r2a

DUE DILIGENCE ENGINEERS

ESSENTIAL ENERGY

ASSET / SYSTEM FAILURE SAFETY RISK ASSESSMENT

JANUARY 2015

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PROJECT DETAILS

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Project Name:	Asset / System Failure Safety Risk Assessment
Client Reference:	Networks NSW RFQE2
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EXECUTIVE SUMMARY

Essential Energy 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 Essential Energy network, all practicable precautions are in place, so far as is reasonably practicable (SFAIRP).

To meet this duty, Essential Energy 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 Essential Energy staff. This methodology underpinned Essential Energy's submission to the Australian Energy Regulator (AER).

The AER's draft determination proposes a 26% reduction in Capex and a 38% reduction in Opex over the 5 year determination period. This would require an abrupt decrease of around 1,500 employees (out of 4,000) and a substantial decrease in equipment inspection frequencies (typically changing from 4 to 6.5 years). This will have a significant effect on the safety performance of Essential Energy's Network Operation.

If Essential Energy 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, a quadrupling of fatalities from networks hazards is most likely to occur. In addition, the likelihood of the Essential Energy network starting a catastrophic bushfire (meaning 100 fatalities and 1,000 houses lost) triples as a result of increased equipment failures due to longer inspection cycles. This assumes 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.

[1] Draft decision Essential Energy distribution determination 2015-16 to 2018-19. Attachment 6: Capital expenditure. P 6-18

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

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

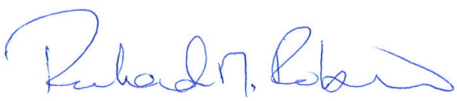
state:

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 Essential Energy, 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 Essential Energy will be able to meet their PCBU WHS obligations based on the proposed operating and capital expenditure allowance in the draft determination.

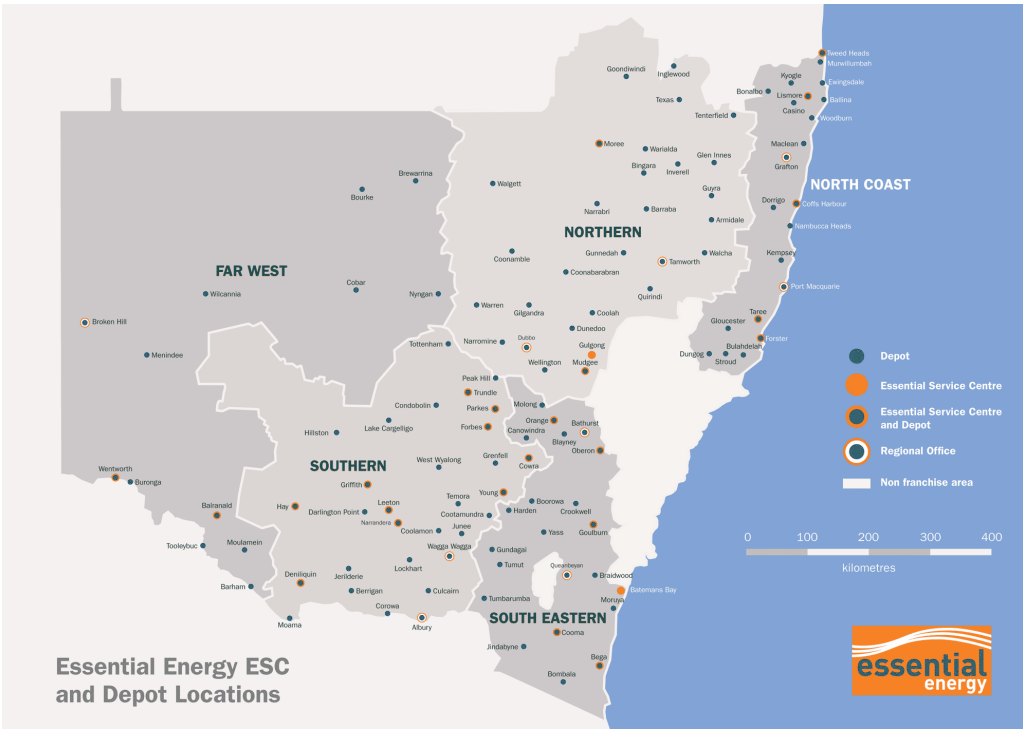
3. BACKGROUND

3.1 ESSENTIAL ENERGY

Essential Energy is responsible for building, operating and maintaining Australia's largest electricity network delivering essential services to around 815,000 homes and businesses across 95 per cent of NSW and parts of southern Queensland. It also has water services with its Essential Water business, which delivers water services to around 20,000 people in Broken Hill, Menindee, Sunset Strip and Silverton, and sewerage services to Broken Hill.

With more than 4,000 employees based across more than 100 depots and regional offices, Essential Energy is a strong contributor to the regional areas it serves.

For the financial year 2013/2014, the network generated a profit after tax of $295.4 million and earnings before interest, tax, depreciation and amortisation (EBitDa) of $1,017.4 million[2].



Essential Energy's Network area[3]

Networks NSW (NNSW) refers to a cooperative operating model across Ausgrid, Endeavour Energy and Essential Energy. The objective of NNSW is to contain the

[2] Essential Energy. 2013-14 Annual Report.
[3] From:
http://www.essentialenergy.com.au/asset/cms/pdf/electricitynetwork/CEPG8029.pdf
viewed 19dec14

future costs of building, maintaining and operating the electricity network in a safe, reliable and sustainable manner.

3.2 AER DETERMINATION BACKGROUND

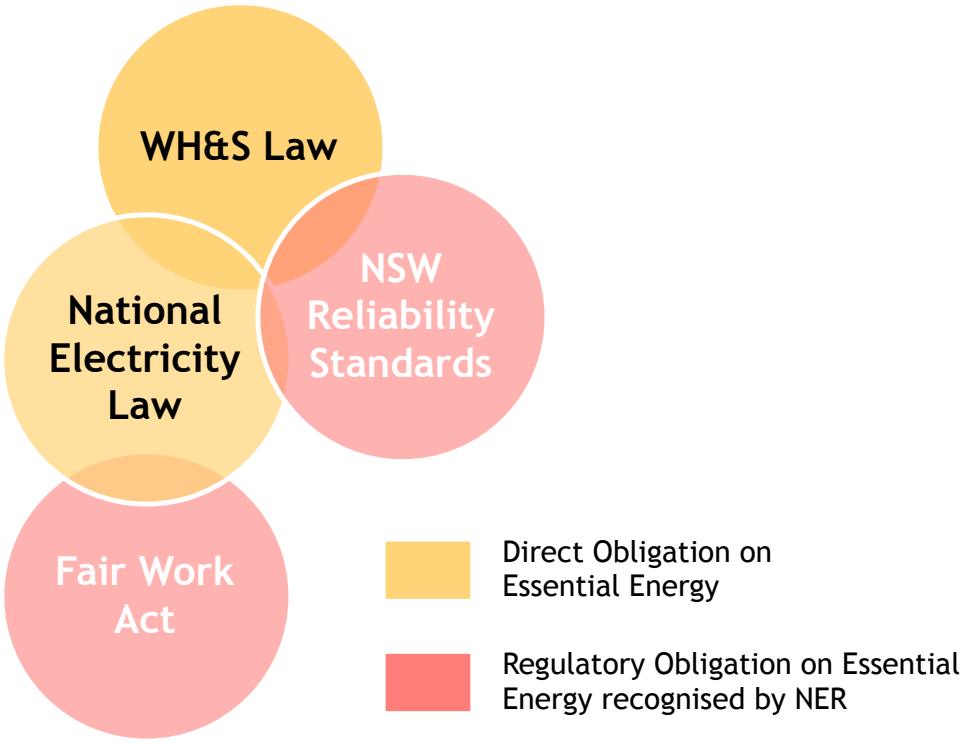
The AER regulates the revenues of the distribution network service providers in eastern and southern Australia under the National Electricity Law (NEL) and National Electricity Rules (NER). The AER is required to determine the revenue allowance for the distribution network service providers under the 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 Essential Energy is shown in the table below.

$ million 2013/14	Submission by Essential Energy	Draft by AER	$ difference	% difference
CAPEX	$2,619	$1,934	-$684	-26%
OPEX	$2,332	$1,437	-$895	-38%
Total	**$4,951**	**$3,371**	**-$1,579**	**-32%**

3.3 LEGAL CONTEXT

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



The overarching legislation in relation to safety is the Work Health and Safety Act 2011 (WHS Act). Under the Act, Essential Energy 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).

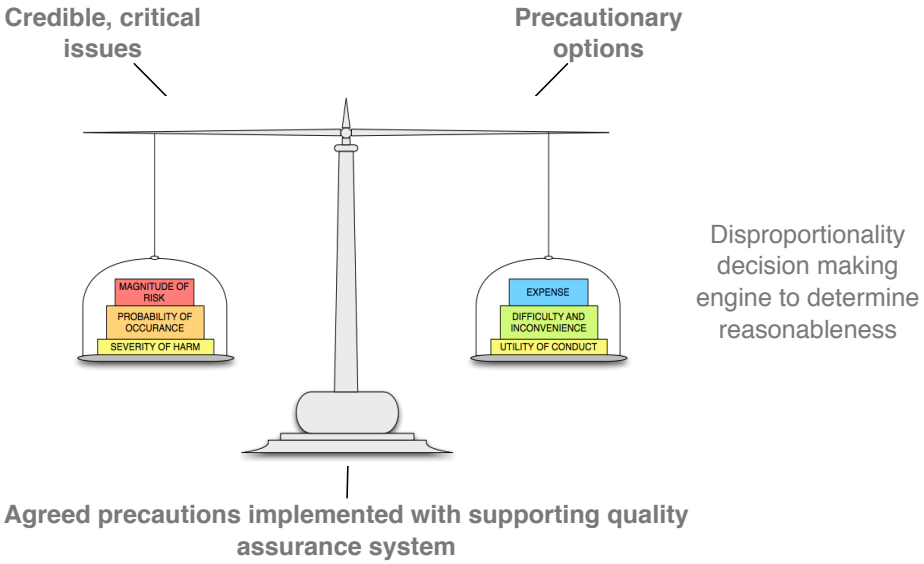
A PCBU needs to consider what is able to be done in relation to the identified risk and then the extent to which those identified control measures are reasonable in the circumstances. However, cost of itself is unlikely to be a sufficient justification for choosing a lower order safety control measure (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.



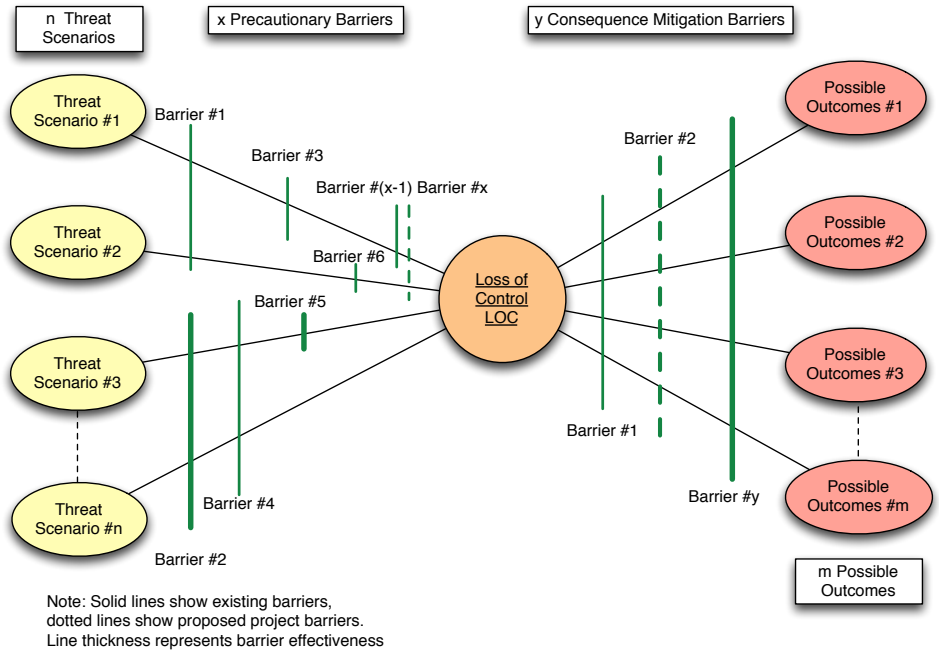
R2A 'Y' Model

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.

[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 and emergency services. Service interruptions present major concerns for those on life support equipment.

Asset related preventative and mitigative maintenance controls are used by Essential Energy 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 Essential Energy 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. Essential Energy also has significant capital programs for replacement of assets as their performance degrades and they reach the end of their service lives.

The draft AER determination is for Essential Energy to reduce Capex by 26% and Opex by 38%.

Currently, 40% of Essential Energy's Opex is spent on vegetation clearance. Essential Energy has committed to continue with its current vegetation clearance program meaning that the effective Opex cuts will need to be greater than 38% across the remaining network asset related maintenance tasks. From an Opex viewpoint, Essential Energy indicates that 1,500 immediate job reductions (out of around 4,000 employees[9]) 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 has an immediate and major impact on the frequency of overhead network equipment inspections, typically extending the inspection cycle from 4 to 6.5 years and creating a substantial expected increase in network faults.

[7] Ausgrid Executive Leadership Group Meeting 28 Feb 2013. FMECA/RCM Project Update. (John Hardwick). See also:. 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] 2013-14 Annual Report. Essential Energy.

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[10] (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 Essential Energy, an abrupt reduction of around 26% in Capex and 38% Opex expenditure represents major corporate change which is very likely to effect safety outcomes at the front line of the organisation.

The ATSB[11] 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[12].

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

[10] 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.
[11] 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*
[12] James Reason (1997). *Managing the Risk of Organizational Accidents*. Ashgate Publishing. Aldershot. p 10.

Reason[13] notes in his introduction to Andrew Hopkins' 2005 book, *Safety Culture and Risk*, *The Organisational Causes of Disasters* that:

> *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[14] 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 brief review of the incident data contained in Essential Energy's Totalsafe database since 2009 was completed. Network related fatalities during this period include an employee fatality at Bulahdelah in September 2013, a public motor vehicle accident fatality in Gunnedah on January 2012, a public contact with low conductor fatality in Coonabarabran on March 2013 and an agricultural work death at Tenterfield which was also reported in the NSW Safety Regulator's data sheet[15].

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 Essential Energy 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

[13] Andrew Hopkins 2005. *Safety, Culture and Risk*. The Organisational Causes of Disaster. CCH Australia Limited.
[14] 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.
[15] NSW Office of Fair Trading. Electrical Accidents in NSW 2009 to 2010. *Fatal accidents summary*.

- Collision with poles
- Loss of electricity supply causing fatal risk to customers on life support equipment

5.3 CATASTROPHIC BUSHFIRE STARTS

The following table summarises the major bushfires in NSW (and ACT) for the last 76 years[16].

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[17].

[16] *History of Fires in NSW* as provided by the NSW Rural Fire Service 7th January 2015.

The state of NSW has not suffered the type of catastrophic bushfire that has occurred in Victoria. However, Professor Tolhurst's draft report[18] 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[19].

The Victorian Powerline Bushfire Safety Taskforce[20] 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[21] 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*

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[17] This is based on dividing the total deaths and houses lost by the number of fire seasons.
[18] Dr Kevin Tolhurst, 2013. Draft *Report on the Bushfire Risk for Power Distribution Businesses in New South Wales.*
[19] In the Black Saturday fires, there were 2133 houses destroyed and 173 deaths occurred. 2009 Victorian Bushfires Royal Commission. Final Report Summary.
[20] Powerline Bushfire Safety Taskforce. Final Report. 30 September 2011 p 24.
[21] The 2009 Victorian Bushfires Royal Commission. July 2010. *Final Report Summary*. P 12.

in the number of fires resulting from asset failures unless urgent preventive steps are taken.

The latest report by EnergySafe Victoria[22] (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:

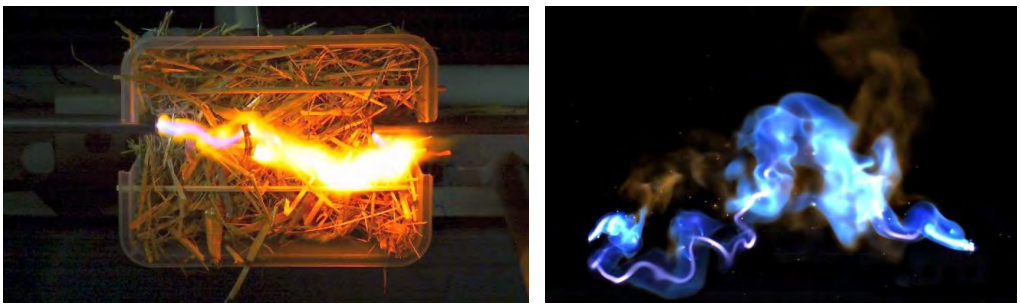
> *Notwithstanding the significant capital investment and maintenance expenditure being made in the network, and the effort that has been put into condition assessment, ESV would have expected to see a reduction in the number of asset failures. Despite these targeted programs, the number of asset failures 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[23]. As the sign suggests, a Catastrophic rated day is a subset of total Toban days.

[22] Energysafe Victoria (June 2014). *Safety Performance Report on Victorian Electricity Networks 2013*. The quote is from the Summary on page 7.
[23] 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 fires starting 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.



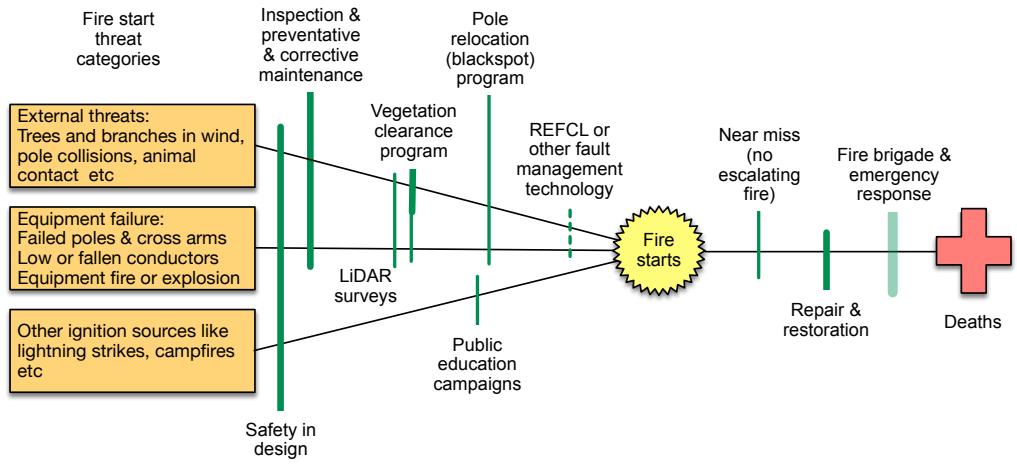
Electric arcs produced during testing[24]

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)[25]

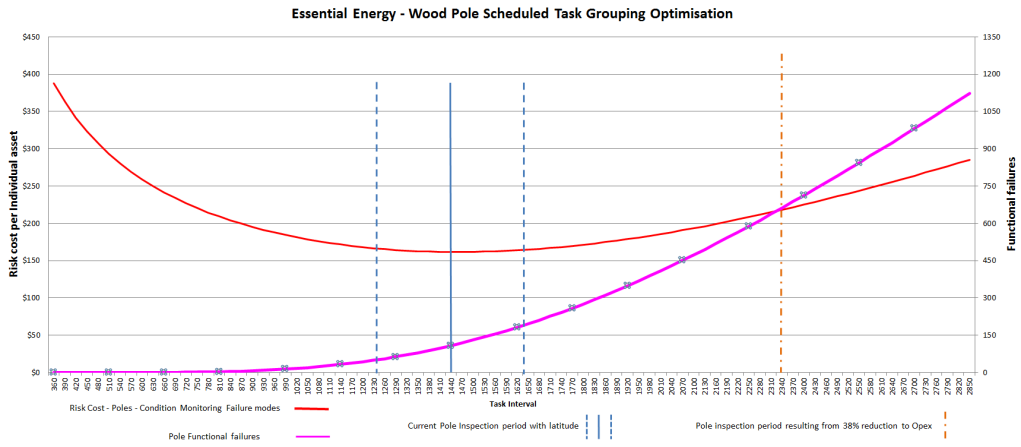
[24] Powerline Bushfire Safety Taskforce. Final Report. 30 September 2011 p 42.
[25] Marxsen Consulting, 4 August 2014. *REFCL Trial: Ignition Tests*. p 17.

The threat barrier diagram below describes the key fire start mechanisms and barriers on a Catastrophic (Code Red) day. This is usually 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 fire fighters and emergency response equipment to go round. This makes the other barriers more important.



Catastrophic (code red) day fire start threat barrier diagram

For example, 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 4 to around 6.5 years[26] as shown below[27]. That is moving from the solid blue line to the dotted orange line. Note that the increase in failure rates by extending inspection periods is exponential in nature.



Wood Pole Failures Summary

[26] Calculated on the basis of the inspection effort being reduced by the AER draft determination expenditure cut. That is: 4 years /(1-0.38) = 6.4 years

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

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
Pole (Timber) reduced strength or failure due to fungal decay - brown rot.	10.3
Pole (Timber) reduced strength or failure due to fungal decay - other type.	5.4
Pole (Timber) reduced strength or failure due to fungal decay - white rot.	5
Pole (Timber) reduced strength or failure due to termites – coptotermes.	5.8
Pole (Timber) reduced strength or failure due to termites – nasutitermes.	3.8
Pole (Timber) reduced strength or failure due to termites - unknown type.	6.3
Average	**6.1**

That is, based on the FMECA/RCM model used by Essential Energy, this is expected to increase wood pole failure rates by about a factor of 6.1[28]. This means that Essential Energy, which currently has a predicted pole failure rate of around 78 per annum is expected to have around 478 per annum once the full impact of the extended inspection cycles has taken effect[29]. (These numbers are probably conservative as the reported number of unassisted pole failures in FY13/14 was 108).

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 6 for pole related failures which includes the poles themselves, cross arms, insulators, ties and conductors[30].

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 Opex changes (particularly the vegetation clearance effectiveness), if the equipment failure rate fire starts increased by a factor of 6, then, all other matters being equal, the overall fire starts due to network faults would increase by a factor of around 2.7[31].

[28] The calculated figure from the FMECA/RCM data taking pole population figures into account is 6.1. See the reference in the following footnote.
[29] Gary Winsor, Manager Network Performance, Network Strategy, Networks NSW. December 2014. *AER OPEX Reduction Implications.doc*. Appendix 1.
[30] Essential Energy has access to data to calculate an average value for all these items, but this has not been done at this point in time.
[31] Calculated on the basis that one of the three fire start sources (network faults) has increased by a factor of 6. That is, increasing the fire starts ratio from 3 to 8, or 8÷3 = 2.66.

If major fires in NSW as a whole occur once every 5 years and the Essential Energy network accounts for one third of these, then instead of a major fire every 15 years in the Essential Energy region, they would increase to around once every 5.5 years[32]. That is, a tripling of fire frequency implying an increase of 10 lives and 100 houses lost. 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 effective as they are now. For example, that the 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[33] and NSW Fire & Rescue[34]. Essentially, if the equipment failure rates increase as predicted, and barrier effectiveness declines (for example, the vegetation clearance program reductions) coincidently with an increase in the number of Catastrophic (Code Red) days (possibly due to global warming) then the fire starts could increase dramatically, effectively transferring a horrendous 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[35] 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.

[32] 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: Essential Energy increases fire starts by about a factor of 2.7 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. Essential Energy is one of 3 networks in NSW. This means the new estimated fire start frequency is about: 2.7÷(5x3) = 0.18 pa or around 1 in 5.5 years in the Essential Energy network area.

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

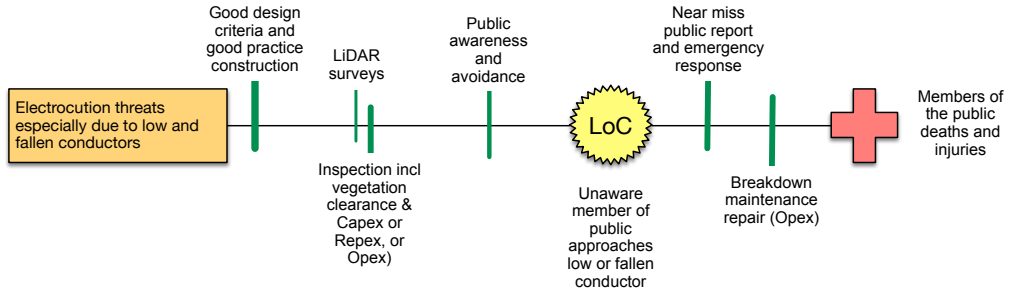
[34] Mr Greg Mullins, Commissioner, NSW Fire and Rescue, 4 December 2014 in a letter to Mr Vince Graham.

[35] 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 at least a fallen pole, broken cross arm, failed insulator, failed tie or broken conductor.



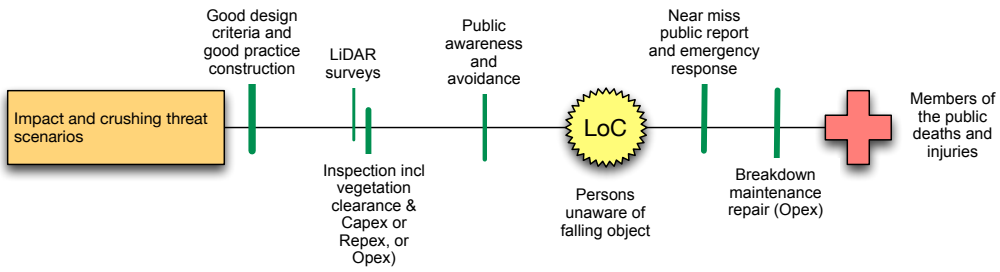
Electrocution threat-barrier diagram

The current Essential Energy Capex 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 the inspection regime of around 4 to 6.5 years as a result of the draft determination, an increase in failure rates of around 6 (using the pole data above) will result in an equivalent increase in the fatality rate.

FALLING OBJECTS

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

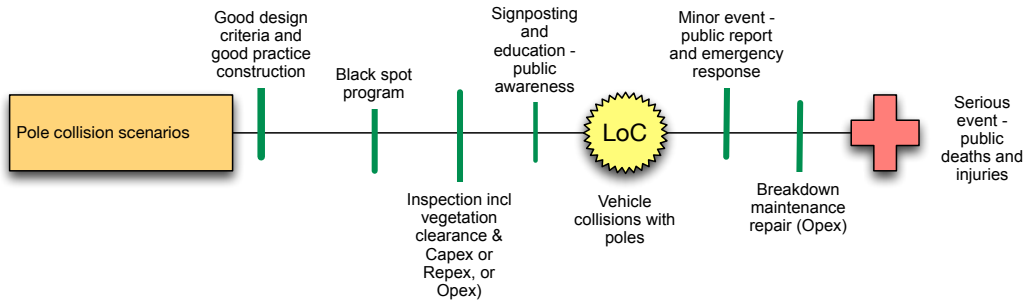


Falling objects threat-barrier diagram

Based on the same analysis as used in the previous example (electrocution), it is expected that the increase in falling object incidents will be around 6 per annum.

COLLISION WITH POLES

The proposed reduction in expenditure will eliminate the capacity for Essential Energy 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[36].



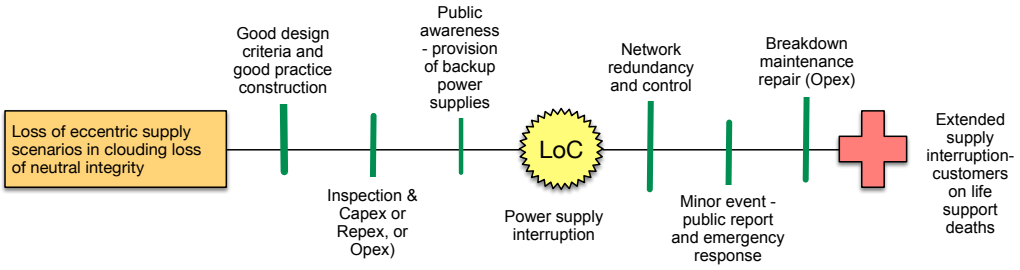
Collision with poles threat-barrier diagram

If the Essential Energy Black Spot Pole program were to continue, there would be presumably commensurate safety improvements.

[36] 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. In the event of an outage, the reduce employee levels would also increase response and restoration times.



Loss of service threat-barrier diagram

A separate study has been commissioned to consider this issue. The fault rate will increase. As a preliminary estimate for this report, a 6 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 Essential Energy, a 4 year inspection appears presently optimal, replacing suspect poles thereby enabling optimal survival of all poles until the next inspection. If the inspection cycle is increased to 6.5 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 6.5 years).

This also means that the immediate failure consequences of extending the inspection periods would not be noticed for probably 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 really show up towards the end of the 4th year. Conceptually, it would only be the poles entering the 5th

year that should be at risk. And by the 6th year pole failures would have become serious and the safety and implications very high if the poles haven't failed already (breakdown maintenance). In short, extending the inspection cycle would provide a short term gain but significantly greater medium and long term cost.

		Current Essential Energy 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	0.18 (1 in 5.5 years)	5	0.9
ii	Electrocution (all persons)	0.1 (1 in 10 years)	1	0.1	0.6 6 increase	1	0.6
iii	Falling objects (all persons)	0.1 (1 in 10 years	1	0.1	0.6 6 increase	1	0.6
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	0.6 6 increase	1	0.6
				0.7			**2.8**

Mortality Implications

Essentially this preliminary understanding of the threat barrier analysis suggests that by the time of the 6th year of the inspection cycle the fatality rate will have quadrupled (2.8÷0.7) 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 Essential Energy. 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 remain less than what they are now.

5.5.2 CAPEX

Essential Energy has provided the Portfolio Investment Plan (PIP), being a prioritised spreadsheet of planned works and tasks for Capex for the 5 year determination period[37]. 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 Essential Energy's projects indicates that they are mostly Repex (meaning replacement of life expired or obsolete equipment) often to do with ensuring security of supply to customers on life support equipment. It also includes Roads and Maritime Services (RMS) Blackspot Pole Relocations, substation fencing upgrades and the like. This means the issues considered appear independent of the Opex network asset inspection implications noted in the section above.

Essential Energy's Capex submission is understood to be based on field assessments by experienced staff, meaning it 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 above.

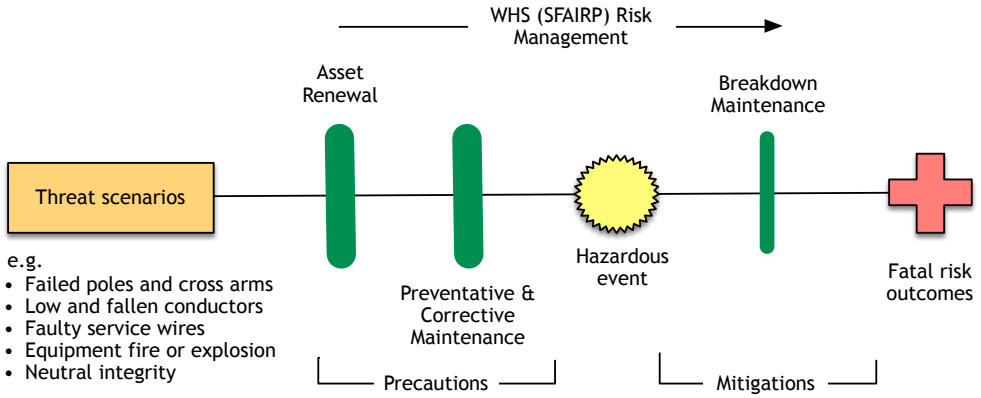
[37] PIP_project_list_20141209 v4.0 safety.xlsx. Mr Gary Winsor, Manager Network Performance, Network Strategy, Networks NSW.

6. CONCLUSION

Essential Energy 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 Essential Energy network, all practicable precautions are in place, so far as is reasonably practicable (SFAIRP).

To meet this duty, Essential Energy has implemented a recognised good practice bottom-up 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 input from experienced and knowledgeable field based Essential Energy staff.

This methodology underpinned Essential Energy'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 Essential Energy has done is to apply the hierarchy of controls, as required by legislation, which means going from the left to the right as shown in the single line threat-barrier 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 occurs, whilst mitigations act after it.

The AER's draft determination proposes a 26% reduction in Capex and a 38% reduction in Opex over the 5 year determination period. This would require an abrupt decrease of around 1,500 employees (out of 4,000) and a substantial decrease in equipment inspection frequencies (typically from 4 to 6.5 years). This will affect Essential Energy's safety performance.

Interestingly, the AER appears to accept that there will be an increase in unexpected events resulting from this draft determination[38]

> *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 Capex to address the issues will be OK. This is directly contrary to my understanding of the purpose of the WHS Act since it suggests Essential Energy should be reactive rather than proactive with regards to the management of hazards.

If Essential Energy 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, a quadrupling of the fatality rate per annum from networks hazards is most likely to occur.

In addition, the likelihood of the Essential Energy network starting a catastrophic bushfire (meaning 100 fatalities and 1,000 houses lost) triples as a result of increased equipment failures due to longer inspection cycles. This assumes existing precautions (especially vegetation clearance and asset condition inspection effectiveness) remain unchanged by the proposed revenue reductions.

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

38 38 Draft decision Essential Energy distribution determination 2015-16 to 2018-19. Attachment 6: Capital expenditure. P 6-18

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