly Appendix E.



The legislation requires that risk control must be based upon the Hierarchy of Controls which is typically, in the order of most to least preferred:

1. Elimination
2. Substitution
3. Engineering controls
4. Administrative controls
5. Personal Protective Equipment and Clothing.

In the diagram above, solid lines (barriers) represent existing controls, dotted lines possible practicable controls. Following the hierarchy above, controls should be tested from left to right on the diagram, starting with the elimination option. Controls to the left of the Loss of Control point are precautions; controls after the Loss of Control point are mitigations.

c. Precautionary analysis. This step looks at all of the precautionary options available and in view of what is already in place what further controls could be implemented. This study is a little different in that to comply with the legislation ordinarily requires an examination of *what else can be done* in precautionary terms. In this case the precautions to address the identified issues are being established with a view as to the impact of the likely reduction of some of these precautions because of the Opex and Capex cuts, suggesting what will be the likely change in fatality outcomes.

5. ANALYSIS

The power distribution business is an essential, complex, high risk industry. It provides substantial benefits and dangers to the community. For example, electrocution is a well known hazard to employees and members of the public. The network can start bushfires and create particular hazards for firefighters. Network outages and service interruptions also present major safety concerns to consumers who are on life support equipment.

Asset related preventative and mitigative maintenance controls are used by Ausgrid to reduce the likelihood and consequence of hazardous events, particularly those events that have the potential to result in loss of life. A recognised good practice FMECA/RCM (failure modes, effects and criticality analysis / reliability centered maintenance) process is used[7]. The modeling algorithms have been validated by the CSIRO[8].

This means that Ausgrid utilises pre-emptive (preventative maintenance and asset renewals) and corrective maintenance as preventative controls to identify and address possible failures before they occur in order to maintain a safe and reliable network so far as is reasonably practicable (SFAIRP) in accordance with the hierarchy of controls. Ausgrid also has significant capital programs for replacement of assets as their performance degrades and they reach the end of their service lives.

The proposed AER determination for Ausgrid is to reduce Capex by 42% and Opex by 39%. Currently, 7% of Ausgrid's Opex is spent on vegetation clearance. Ausgrid has committed to continue with their current vegetation clearance program meaning that the effective Opex cuts will need to be greater than 40% across the remaining network asset related maintenance tasks. From an Opex viewpoint, Ausgrid[9] indicates that 2,400 immediate job reductions (out of 5,388[10] full-time equivalent employees or about 44%) would need to be implemented, plus an inability to place any Apprentices currently in training. The immediate likely safety significance of such cuts is expected to be substantial and discussed in the next section, *Human Error and Safety Culture*.

The Opex reduction also has an immediate and major impact on the frequency of overhead network asset inspections, typically extending the inspection cycle from 5

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[7] Ausgrid Executive Leadership Group Meeting 28 Feb 2013. FMECA/RCM Project Update. (John Hardwick). See also: Ausgrid. March 2014. Asset Condition & Planning Summary. ACAPS4010 Distribution mains – Low Voltage (LV) Overhead Services. (Paul Kril).

[8] CSIRO Mathematical and Information Sciences, Report CMIS 01/44, 26 March 2001. *Validation of Specified Algorithms in MIMIR*.

[9] See: http://www.ausgrid.com.au/Common/About-us/Newsroom/Media-Releases/2014/November/Call-for-safe-reliable-affordable-NSW-electricity-network.aspx?page=1&year=&month=&id=5dc6b7ee-56b3-4a69-bb6a-46352d18564f viewed 11 Dec 14.

[10] Ausgrid Annual Report 2013/14. p 4.

to 8 years and creating a substantial increase in expected network faults. This fault rate increase is exponential in nature. This means a doubling of inspection periods can produce orders of magnitude increases in equipment failures, depending on particular equipment failure rates. This also creates alarming bushfire start potentials particularly for Catastrophic (Code Red) days. This is discussed in Section 5.3, *Catastrophic Bushfire Starts*. This is also likely to have an additional impact for public safety as discussed in Section 5.4, *Other Critical Public Safety Issues*.

5.1 HUMAN ERROR AND SAFETY CULTURE

The importance of a good safety culture in preventing human error and accidents in high risk industries (which includes aviation, trains, shipping, power, off shore oil and gas) has been formally recognised during the last 30 years. Presently in Australia, for example, the National Offshore Petroleum Safety and Environmental Management Authority[11] (NOPSEMA) and the Australian Transport Safety Bureau (ATSB) discuss the importance of human factors and safety culture in accident prevention in some depth.

For a complex organisation in a high risk industry like Ausgrid, an abrupt reduction of around 40% expenditure in Capex and Opex represents major corporate change which is very likely to effect safety outcomes at the front line of the organisation.

The ATSB[12] uses a safety culture - human factors approach as a primary basis for accident analysis, adapted from work by the British psychologist James Reason. Organisational conditions and influences in the ATSB's view include regulatory factors. The concept flows from Reason's biological model and his concept of a *healthy organisation*. He promotes the notion of *latent conditions* which for Reason are the things that enable competent people working in complex systems to make mistakes. Reason believes that[13].

> *They arise from strategic and other top-level decisions made by governments, regulators, manufacturers, designers and organizational managers.*

Reason[14] notes in his introduction to Andrew Hopkins' 2005 book, *Safety Culture and Risk, The Organisational Causes of Disasters* that:

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[11] The National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA), *Human Factors Information papers*. See: http://www.nopsema.gov.au/resources/human-factors/ viewed 20dec14.

[12] For example, see Aviation Research and Analysis Report – AR-2007-053. *Analysis, Causality and Proof in Safety Investigations. p 37. See: http://www.atsb.gov.au/media/27767/ar2007053.pdf*

[13] James Reason (1997). *Managing the Risk of Organizational Accidents*. Ashgate Publishing. Aldershot. p 10.

[14] Andrew Hopkins 2005. *Safety, Culture and Risk*. The Organisational Causes of Disaster. CCH Australia Limited.

Much as it was (and still is) managerially and legally convenient to blame those in the front line, it was gradually becoming apparent that accidents in well-defended systems arose from a concatenation of many different factors arising from all levels of the organisation.

This overall safety culture argument is summarised at some length in the Special Commission of Inquiry into the Waterfall Accident. In the Executive Summary, the Commissioner[15] notes:

Management of safety cannot be divorced from the overall management of the railway business in which a company is engaged.

5.2 CREDIBLE CRITICAL ISSUES

A list of the fatalities and serious injuries to third parties and members of the public recorded by Ausgrid[16] since 2005 was reviewed. Instances include one fallen pole crushing incident to a child, one low conductor fatality, one pole crash with wire down resulting in a serious shock, one neutral fault to premises event and one vegetation clearance incident.

Given the incident data and industry knowledge, controllable network asset/system related failures that have, or could foreseeably cause a fatality and/or injury or property damage and about which Ausgrid are greatly concerned include:

- Failed poles and cross arms
- Low and fallen conductors
- Faulty service wires
- Equipment fire or explosion (particularly as a bushfire start)
- Loss of neutral integrity to customer premises

These potentially have fatality risk consequences to employees and members of the public as a result of:

- Bushfire or other fire causing death and property damage
- Electrocution due to contact with failed electrical assets
- Being struck by falling network equipment or material expelled by hot gases or explosion
- Collision with poles
- Loss of electricity supply causing fatal risk to customers on life support equipment

[15] The Honourable Peter Aloysius McInerney QC *Special Commission of Inquiry into the Waterfall Rail Accident*. Final Report Volume 1 January 2005. Executive Summary p ii.

[16] Asset Management Safety Risks 1512.xlsx

5.3 CATASTROPHIC BUSHFIRE STARTS

The following table summarises the major bushfires in NSW for the last 76 years[17].

Date	No. Deaths	Area (ha)	Losses	Location(s)
1938 December – 1939 January	13	73000	Many houses, pine plantations	Dubbo, Lugarno, Snowy Mountains, Canberra
1951 November – 1952 January	11	>4 000 000		Worst affected district around Wagga Wagga and Pilliga in the north-west
1968 September – 1969 January	14	>2 000 000	161 buildings (80 houses)	South Coast (Sept.), much of the coastal and nearby range areas of the state
1974–75	6	4 500 000	50 000 stock, 10 170km fencing	Bourke to Balranald, Cobar Shire, Moolah–Corinya—most of the Western Division
1977–78	3	54000	49 buildings	Blue Mountains
1978–79	Nil	>50 000	5 houses, heavy stock loss	Southern Highlands, south-west slopes
1979–80	13	>1 000 000	14 houses	Mudgee, Warringah and Sutherland Shires, majority of council area, Goulburn and South Coast
1984–85	5	>3 500 000	40 000 stock, $40 million damage	Western Division
1990–91	Nil	>280 000	8 houses, 176 000 sheep, 200 cattle, hundreds of km of fencing	Local government shires of Hay, Murrumbidgee, Carrathool; Hornsby, Ku-ring-gai, Cessnock, Hawkesbury, Warringah, Wollondilly, Gosford, Wyong
1991–92	2	30 fires	14 houses	Baulkham Hills, Gosford City, Wyong Shire, Lake Macquarie
1993 December – 1994 January	4	>800 000 (>800 fires)	206 houses destroyed, 80 other premises destroyed	North Coast, Hunter, South Coast, Blue Mountains, Baulkham Hills, Sutherland, most of Royal National Park, Blue Mountains, Warringah–Pittwater
2001 December – 2002 January	Nil	744 000 (454 Fires)	109 houses destroyed; 6000 head of livestock	Across 44 local government areas in the Greater Sydney, Hunter, North Coast, mid-north coast, Northern Tablelands, Central Tablelands areas
2002 July – 2003 February	3	1 464 000 (459 fires)	86 houses destroyed; 3400 stock; 151 days of severe fire activity	81 local government areas in Greater Sydney, Hunter, North Coast, Northern Tablelands, Northern Rivers, north-west slopes, north-west plains, Central Tablelands, Southern Tablelands, Illawarra, South Coast
2012-13	Nil	1.4 million ha	62 homes destroyed; 5,885 bush and grass fires; large areas of Catastrophic fire danger	Coonabarabran, Shoalhaven, Yass, Cooma-Monaro, Greater Sydney, Far West NSW, Northern Rivers and Northern Tablelands
2013-14	2	575 000 ha	217 homes destroyed; 129 damaged.	Blue Mountains, Central Coast, Southern Highlands, Port Stephens, Riverina, North Coast
Total	76	Deaths	801 houses	

Major Fires in NSW

This history suggests that major fires occur about every 5 years in NSW which results in the deaths of around 5 persons and the destruction of around 50 houses[18].

[17] *History of Fires in NSW* as provided by the NSW Rural Fire Service 7th January 2015.
[18] This is based on dividing the total deaths and houses lost by the number of fire seasons.

The state of NSW has not suffered the type of catastrophic bushfire that has occurred in Victoria. However, Professor Tolhurst's draft report[19] into bushfire risk for power distributors in NSW notes in the summary:

> *This analysis has shown that there are several areas in the study area where Catastrophic impacts could occur, i.e. where more than 1,000 houses could be lost in a single event. Fires starting in the Katoomba, Blue Mountains, Sydney Basin, Nowra, Yass, Goulburn, Canberra, and south of Newcastle areas all had the potential to be Catastrophic under the "worst-case" conditions considered.*

Based on Victorian experience, the loss of 1,000 houses correlates to upwards of 100 deaths[20].

The Victorian Powerline Bushfire Safety Taskforce[21] reported that:

> *Historically, powerlines are thought to start a relatively small proportion of bushfires (around 1-4%). Significantly, inquiries following major bushfires and the Royal Commission have concluded that on a disproportionate number of catastrophic bushfires, with major loss of life and property, have been caused by powerlines. Powerlines are thought to have started:*
>
> - *Nine of the 16 fires on 12 February 1977*
> - *Four of the eight major fires on Ash Wednesday (16 February 1983)*
> - *Five of the 15 major fires on Black Saturday (7 February 2009) that were considered by the Royal Commission.*

As noted above, the Victorian Bushfire Royal Commission (VBRC) concluded that[22] 5 of the 15 fire starts on Black Saturday were associated with the failure of electricity assets. The Commission went on to say that:

> *Distribution businesses' capacity to respond to an ageing network is, however, constrained by the electricity industry's economic regulatory regime. The regime favours the status quo and makes it difficult to bring about substantial reform. As components of the distribution network age and approach the end of their engineering life, there will probably be an increase in the number of fires resulting from asset failures unless urgent preventive steps are taken.*

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[19] Dr Kevin Tolhurst, 2013. Draft *Report on the Bushfire Risk for Power Distribution Businesses in New South Wales.*

[20] In the Black Saturday fires, there were 2133 houses destroyed and 173 deaths occurred. 2009 Victorian Bushfires Royal Commission. Final Report Summary.

[21] Powerline Bushfire Safety Taskforce. Final Report. 30 September 2011 p 24.

[22] The 2009 Victorian Bushfires Royal Commission. July 2010. *Final Report Summary*. P 12.

The latest report by EnergySafe Victoria[23] (ESV) seems to confirm this increase in fire starts and asset failures.

> *The performance of the Victorian electricity distribution network has, on average, deteriorated each year for the past three years. This is, however, not uniform across the industry with some of the Victorian MECs, principally SP AusNet, improving its performance. Overall trends have continued into the first quarter of 2014. In 2013 there were:*
>
> * *925 **fire starts** from electrical distribution assets, which have increased each year for the past three years. This number exceeds the annual f-factor target of 870 fires*
> * *2269 electrical distribution **asset failures**, which have increased each year for the past three years. This is compared with 1119 asset failures in 2011*
> * *780 **fire starts due to asset failure**. These have increased each year from 341 fire starts in 2011, mostly due to pole top structure failures.*

and:

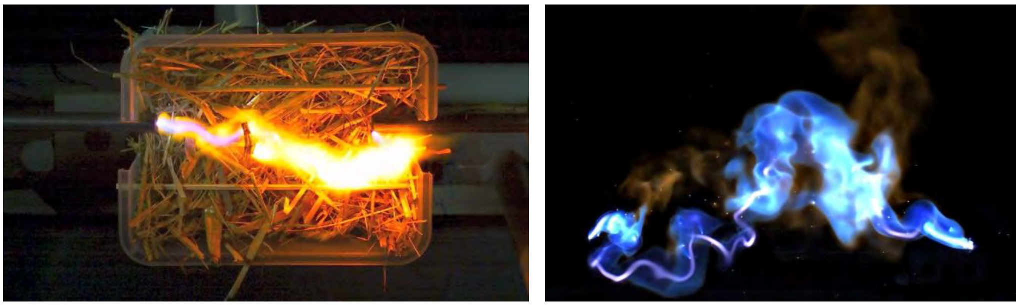
> *Notwithstanding the significant capital investment and maintenance expenditure being made in the network, and the effort that has been put into condition assessment, ESV would have expected to see a reduction in the number of asset failures. Despite these targeted programs, the number of asset failures has increased, especially power pole top, HV fuse, LV asset, bare conductor, and HV ties. The failure rate remains high and is the major cause of asset and vegetation fires.*
>
> *The total number of asset failures in 2013 (2269 compared with 1119 in 2011) represents a 103 per cent increase in two years.*

The Rural Fire Service (RFS) has introduced the concept of a Catastrophic (Code Red) for some total fire ban (Toban) days as shown in the picture below of the *Fire Danger Rating Today* sign extracted from the RFS publication Total Fire Bans Factsheet[24]. As the sign suggests, a Catastrophic rated day is a subset of total Toban days.

[23] Energysafe Victoria (June 2014). *Safety Performance Report on Victorian Electricity Networks 2013*. The quote is from the Summary on page 7.
[24] From: http://www.rfs.nsw.gov.au/__data/assets/pdf_file/0016/9430/Total-Fire-Bans-Factsheet.pdf viewed 23dec14.

Total Fire Ban (Toban) and Catastrophic

Substantial work has been occurring to determine the probability of starting fires from network faults on Catastrophic (Code Red) days. The work of the Powerline Bushfire Safety Taskforce confirmed that 22kV electric arcs (shown below) can almost instantly start fires.



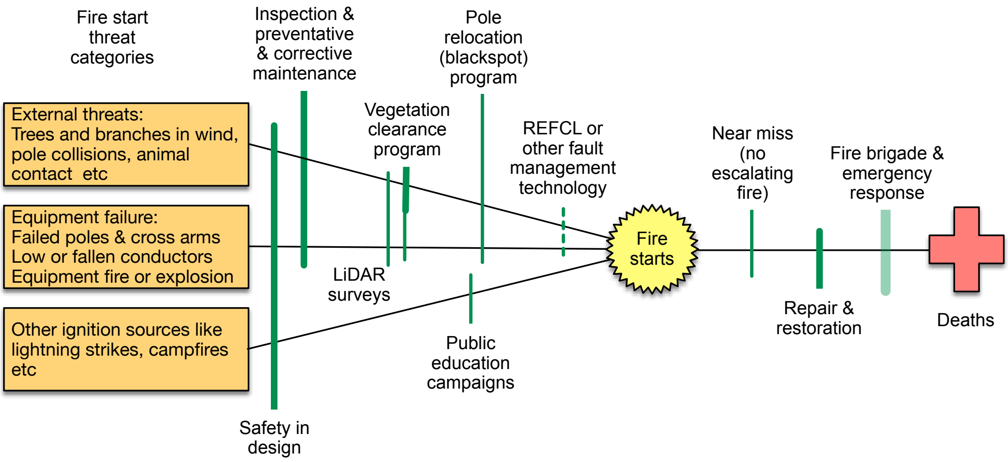
Electric arcs produced during testing[25]

Further work reveals that under Ash Wednesday conditions a fallen conductor will most likely start a fire as shown below.

Distribution of conductor-soil arcs at instant of initial contact (16 amps, 19/3.25AAC conductor)[26]

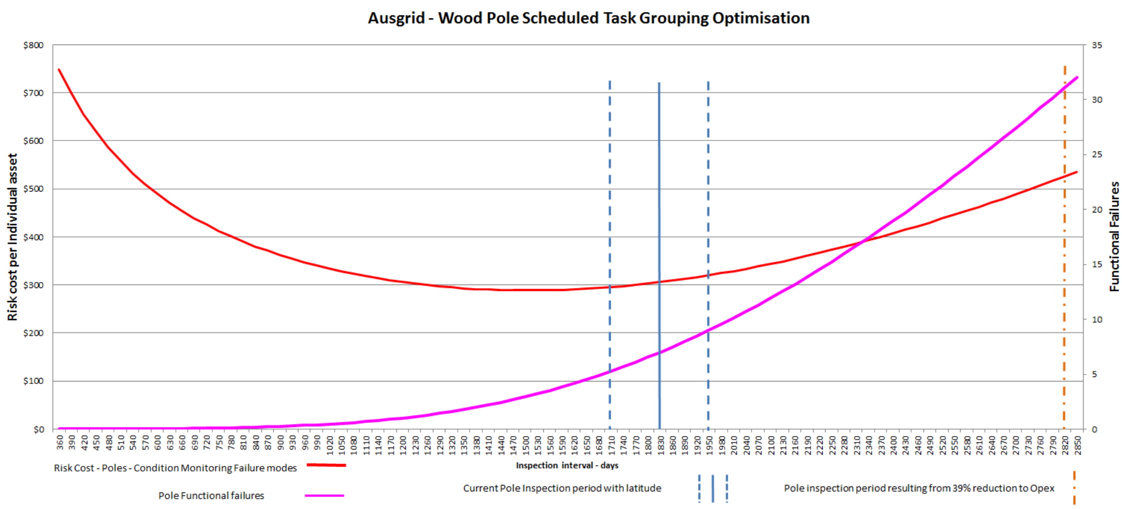
[25] Powerline Bushfire Safety Taskforce. Final Report. 30 September 2011 p 42.
[26] Marxsen Consulting, 4 August 2014. *REFCL Trial: Ignition Tests*. p 17.

The threat barrier diagram below describes the key fire start mechanisms and barriers. On a Catastrophic (Code Red) day conditions are much worse than on an ordinary Toban day. Fires start more easily, grow faster and there is just so much fire about that the effectiveness of the emergency response is reduced. There are not enough firefighters and emergency response equipment to go round. This makes the success requirements of the other barriers more important.



Catastrophic (code red) day fire start threat barrier diagram

Based on the draft determination of the AER, the reduced Opex is expected to increase the inspection cycle on poles and associated equipment from around 5 to 8 years. For example[27], the maintenance period optimisation undertaken as part of the FMECA/RCM analysis review in 2009-2011 is summarised below for the critical failure modes associated with wood poles.



Wood Pole Failures Summary

[27]Gary Winsor, Manager Network Performance, Network Strategy, Networks NSW. January 2015. *AER OPEX Reduction Implications.doc*

The current maintenance strategy applies a period of 5 years with 4 month latitude, as shown by the vertical blue lines. A reduction in inspection task OPEX of 39% would result in a new period of ~2820 days (7.7 years[28]) as shown by the vertical orange line.

The important aspect of this is the rapid increase in the collective functional failures of the poles associated with the increase in the inspection period required by the AER draft determination, shown by the purple line. The expected multipliers for functional failure (breakdown) events for poles with the extended inspection period are tabulated below.

Failure mode	Expected multiplier
Wood pole strength degraded due to Termites - Unknown termite type.	4.7
Wood pole Buried / exposed due to Ground level changes / erosion.	3.7
Wood pole strength degraded due to Rot - Other than brown rot.	6.6
Reinstated pole Leaning / failed due to Timber degradation near attachment.	4.7
Reinstated pole Leaning / failed due to Corroded pole nail / splint / fittings.	4.7
Wood pole strength degraded due to Cracking / splitting.	1.8
Wood pole strength degraded due to Termites - Coptotermes.	4.7
Wood pole strength degraded due to Termites - Glyptotermes.	4.7
Wood pole strength degraded due to Rot - Brown.	6.6
Wood pole strength degraded due to Termites - Nasutitermes.	4.7
Wood pole Obstructed by vegetation due to Normal vegetation growth.	4.7
Wood pole strength degraded due to Pipe in pole.	4.7
Earth wire batten Broken / damaged due to Various.	4.7
Wood pole strength degraded due to Termite attack - General.	3.9
Average	**4.6**

That is, based on the FMECA/RCM model used by Ausgrid, this is expected to increase wood pole failure rates by about a factor of 4.6[29]. Ausgrid had 7 unassisted pole failures in FY13/14[30]. This is expected to increase to around 33 failures per annum once the full effect of the extended inspection cycles becomes apparent.

Assuming a similar increased failure rate for other pole top elements this means the equipment fault rate that might start a fire will increase by a factor of around 5 for pole related failures which includes the poles themselves, cross arms, insulators, ties and conductors[31].

In terms of the model above, if each fire start threat category has an equal contribution to fire starts on Catastrophic (Code Red) days (following the VBRC indications), and, ignoring any impacts of reduced barrier effectiveness due to the

[28] Calculated on the basis of the inspection effort being reduced by the AER draft determination expenditure cut. That is: 4.75 years /(1-0.39) = 7.78 years

[29] Different pole failure mechanisms have higher or lower multipliers as shown above. Whilst an average multiplier is calculated, this is approximate. An accurate estimation would require the number of poles subject to each failure mode to be known (and some would be subject to multiple modes). This would then need to be multiplied out by class and failure mode increase and then re-divided by the totals. The calculated value for wooden poles for Ausgrid is 4.8 from the reference in the following footnote.

[30] Gary Winsor, Manager Network Performance, Network Strategy, Networks NSW. January 2015. *AER OPEX Reduction Implications.doc*. Appendix 1.

[31] Ausgrid has access to data to calculate an average value for all these items, but this has not been done at this point in time.

Opex changes (particularly the vegetation clearance effectiveness), if the equipment failure rate fire starts increased by a factor of 5, then, all other matters being equal, the overall fire starts due to network faults would increase by a factor of around 2.3[32].

If major fires in NSW as a whole occur once every 5 years and the Ausgrid network accounts for one third of these, then instead of a major fire every 15 years in the Ausgrid region, they would increase to around once every 6.5 years[33]. That is, more than doubling the fire frequency implying the loss of another 5 lives and 50 houses. This ignores the increased possibility of the potential for a catastrophic event causing the loss of 1,000 houses (and presumably upwards of 100 lives) mentioned in Professor Tolhurst's draft report.

Such an analysis assumes that all the existing precautions remain as effective as they are now. For example, that the asset inspection reliability of field staff remains unchanged despite the Opex reductions, which would seem unlikely at least in the short term in view of the discussion under Safety Culture in Section 5.1.

This understanding reinforces the concerns of the NSW Rural Fire Service[34] and NSW Fire & Rescue[35] that, if the equipment failure rates increase as predicted, and barrier effectiveness declines (for example, field staff technical asset inspection effectiveness and vegetation control) coincidently with an increase in the number of Catastrophic (Code Red) days (possibly due to global warming) then the fire starts would increase dramatically, effectively transferring the increasing safety risk to the emergency services and the larger community.

As an indication of the order of magnitude of community costs associated with catastrophic events, the very recent resolution of the Black Saturday Kilmore East bushfire class action in Victoria[36] of $494m underscores this situation. SP AusNet agreed to pay $378m and Utility Services Corporation Ltd $12.5m. The Victorian Government which includes Victoria Police and the Country Fire Authority, have agreed to pay $103.6m.

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[32] Calculated on the basis that one of the three fire start sources (network faults) has increased by a factor of 5. That is, increasing the fire starts ratio from 3 to 7, or 7÷3 = 2.33.

[33] This analysis makes the assumption that major fires in NSW have occurred on what would now be considered to be a Catastrophic or (Code Red) day. To confirm this assumption would require a historical review of major fires and the weather conditions etc on those days.
The arithmetic for this paragraph is as follows: Ausgrid increases fire starts by about a factor of 2.3 on Catastrophic (Code Red) days. The present major fire frequency in NSW (presumed to occur on what is now defined as a Catastrophic (Code Red) day) as a whole is around 1 in 5 years. Ausgrid is one of 3 networks in NSW. This means the new estimated fire start frequency is about: 2.3÷(5x3) = 0.15 pa or around 1 in 6.5 years in the Ausgrid network area.

[34] Mr Shane Fitzsimmons, Commissioner of the NSW Rural Fire Service. 5 December 2014 in a letter to Mr Vince Graham.

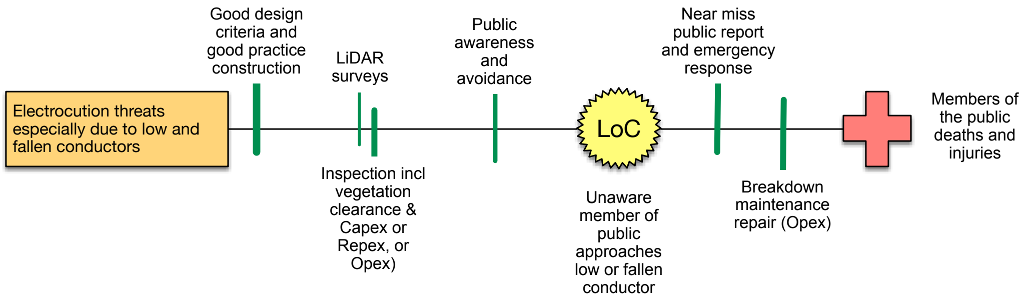
[35] Mr Greg Mullins, Commissioner, NSW Fire and Rescue, 4 December 2014 in a letter to Mr Vince Graham.

[36] See: http://www.abc.net.au/news/2014-12-23/judge-approves-black-saturday-class-action-settlement/5984374 viewed 5jan15.

5.4 OTHER CRITICAL PUBLIC SAFETY ISSUES

ELECTROCUTION

The following threat barrier diagram has been developed for electrocution threats especially due to low and fallen conductors. A low or fallen conductor can result from mechanisms including a fallen pole, broken cross arm, failed insulator, failed tie or broken conductor.



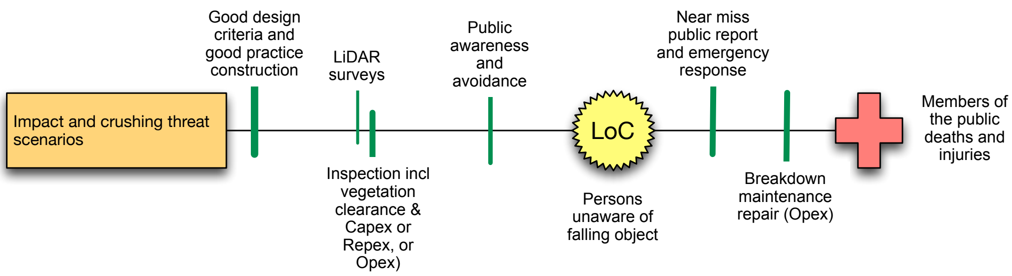
Electrocution threat-barrier diagram

The current Ausgrid replacement Capex (Repex) and Opex requirements are based on a FMECA/RCM (failure modes effects and criticality analysis / reliability centred maintenance) process. It is built bottom up based on each individual asset (for example, pole or conductor span) on the optimisation of Capex and Opex.

Based on an expected increase in inspection period from 5 to 8 years as would result from the draft determination, an increase in failure rate of around 5 per annum is expected for each of these elements (using the pole data above).

FALLING OBJECTS

Falling objects can result from mechanisms including falling poles, broken cross arms, failed insulators and broken conductors (being hit by a falling wire, even if it is de-energised remains a significant hazard).

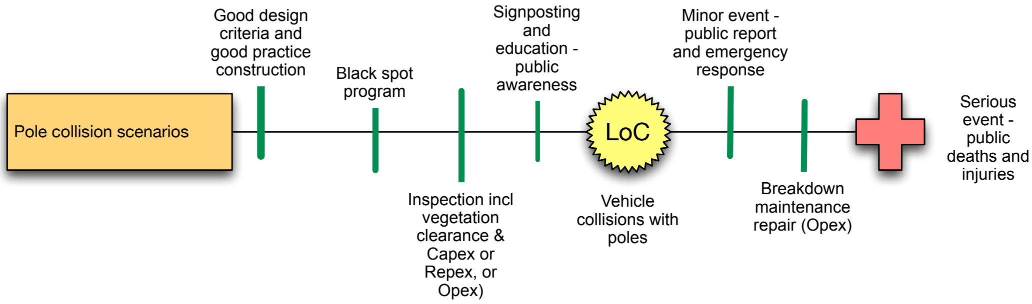


Falling objects threat-barrier diagram

Based on the same analysis as used in the previous example (electrocution), it is expected that the increase in falling object incidents will be 5 per annum.

COLLISION WITH POLES

The proposed reduction in expenditure will eliminate the capacity for Ausgrid to continue with the Black Spot Program for the relocation of power poles. Of the three NSW Network Businesses, Endeavour Energy has been the originator of this program investing more than $7 million over the past five years in the relocation of power poles. The program contributed to the reduction of driver fatalities reducing the average rate from 14.9 fatalities per year (in the previous ten year period) to an average of 5 fatalities per year over the last five years within the same franchise area[37].



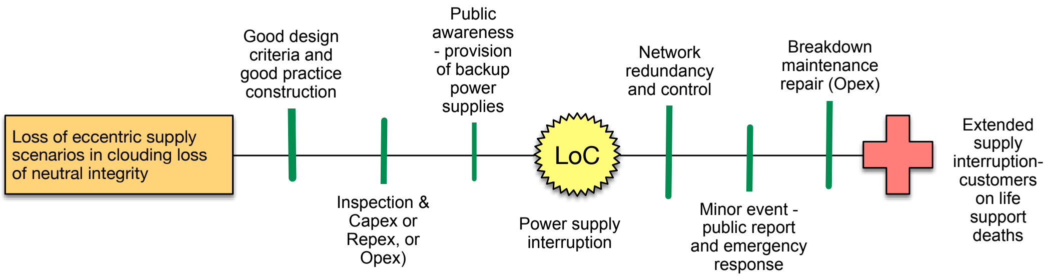
Collision with poles threat-barrier diagram

If the Ausgrid Black Spot Program was to further develop, the results expected would be similar, if not better than those experienced by Endeavour Energy given the high traffic density of Ausgrid's franchise area.

[37] Pole Black Spot Program 2009 – 2014. Memo from Kelly Davidson – Public Safety Program Manager. 22 December 2014.

LOSS OF SERVICE

Loss of service as it may affect customers on life support would appear to be similarly increased. This appears more difficult to model. Whilst service wire faults and loss of neutral integrity to customer premises would directly affect premises, other faults may be mitigated by network redundancy and control systems.



Loss of service threat-barrier diagram

A separate study has been commissioned by Ausgrid to consider this issue. The fault rate will increase. As a preliminary estimate for this report, a 5 fold increase solely due to faults on service wires arising in the 3 year extended inspection period has been used.

5.5 MORTALITY IMPACT OF AER DRAFT DETERMINATION

5.5.1 OPEX

Distribution assets typically have a life time replacement cycle of around 50 years. But in-service conditions vary, for example, wooden poles in termite infested regions are subject to earlier failure. To avoid such failure, such poles are inspected regularly. The frequency of the inspection is determined by an assessment as to the likelihood of that class of equipment surviving until the next inspection. So, for example, looking at the wood poles for Ausgrid, a 5 year inspection presently appears optimal, replacing suspect poles thereby enabling optimal survival of all poles until the next inspection. If the inspection cycle is increased to 8 years, which is understood to be necessary to achieve the costs supported by the draft determination, many would fail within the inspection period (unless of course they were replaced with poles capable of lasting 8 years).

The immediate failure consequences of extending the inspection periods would not be evident on a widespread basis for 2-3 years (from the start of the regulatory period as there should be no expected changes 2-3 years since the last 5 year cycle). It would gradually become apparent and only become strongly evident towards the end of the 5th year (since the start of the regulatory period). Conceptually, it would only be the poles entering the 6^{th} year since the last inspection that should be at risk. By the 7th and 8th year pole failures would have become serious and the safety and Capex replacement implications very high if the degraded poles haven't failed already (breakdown maintenance). In short, extending the inspection cycle would provide a limited short term gain but greater medium and long term cost.

		Current Ausgrid Submission			AER Draft Determination		
		Likelihood p.a.	Fatalities	Fatalities p.a.	Likelihood p.a.	Fatalities	Fatalities p.a.
i	Bushfire (all persons)	0.06 (1 in 15 years)	5	0.3	0.15 (1 in 6.5 years)	5	0.75
ii	Electrocution (all persons)	0.1 (1 in 10 years)	1	0.1	0.5 5 increase	1	0.5
iii	Falling objects (all persons)	0.1 (1 in 10 years	1	0.1	0.5 5 increase	1	0.5
iv	Collision with poles (colliding party)	0.1 (1 in 10 years	1	0.1	0.1 no change	1	0.1
v	Loss of supply (life support customers)	0.1 (1 in 10 years	1	0.1	0.5 5 increase	1	0.5
				0.7			**2.35**

Mortality Implications

The table above conceptually summarises the results of the threat barrier analysis. Essentially this suggests that by the time of the 8th year of the inspection cycle the fatality rate will be 3.4 times (2.35 ÷ 0.7) the current rate due to the Opex implications alone, excluding catastrophic fire possibilities.

Note that this table is a preliminary characterisation to gauge the quantum of safety change expected if the draft AER determination is applied to Ausgrid. If the safety culture does not recover from the initial staff reductions required by the determination then these numbers could be much worse as the effectiveness of the precautionary barriers would become less than what they are now.

5.5.2 CAPEX

Ausgrid has provided the Portfolio Investment Plan (PIP) a prioritised spreadsheet of planned works and tasks for Capex for the 5 year determination period[38]. It is understood that the PIP prioritises expenditure resources relative to risk. The AER draft determination would require the removal of a number of prioritised tasks and activities associated with the prevention / and or reduction of asset failure modes with adverse safety consequences.

The spreadsheet is ranked by risk in priority categories: *safety, reliability, security, compliance* and *other*. By drawing a line at the AER draft determination spend levels in this spreadsheet, an initial understanding of projects which may be impacted or not done at all can be determined. It is worth noting that for the vast majority of the projects to that line, the primary priority is safety, but that nevertheless, many safety projects are cut off. It is these projects that are the focus of this part of the review.

Examining Ausgrid's projects indicates that they are mostly Repex (meaning replacement of life expired or obsolete equipment). For example, the *11kV Switchboard and Circuit Breaker Replacement* program is particularly directed at ensuring that circuit breakers work when they are called upon to do so without resulting in an explosion or building fire. A second item, *Mains Replacement* is replacing known deteriorated pole top equipment particularly conductors, cross arms and insulators. It includes replacing open wire (bare conductor) low voltage systems conversion to insulated aerial bundled cable (ABC) in bushfire prone areas consistent with the work of the Victorian Powerline Bushfire Program[39] and offers improved safety in special situations, such as near boat ramps, loading docks, hang glider launch sites and in narrow easements.

The excluded items also includes Roads and Maritime Services (RMS) Blackspot Pole Relocations, substation fencing upgrades, compliance programs and the like. These particular Repex programs appear independent of the Opex network asset inspection implications.

Ausgrid's Capex submission is understood to be based on the field assessments by experienced staff, meaning such assets will most likely functionally fail if not replaced within the appropriate time frame. That is, the elimination of these programs will independently increase the hazardous event frequencies described in the threat-barrier analysis.

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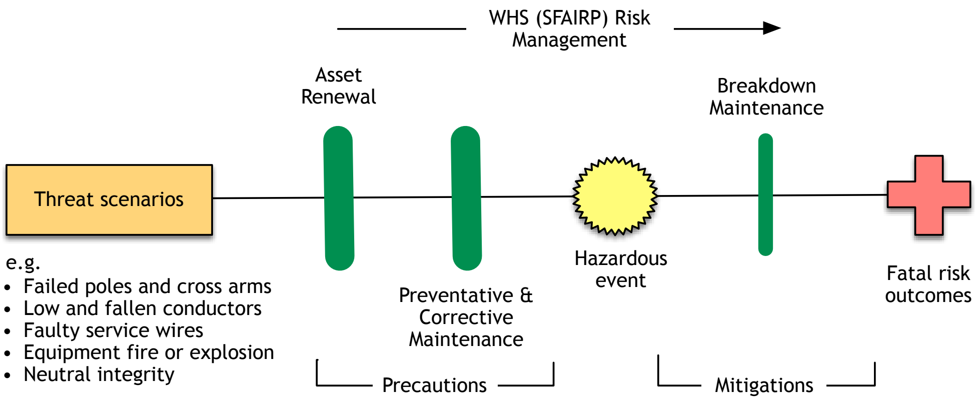
[38] PIP_project_list_20141209 v4.0 safety.xlsx. Mr Gary Winsor, Manager Network Performance, Network Strategy, Networks NSW.

[39] See: http://www.energyandresources.vic.gov.au/__data/assets/pdf_file/0016/205261/PBSP-fact-sheets-1-Working-to-reduce-Victorias-fire-risk.pdf viewed 23dec14 for a summary.

6. CONCLUSION

Ausgrid as a PCBU (person conducting a business or undertaking) has a duty under the provisions of the Work Health and Safety Act 2011 to ensure that, for all foreseeable hazards associated with the operation of the Ausgrid network, all practicable precautions are in place, so far as is reasonably practicable (SFAIRP).

To assist it meeting this duty, Ausgrid has implemented a recognised good practice bottom-up FMECA/RCM (failure mode effects and criticality analysis/reliability centered maintenance) process that optimises lifecycle costs of plant and equipment including safety performance based on the input from experienced and knowledgeable field based Ausgrid staff. This methodology underpinned Ausgrid's submission to the Australian Energy Regulator (AER) particularly for network operating expenditure requirements. The process is conceptually shown in the threat-barrier diagram below.



WHS (SFAIRP) Risk Management Concept Threat-barrier diagram

Effectively, what Ausgrid has done is to apply the hierarchy of controls, as required by the legislation, which means going from the left to the right as shown in the diagram above. That is, foreseeable hazards should be eliminated if reasonably practicable, and if this is not possible, reduced so far as is reasonably practicable. Legally, precautions act before the hazardous event, whilst mitigations act after it.

The AER's draft determination proposes around a 40% reduction in both Capex and Opex over the 5 year determination period. This would require an abrupt decrease of around 2,400 employees (out of 5,388 full-time equivalent employees) and a substantial decrease in equipment inspection frequencies (typically from 5 to 8 years). This will affect Ausgrid's safety performance.

Interestingly, the AER appears to accept that there will be an increase in unexpected events resulting from this draft determination[40]:

> *Where an unexpected event leads to an overspend of the capex amount approved in this determination as part of total revenue, a service provider will be only required to bear 30% of this cost if the expenditure is found to be prudent and efficient. For these reasons, in the event that the approved total revenue underestimates the total capex required, we do not consider that this should lead to undue safety or reliability issues.*

The implication is that if incidents occur, spending money beyond the approved Capex amount to address or rectify the issues will be acceptable to the AER. This is directly contrary to my understanding of the purpose of the WHS Act since it suggests Ausgrid should be reactive rather than proactive with regards to the management of hazards.

If Ausgrid were to operate within the constraints of the AER's draft determination, then in the short term, the number of safety incidents, especially to employees, is expected to spike due to the change in safety culture associated with this scale of staff loss. In the longer term, this analysis indicates that for the foreseeable threats to members of the public considered in this review, an increase of around 3.4 in the fatality rate per annum from network hazards would most likely occur. In addition, the likelihood of the Ausgrid network starting a catastrophic bushfire (meaning 100 fatalities and 1,000 houses lost) more than doubles as a result of increased equipment failures due to longer inspection cycles. This assumes that existing precautions (especially vegetation clearance and asset condition inspection effectiveness) remain unchanged by the proposed revenue reductions.

The AER draft determination, is in effect, directing Ausgrid to disregard Ausgrid's own determination of what Ausgrid believes is necessary to demonstrate SFAIRP under the provisions of the Work Health and Safety Act 2011.

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40 AER Ausgrid draft decision. Attachment 6: Capital expenditure. P 6-18

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