SA Power Networks

Supporting document 5.5

Cutler Merz - CBRM Model Value of Consequence Independent Report

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CutlerMerz Pty Ltd
ABN 16 607 833 590
201 Sussex Street
Sydney NSW 2000 Australia
T +61 2 9006 1024
www.cutlermerz.com

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1 Executive Summary

SA Power Networks engaged CutlerMerz to conduct an independent review of the Value of Consequence assumptions in the Condition Based Risk Management (CBRM) models that support SA Power Networks' repex forecast for the 2020-25 regulatory submission. CutlerMerz is to make recommendations to SA Power Networks where CBRM assumptions should be updated to align with standard industry practice.

CutlerMerz' review of SA Power Networks' CBRM model assumptions for risk Value of Consequence identified six recommendations to improve the accuracy of the models:

1) Safety risk: Update the safety risk valuation methodology to use the latest Value of Statistical Life (VSL) estimates published by the Australian Government

2) Safety risk: Formalise the use of Disproportionality Factors in the safety risk valuation methodology and select factors that align with Australian industry practice

3) Fire risk: Recalculate the probability of starting a bushfire in the poles CBRM model

4) Fire risk: Revise the calculation for the bushfire risk value using the updated safety Value of Consequence

5) Environmental risk: Update the value of SF6 environmental risk using updated data

6) Environmental risk: Review the assumptions underlying oil loss for substation power transformers

2 Background

SA Power Networks used Condition Based Risk Management (CBRM) models to support is initial proposal to the Australian Energy Regulator (AER) for the 2020-25 regulatory period. The CBRM models were used for Poles, Substation Power Transformers, Substation Circuit Breakers and Substation Protection.

The models are built into SA Power Networks internal computer systems and were not able to be provided to the AER. Although the models were described to the AER in documentation and workshops, the AER raised concerns about the Value of Consequence assumptions used in the models. In particular, the AER was concerned that the risk values represented only the most severe consequences when most asset failure events would be expected to only result in minor or moderate consequences.

SA Power Networks engaged CutlerMerz to conduct an independent review of the Value of Consequence assumptions in the CBRM models. CutlerMerz was to make recommendations to SA Power Networks where CBRM assumptions should be updated to align with standard industry practice. The review was to be summarised in an Independent Report to be included in the Revised Regulatory Proposal for the 2020-25 regulatory period.

2.1 CBRM Models

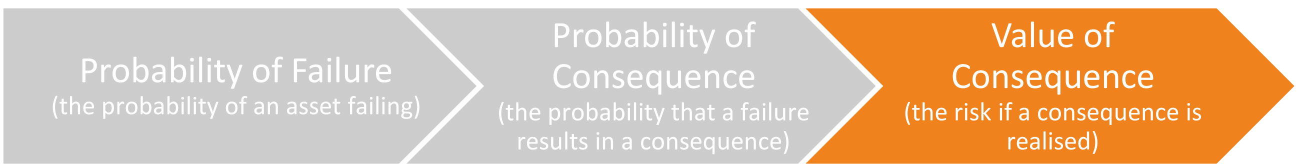
Condition Based Risk Management is an asset renewal forecasting methodology that utilises asset information, engineering knowledge, historical performance and practical experience to quantify the condition of an asset and the associated risk it poses. Since it was first developed in 2002 by EA Technology Limited, the CBRM methodology has become widely used by utility operators and regulators throughout Australasia and the world to forecast renewal expenditures of asset populations.

In 2013 CBRM was adopted by SA Power Networks and it formed part of its basis in forecasting replacement expenditure during the 2015-2020 regulatory proposal. SA Power Networks has further developed its CBRM models and increased the scope to include protection assets for its 2020-25 regulatory proposal.

SA Power Networks has adopted a 'maintain risk' methodology for converting the outputs of the CBRM models into capex forecasts for five-year regulatory periods. The methodology determines the minimum number of asset replacements or refurbishments required so that modelled risk at the end of the period is the same as it was at the start.

2.2 Independent Assessment Scope

The purpose of the independent report is to review the Value of Consequence in the CBRM models.



The focus of this report is the Value of Consequence. Any review of the Probability of Failure and Probability of Consequence was limited to where it was necessary to determine the reasonableness of the Value of Consequence being used.

3 Review of Risk Consequence Parameters

The review outcomes are presented below for Safety, Fire, Environmental, Network Performance and Financial risks.

3.1 Safety Risks

3.1.1 SA Power Networks' inputs

The CBRM models use three severity levels for safety consequences. These are fatality, major injury and minor injury. The value of consequence for each severity follows a log scale where each consequence is one tenth of the next most severe level.

The value of consequence for a fatality is used to determine the value of consequence for all three severity levels. SA Power Networks selected the value of $10m for a fatality, which was recommended by EA Technologies, the developer of the CBRM Models.

Severity	Value of Consequence
Fatality	$10,000,000
Major Injury	$1,000,000
Minor Injury	$100,000

A formal explanation of how the $10m figure was derived is not available. However, it appears that it is based on the value used by Ofgem of £10m with no currency adjustment applied. The Ofgem value is derived from values reported by the Health & Safety Executive (HSE), a UK government independent regulator. The HSE values are £1.6m for a fatality and a Disproportion Factor of 6.25 for a total value of £10m.

The HSE value covers both death and serious injury. Therefore, the £10m value represents the weighted average of the Fatality and Minor Injury categories used by the CBRM models.

3.1.2 Industry standard values

The value of a fatality is typically valued using the Value of Statistical Life (VSL). The VSL represents willingness to pay for reductions in the risk of physical harm.

In 2014, the Australian Government published a guidance note on applying VSL in regulatory impact statements and cost benefit analysis[1]. Based on international and Australian research, the guidance note provided a credible estimate of the value of a statistical life of $4.2m in 2014 dollars. This value was used in the model for the catastrophic safety consequence.

Standard industry practice since the guidance note was released has been to escalate the VSL using CPI. However, this approach does not factor in increasing worker productivity and income over time.

In 2019 the Australian Government published an updated guidance note with revised figures[2]. This note puts the VSL at $4.9m in 2019 dollars. This updated value was derived by using ABS Wage Price Index data[3] to escalate the 2014 estimate to 2019 dollars.

[1] Department of the Prime Minister and Cabinet: Office of Best Practice Regulation, Best Practice Regulation Guidance Note: Value of statistical life, Australian Government, 2014

[2] Department of the Prime Minister and Cabinet: Office of Best Practice Regulation, Best Practice Regulation Guidance Note: Value of statistical life, Australian Government, 2019

[3] Australian Bureau of Statistics, Wage Price Index, Cat. No. 6345.0, Table 1, Column G

Disproportionality Factors

Australian Standard AS5577 Electricity Network Safety Management Systems covers the managing of safety risks associated with the operation of an electricity network. The standard requires network safety risks to be eliminated, and if this is not reasonably practicable, then to be reduced to as low as reasonably practicable (ALARP). A common approach applied within the industry to determine whether ALARP has been achieved is to determine whether the cost of reducing the risk is grossly disproportionate to the quantified safety benefits gained.

The application of a Disproportionate Factors (DFs) to the consequence value represents an organisations appetite to spend more than the value of the safety risk avoided to reduce the risk.

The Australian Office of the National Rail Safety Regulator (ONRSR) was an early user of Disproportionality Factors in Australia. In a paper[4], ONRSR suggested that the evidence at the Sizewell B Public Inquiry in the UK provides a starting point for the development of Disproportionality Factors. In this evidence it was suggested a gross disproportion factor of up to 3 for workers and for risks to the public, it was suggested that the factor would depend on the level of risk, and where the risks were low (consequence and likelihood) a factor of about 2 was suggested, whereas for higher risks the factor should be about 10. The Sizewell B Public Inquiry is the basis for most Disproportionality Factor estimates in Australia and around the world.

Ofgem have stated[9] that it is unlikely the Disproportionality Factor should be higher than 10. A similar statement[5] has been made by the Health Safety Executive (UK). However, in this case it was also stated that a duty holder would have to justify use of a Disproportionality Factor smaller than 10, indicating that a factor of 10 should be considered the benchmark.

The New Zealand Transport Agency states "the greater the degree of potential harm, the more effort (and potential expense) will be expected in regards to ensuring safety. This balance must be assessed on a case-by-case basis, but would need to be several times the benefits before it could be considered 'grossly disproportionate'."[6] This indicates an increasing scale in the low to medium single digits.

The range of 2 through 10 has been used by electricity distribution networks in Australia.

The table below shows the application of Disproportionality Factors by a sample of organisations. A severity level of catastrophic is interpreted as a fatality.

			Severity Level		
Organisation	Insignificant	Minor	Moderate	Major	Catastrophic
Sizewell B Public Inquiry - Worker	3	3	3	3	3
Sizewell B Public Inquiry – Public	2	4	6	8	10
Ausgrid	2	4	6	8	10
EQL	2	4	6	8	10 (single fatality) 12 (multiple fatality)
United Energy[7]				3	3 (single fatality) 6 (multiple fatality) 1-10 (bushfire)

[4] https://www.onrsr.com.au/__data/assets/pdf_file/0009/2412/Guideline-Meaning-of-Duty-to-Ensure-Safety-SFAIRP.pdf
[5] http://www.hse.gov.uk/risk/theory/alarpcheck.htm
[6] https://www.nzta.govt.nz/roads-and-rail/rail/operating-a-railway/risk-management/so-far-as-is-reasonably-practicable/
[7] Fixed values are used for safety and a sliding scale from 1 to 10 for bushfires (based on bushfire zone)

Organisation	Insignificant	Minor	Severity Level Moderate	Major	Catastrophic
Essential Energy (Electric Shock)[8]	3	3	3	3	3
Ofgem[9]			6.25	6.25	6.25
HSE (Offshore installations)			6	6	6
Office of Nuclear Regulation (UK)[10]	3	10			

3.1.3 Summary and recommendations

The value for a fatality used in the CBRM models should be updated to align with Australian VSL using the 2019 guidance note value. Where the VSL requires escalation to future years, the ABS Wage Price Index should be used.

SA Power Networks should formalise the use of Disproportionality Factors with the intention of using values that are in line with those used by comparable businesses in Australia and internationally. Disproportionality factors can be applied at either a flat rate or an increasing scale. In Australia, current industry trends are towards the use of a scale where a lower factor is applied to smaller risks and a higher factor to larger risks such as fatalities. A typical increasing scale would fill a range with a starting value of around 2 and an upper limit of around 10. If a single value is to be applied, a typical reasonable value would sit in the mid to upper end of this range, between 5 and 8.

The use of a log scale for determining the value of major or minor injuries is a common approach to valuing severity levels. However, there is a basis for the value of a major injury being greater than 10% of a fatality, with values used internationally for types of major injuries such as amputations using factors of 30% of VSL.

CutlerMerz expects that these changes would result in a significant increase in the value of fatality used in the CBRM models. This would also have a flow on effect to the Value of Consequence for major injuries and minor injuries.

[8] Essential Energy also used values of 2 for physical impact, 6 for bushfire and 3 for worker. Essential Energy did not apply a sliding scale.
[9] DNO Common Network Asset Indices Methodology v1.1 (2017)
[10] ONR Guidance on the Demonstration of ALARP. T/AST/005 - Issue 4 - Rev 1 20- 01-2009
For radiation exposure where Minor=Just Tolerable and Insignificant=Broadly Acceptable

3.2 Fire Risks

3.2.1 SA Power Networks' inputs

Only the poles and protection CBRM models include bushfire risks. In the poles model the probability of an individual pole starting a bushfire is so low that the software rounds the probability to zero. This results in the bushfire risk of the total population of poles also being zero. CutlerMerz has reviewed the bushfire assumptions in the poles CBRM model and the risk values that would be generated if the rounding to zero error did not occur.

The CBRM models use two severity levels for fires, bushfire (meaning a catastrophic bushfire) and fire start (meaning a major bushfire). The Value of Consequence for a bushfire was developed using a bottom up approach.

The consequence is made up of three components, safety risk, environmental risk and opex risk. The safety risk was developed from the CBRM safety risk inputs and assumptions about the number of fatalities, major injuries and minor injuries that can be expected from a typical catastrophic or major bushfire. The build-up of the Value of Consequence for both Bushfire and Fire Start is presented in the tables below.

Bushfire (Catastrophic Bushfire) Value of Consequence

The safety assumptions for a bushfire are presented below:

Severity	Number of persons affected	Risk Value	Value of Risk
Fatalities	20	$10,000,000	$200,000,000
Major Injuries	50	$1,000,000	$50,000,000
Minor Injuries	100	$100,000	$10,000,000
Total Safety Risk			**$260,000,000**

Total bushfire risk is:

Risk	Value of Consequence
Safety	$260,000,000
Environment	$5,034,750
Opex	$250,000,001
Total Risk	**$515,034,751**

Fire Start (Major Bushfire) Value of Consequence

The safety assumptions for a fire start are presented below:

Severity	Number of persons affected	Risk Value	Value of Risk
Fatalities	0.1	$10,000,000	$1,000,000
Major Injuries	0.5	$1,000,000	$500,000
Minor Injuries	1	$100,000	$100,000
Total Safety Risk			**$1,600,000**

Total fire start risk is:

Risk	Value of Consequence
Safety	$1,600,000
Environment	$2,025
Opex	$2,000,001
Total Risk	**$3,602,026**

The CBRM models do not apply specific Disproportionality Factors to bushfires. However, Disproportionality Factors are contained within the safety risk component of the Value of Consequence.

No documentation is available to explain the original selection of the above values, other than they were determined jointly by SA Power Networks and EA Technologies. However, SA Power Networks was able to provide additional reports that support the values that are being used.

The opex risk aligns with values determined by Willis Re in a report for SA Power Networks[11]. The table below was included in the report indicating opex costs in the range of $194m to $509m depending on the location of the fire:

		($,m)				
Region	Estimated number of addresses	Residential Property Damage	Fatalities & injuries	Other Costs	Claims handling	Total
Adelaide Hills	847	263	17	183	46	509
Port Lincoln	821	228	16	158	40	442
South East	594	134	12	93	24	264
Willunga	402	100	8	69	18	194

Although a detailed review of this report is out of the scope of this review, the methodology and use of detailed data and sophisticated fire modelling software indicate that a reasonable approach has been taken to calculate these values. The report is limited to an assessment of high fire risk areas so may not be representative of the entirety of SA Power Networks' network coverage. However, the CBRM models reduce bushfire risk to zero for assets in low risk network areas so that the values used in the model only represent fire risks in high risk areas, which improves the comparability of the figures.

The report supports the use of $250m, as this value is lower than the average value of the four regions in the report of $293m.

The Willis Re report also includes an assessment of the number of fatalities and injuries that would be expected from a catastrophic bushfire in the same four regions. This is based on fatality rates for fires in similarly populated areas and expected fire size (in hectares). The report produces a range that includes the 20 fatalities per fire included in the safety risk calculation.

3.2.2 Industry standard values

Bushfires are not a clearly defined event. A higher Value of Consequence can be justified by limiting the definition of a catastrophic bushfire to only those fire events that are among the very worst. Therefore, to determine the reasonableness of the Value of Consequence of a bushfire it is just as important to assess the likelihood of the fire occurring as it is to review the valuation of the consequence.

For a fire with a consequence of over $100m there is a reasonable expectation that the likelihood of these occurring is low. The likelihood of such a fire being caused by the failure of an electricity network asset will be lower still and the likelihood of the fire being started by a particular type of network asset (such as poles) to be even lower.

[11] SA Power Networks Australia Limited Bushfire Modelling (2013)

Also, there is a significant gap between the Value of Consequence for a bushfire and a fire start. Standard industry practice for risk modelling is to apply severity levels using a log scale. This is often in the form of each increase in severity level increasing the consequence value by 10 times. The CBRM models do not have a comparable bushfire severity in the $25m-$250m range. To compare with standard industry values, it is assumed the top end of the missing severity level is assigned to bushfire and the lower end to fire start.

Unlike some other networks, SA Power Networks has not included the risk value of minor fires (<$~1m of risk) in the CBRM models. As these small fires are more numerous, they can in some cases make a noticeable contribute to total fire risk.

South Australia Bushfire Value of Consequence Comparisons

SA Power Networks have recently undertaken detailed bushfire mitigation CBA modelling using experts such as the CSIRO[12]. This modelling is the most relevant comparison available to determine the reasonableness of the bushfire Value of Consequence inputs used in the CBRM models. This is because: the analysis is recent and reflects current conditions; the analysis covers South Australia and specifically SA Power Networks' region of operation; and the outcomes of the analysis (bushfire mitigation capex) have been accepted by the AER.

The model used for the Bushfire Mitigation CBA assumed a major bushfire ($50m or greater) would be started once every 10 years and a catastrophic bushfire ($250m or greater) once every 70 years. This is significantly less common than the assumptions used for poles in the CBRM, which forecast a major bushfire every five years and a catastrophic bushfire every 33 years.

The analysis resulted in an annual bushfire risk $18.6m from all network assets. Approximate recent fire start numbers for SA Power Networks indicate about 10% of fire starts are due to poles, suggesting an annual risk value attributable to poles should be on the order of $1.9m. In the extreme case where all of this risk is from catastrophic bushfires only, the rate of occurrence would be approximately 1 in 270 years[13], which is significantly higher than the 1 in 33 years assumed in the poles CBRM model.

Other Bushfire Value of Consequence Comparisons

Comparison of bushfire risk between networks is difficult due to significant geographical and meteorological differences. CutlerMerz has previously reviewed the relative fire risks between Victoria and NSW and determined that NSW had a significantly lower risk of catastrophic bushfires than Victoria. Key findings from the investigation were:

- NSW did not have any extreme bushfire potential zones whereas Victoria, Tasmania and Western Australia did.
- The regular occurrences of meteorological conditions that are conducive to fire starts on extreme bushfire prone days occurred in Victoria but not in NSW. When combining both factors, Victoria is exposed to "Extreme" bushfire risks which are not present in NSW;
- "Extreme" bushfire potential zones have 3-5 times greater frequency of house damage than a "Very High" zone;
- 30% of all historical bushfire losses are in "Extreme" bushfire potential zones;
- 90% of properties destroyed are within 100 metres of bushland. Victoria has over 9,500 houses within 100 metres of bushland in an "Extreme" bushfire potential zone, whereas NSW has none;
- Loss causing bushfires have a similar frequency in Victoria and NSW at approximately 1 in 3 years. However, Victoria has a greater magnitude of bushfire losses and severe fire days than NSW; and
- Victoria has experienced the greatest percentage of bushfire related building damage over the last 110 years

Fire consequence modelling (Phoenix RapidFire developed by the University of Melbourne) carried out by Professor Tolhurst delivered results broadly consistent with the above observations.

[12] SAPN - 5.16 - CSIRO Electrically-Initiated Bushfire Suppression Model Analysis - 29 January 2019

[13] $515m / $1.9m = 271 years to event

The valuation of the economic costs associated with 2009 Victorian bushfires estimated the cost at $4,369 million ($4.4b in 2009 dollars) with the average cost for each fire that broke out in the order of $330 million. A Regulatory Impact Statement (RIS) associated with proposed policy changes in Victoria following the 2009 fires (ACIL ALLEN, 2015) investigated a range of data and information and found that the average cost per fire over $10 million was in the order of $300 million. Of note however is those fires started by electricity assets contributes a proportion to the average. On this basis, the value applied in the RIS for the average annual cost of fires cause by electricity assets was $80 million.

Combining the analysis following the 2009 Victorian fires with the NSW investigations into bushfire risk, it is expected that on average, a catastrophic fire in NSW is likely cost between $66 million and $110 million.

It is well accepted that Victoria faces the highest risk of catastrophic bushfires. With more data available, Victoria forms a benchmark for valuation of fire risk, but NSW is a more reasonable comparator for fire risk in South Australia. Therefore, a reasonable starting point for the Value of Consequence of a catastrophic bushfire in South Australia is the range of $66m to $110m before a Disproportionality Factor is applied. Usual Disproportionality Factors used in Australia for bushfires (see Safety section) are in the range 6 to 10. This indicates a starting point for bushfire risk of $396m to $1,100m.

An example of a commonly applied fire risk valuation is shown below:

Risk	Value of Consequence	Disp. Factor	
Insignificant	$6,600	1-2	$13,200
Minor	$66,000	2-4	$264,000
Moderate	$660,000	4-6	$3,960,000
Major	$6,600,000	6-8	$52,800,000
Catastrophic	$66,000,000	8-12	$660,000,000

We have observed that Disproportionality Factors are applied to the entire fire risk. However, it is likely that only a portion of the Value of Consequence is related to safety and therefore warrants a Disproportionality Factor.

3.2.3 Summary and recommendations

As the CBRM models only consider a subset of SA Power Networks' assets, it is necessary to consider the implications of the modelled bushfire risks across other network assets and the implied bushfire risk for the whole network to ensure the reasonableness of the assumptions for the subset of assets that are modelled.

The likelihood of starting a catastrophic bushfire is overstated in the CBRM model for poles. The assumptions that are used in the poles CBRM, which we understand were determined a number of years ago and have not been changed or updated since, do not align with more recent assumptions used by SA Power Networks in the CBA model for the bushfire mitigation program and are therefore inconsistent with other parts of SA Power Networks' recent submission to the AER. SA Power Networks should review the expected number of bushfires caused by poles, considering the parameters used in the Bushfire Mitigation CBA model and the proportion of fires that are started by poles.

The Value of Consequence for a catastrophic bushfire is within a reasonable range and the basis for the value used is reasonable. However, the bottom-up approach to developing the consequence value should be updated to align with the recommended changes to the Value of Consequence for safety risks. As this will result in the bushfire consequence value increasing significantly, SA Power Networks should reconsider the assumptions used in the bottom-up methodology to offset the increase. For example, reducing the expected number of fatalities to offset the increased cost per fatality.

The method used by SA Power Networks to apply Disproportionality Factors to fire risk is the most technically correct method. Disproportionality Factors should only be applied to safety risks, not to environmental or financial risks. SA

Power Networks is the only network reviewed that breaks down the composition of bushfire risk into its constituent parts and only applies a Disproportionality Factor to the safety component.

Bushfire risk is not included in the transformer or circuit breaker CBRM models. Bushfire risk is included in the protection CBRM but the likelihood of starting a bushfire is extremely low. Any change to the bushfire risk Value of Consequence calculation should be reflected in the protection CBRM but no further changes to model assumptions are recommended.

3.3 Environment Risks

3.3.1 SA Power Networks' inputs

The largest sources of environmental risk in the CBRM models is the release of oil or SF6 gas into the environment. The models also include small contributions for waste, disturbance, small fires and smoke. This review has been limited to oil and SF6 Value of Consequence as these make up the vast majority of the total risk value.

The CBRM models use values for oil and SF6 that were proposed by EA Technologies and are based on European risk values.

Risk	Value of Consequence
Oil	$100/litre
SF6	$400/kg

As SF6 is a potent greenhouse gas, the value of releasing SF6 into the environment was derived from European carbon pricing at the time the model was initially set up. The oil risk is based on reasonable clean-up costs that would be expected to be incurred.

For a major failure mode, the CBRM models assume most of the oil contained in a device is lost to the environment and therefore incurs risk. Lesser proportions of oil are lost due to minor and significant failure modes, but it is implied that almost every instance of these failure modes results in oil being lost. Criticality factors are applied to reflect the presence of bunding, but the average oil lost due to a failure is very high. The modelled oil loss therefore appears to exceed historic oil losses, although detailed records of this are not kept which prevents further assessment.

3.3.2 Industry standard values

Oil

The value of $100/litre has been observed across several electricity networks in Australia. This results in a major oil loss due to the failure of a large zone substation transformer (16,000 litres) having a value of approximately $1.6m if no bunding is in place.

Other networks have set a maximum value based on the worst leak that they have experienced. This cost included the associated cost of ground water impact and the potential offence cost (irrespective of whether penalties were actually enforced).

Ofgem use £36/litre (2012/13 pounds) and state that this value is derived from the trading value of carbon emissions associated with the oil[14], similar to the methodology for SF6. However, it is not clear how such a value could be derived using carbon prices. After adjusting for exchange rates and inflation it is similar to the value used in the CBRM model.

After the failure of an oil containing device, only a portion of the oil is expected to be lost to the environment, even after the most catastrophic form of failure. This is factored into most networks' models through criticality factors or similar adjustable toggles that reflect the presence of bunding and probability of less than the total capacity of oil being released. The probability of oil being lost (the probability of consequence) is generally assumed to be lower for minor failures than it is for major failure, which is usually factored into models by further reducing the average oil loss for these failure modes.

[14] DNO Common Network Asset Indices Methodology v1.1 (2017)

SF6

As there is no clear cost associated with the release of SF6 (the gas cannot be 'cleaned-up' after it is released), using carbon pricing is the de-facto method for valuing the release of SF6 gas.

SF6 gas is equivalent to 22,800kg of CO2. At the current EU carbon price (as there is no formal carbon price in Australia) 1kg of SF6 can be valued at approximately $935. The appendix to a 2013 report by EA Technology[15] recommended a similar value of $1,000/kg (the same report also states that the value of $400/kg is used in the CBRM model).

It is reasonable to expect that after a gas leak all the gas in a device is lost to the environment. It is standard practice to assume the risk cost is equal to value of SF6 multiplied by the kilograms of SF6 contained in the device.

3.3.3 Summary and recommendations

SA Power Networks should update the value used for SF6. Although the lack of a formal carbon price in Australia precludes the AER from approving network investment decisions on the basis of the mitigation of greenhouse gas emissions, it is recognised that networks should make efforts to prevent the release of potent gasses such as SF6. An international carbon price should be considered a reasonable proxy for assessing network investments to prevent avoidable gas release. In this case, it is also reasonable that the calculated value be kept up to date. SF6 risks also have a negligible impact on the model results due to the presence of much larger risks (network performance and capex).

The Value of Consequence used for oil is reasonable as it is in line with values used throughout the industry. However, it appears that the CBRM models (in particular the Transformer CBRM), overstate the expected quantity of oil that will be lost. SA Power Networks should review the oil loss assumptions to ensure that the models consider that not every failure will result in the loss of oil. This is most significant for minor failure modes, which are much more common with hundreds of events per year.

[15] Application of CBRM to SA Power Networks' Conductors, Poles, Circuit Breakers and Transformers (2013)

3.4 Network Performance Risks

3.4.1 SA Power Networks' inputs

The CBRM models use Value of Customer Reliability (VCR) for measuring subtransmission model network performance. The models consider both load at risk (load without redundancy) and load at additional risk (where one level of redundancy is available).

For distribution network assets, SAIDI and SAIFI penalty payments are used for network performance. As these are derived from VCR (along with expected outage frequency and duration) the inputs are effectively the same as used for subtransmission assets.

Load at additional risk is multiplied by a risk factor to reflect the probability of an additional asset failing before the first asset failure is repaired is less than 100%. In the CBRM model, this factor is set to 0.05.

3.4.2 Industry standard values

VCR is widely used across the industry to value network performance. Some networks also use SAIDI and SAIFI approaches, although these are less common.

Where assets have redundancy there is more variety in approaches used. In small scale models, modelled Probability of Failure for related assets may be used in n-1 situations to calculate the likelihood of a dual outage. Generally, the risk where n-2 is available is assumed to be zero due to the very low likelihood of a triple asset failure. In single asset models, such as a NPV model for a single transformer replacement project, a detailed assessment of partial load restoration times (automatic switching, followed by manual switching and back-up generation and eventually transformer replacement) involving actual substation load profiles may be used. However, this level of detail is rarely used for assessing the reliability of a fleet of assets on a network[16].

In large models incorporating hundreds of individual assets, average redundancy and empirical data may be used. For example, one Australian DNSP modelled the risk of lost load for redundant assets by setting the Probability of Consequence for an outage to be the percentage of recent redundant asset failures that resulted in an outage.

3.4.3 Summary and recommendations

The use of VCR is standard practice. SA Power Networks current approach is reasonable, and no changes are recommended.

The risk adjustment for redundant assets at 0.05 is at the high end of the expected range. However, this is dependent on the level of automation in a network. It is common that a major asset failure (such as a substation transformer) will result in lost load after a failure event even where redundancy is present because switching is required to isolate the affected asset and reroute power via the remaining assets. A more detailed assessment of SA Power Networks' network would be required to make a statement on the reasonableness of this factor that is outside the scope of this review.

[16] An exception is reliability compliance modelling for transmission networks, where at least one network has included this level of detail.

3.5 Financial Risks

3.5.1 SA Power Networks' inputs

SA Power Networks has used its standard unit rates for the opex and capex cost of replacing a failed asset (or refurbishing the asset in the case of poles).

The values have been developed from recent actual replacement or refurbishment project data from SA Power Networks' systems.

3.5.2 Industry standard values

The asset classes covered by the CBRM models do not lend themselves to comparison with wider industry values. This conclusion has also been reached by the AER which chose to omit most of these assets from assessment by the AER Repex model.

3.5.3 Summary and recommendations

The valuations used by SA Power Networks for asset replacement appear reasonable. Explanations have been provided for the sources of each value and appear to be a faithful representation of recent actual replacement and refurbishment costs.

4 Summary and Recommendations

4.1 Safety Risks

The value for a fatality used in the CBRM models should be updated to align with Australian VSL using the 2019 guidance note value. Where the VSL requires escalation to future years, the ABS Wage Price Index should be used.

SA Power Networks should formalise the use of Disproportionality Factors with the intention of using values that are in line with those used by comparable businesses in Australia and internationally. Disproportionality factors can be applied at either a flat rate or an increasing scale. In Australia, current industry trends are towards the use of a scale where a lower factor is applied to smaller risks and a higher factor to larger risks such as fatalities. A typical increasing scale would fill a range with a starting value of around 2 and an upper limit of around 10. If a single value is to be applied, a typical reasonable value would sit in the mid to upper end of this range, between 5 and 8.

The use of a log scale for determining the value of major or minor injuries is a common approach to valuing severity levels. However, there is a basis for the value of a major injury being greater than 10% of a fatality, with values used internationally for types of major injuries such as amputations using factors of 30% of VSL.

CutlerMerz expects that these changes would result in a significant increase in the value of fatality used in the CBRM models. This would also have a flow on effect to the Value of Consequence for major injuries and minor injuries.

4.2 Fire Risks

As the CBRM models only consider a subset of SA Power Networks' assets, it is necessary to consider the implications of the modelled bushfire risks across other network assets and the implied bushfire risk for the whole network to ensure the reasonableness of the assumptions for the subset of assets that are modelled.

The likelihood of starting a catastrophic bushfire is overstated in the CBRM model for poles. The assumptions that are used in the poles CBRM, which we understand were determined a number of years ago and have not been changed or updated since, do not align with more recent assumptions used by SA Power Networks in the CBA model for the bushfire mitigation program and are therefore inconsistent with other parts of SA Power Networks' recent submission to the AER. SA Power Networks should review the expected number of bushfires caused by poles, considering the parameters used in the Bushfire Mitigation CBA model and the proportion of fires that are started by poles.

The Value of Consequence for a catastrophic bushfire is within a reasonable range and the basis for the value used is reasonable. However, the bottom-up approach to developing the consequence value should be updated to align with the recommended changes to the Value of Consequence for safety risks. As this will result in the bushfire consequence value increasing significantly, SA Power Networks should reconsider the assumptions used in the bottom-up methodology to offset the increase. For example, reducing the expected number of fatalities to offset the increased cost per fatality.

The method used by SA Power Networks to apply Disproportionality Factors to fire risk is the most technically correct method. Disproportionality Factors should only be applied to safety risks, not to environmental or financial risks. SA Power Networks is the only network reviewed that breaks down the composition of bushfire risk into its constituent parts and only applies a Disproportionality Factor to the safety component.

Bushfire risk is not included in the transformer or circuit breaker CBRM models. Bushfire risk is included in the protection CBRM but the likelihood of starting a bushfire is extremely low. Any change to the bushfire risk Value of Consequence calculation should be reflected in the protection CBRM but no further changes to model assumptions are recommended.

4.3 Environment Risks

SA Power Networks should update the value used for SF6. Although the lack of a formal carbon price in Australia precludes the AER from approving network investment decisions on the basis of the mitigation of greenhouse gas emissions, it is recognised that networks should make efforts to prevent the release of potent gasses such as SF6. An international carbon price should be considered a reasonable proxy for assessing network investments to prevent avoidable gas release. In this case, it is also reasonable that the calculated value be kept up to date. SF6 risks also have a negligible impact on the model results due to the presence of much larger risks (network performance and capex).

The Value of Consequence used for oil is reasonable as it is in line with values used throughout the industry. However, it appears that the CBRM models (in particular the Transformer CBRM), overstate the expected quantity of oil that will be lost. SA Power Networks should review the oil loss assumptions to ensure that the models consider that not every failure will result in the loss of oil. This is most significant for minor failure modes, which are much more common with hundreds of events per year.

4.4 Network Performance Risks

The use of VCR is standard practice. SA Power Networks current approach is reasonable, and no changes are recommended.

The risk adjustment for redundant assets at 0.05 is at the high end of the expected range. However, this is dependent on the level of automation in a network. It is common that a major asset failure (such as a substation transformer) will result in lost load after a failure event even where redundancy is present because switching is required to isolate the affected asset and reroute power via the remaining assets. A more detailed assessment of SA Power Networks' network would be required to make a statement on the reasonableness of this factor that is outside the scope of this review.

4.5 Financial Risks

The valuations used by SA Power Networks for asset replacement appear reasonable. Explanations have been provided for the sources of each value and appear to be a faithful representation of recent actual replacement and refurbishment costs.