Operating Environment Factors (OEFs)

A REPORT PREPARED FOR ESSENTIAL ENERGY

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1 Introduction

On 11 December 2017, the AER initiated a review of the operating environment factor (OEF) adjustments to be included in its benchmarking analysis. Frontier Economics welcomes the AER's review of its approach to economic benchmarking, and its dedicated review of how OEFs should be accounted for when conducting economic benchmarking. In our view, it is not possible to draw meaningful conclusions about the relative efficiency of regulated DNSPs unless OEFs are controlled for appropriately. Failure to control properly for OEFs would defeat the objective of conducting economic benchmarking: namely, to identify the true scope for efficiency improvements for the DNSPs. Therefore, we welcome the AER's attention towards this issue, and consider that this is an important opportunity to make lasting improvements to the way the AER conducts economic benchmarking to promote the long-term interest of consumers.

The AER sought responses to its December 2017 OEFs consultation[1] by February 2018. Alongside its response to the AER, Essential Energy submitted a report prepared by Frontier Economics, henceforth referred to as our 'February 2018 OEFs report',[2] outlining our recommended framework for accounting for operating environment factors in the AER's economic benchmarking analysis. We noted in our February 2018 OEFs report that, given the complexity and importance of identifying the relevant OEFs for use within the AER's benchmarking analysis, it is unlikely that this consultation can be concluded within a few months. In the interest of developing a sound approach that all stakeholders can have confidence in, we recommended that the AER take the time necessary to consult fully and comprehensively with all stakeholders on this issue.

This report builds on our February 2018 OEFs report, in which we recommend that the AER start by consulting afresh on the list of OEFs it should potentially account for when benchmarking DNSPs. We have therefore set aside past decisions that the AER has made to date about the relevance or materiality of individual OEFs and begun with a blank slate.

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[1] Australian Energy Regulator, Independent review of Operating Environment Factors used to adjust efficient operating expenditure for economic benchmarking, December 2017. https://www.aer.gov.au/system/files/SapereMerz%20review%20of%20operating%20environment%20factors%20-%20December%202017.pdf

[2] See Attachment C of Essential Energy's submission to the AER: https://www.aer.gov.au/system/files/Essential%20Energy%20-%20Submission%20on%20review%20of%20Operating%20Environment%20Factors%20for%20Distribution%20Network%20Service%20Providers%20-%2016%20February%202018.pdf

In this report we present our preliminary and illustrative assessment of OEFs in relation to subtransmission (Section 2), diversity of weather (Section 3), fauna (Section 4) and timber poles (Section 5). Where possible with the available data and within the available timeframes, we have attempted to quantify the potential cost impact of this subset of OEFs for Essential Energy and other DNSPs. Where it has not been possible to quantify cost impacts, we have outlined the factors that we consider the AER should have regard to when collecting further data going forward to facilitate further quantification.

We emphasise strongly that our assessment of OEFs presented in this report is preliminary and illustrative, and can be improved substantially in consultation with other DNSPs and stakeholders, with support from the AER. Therefore, by presenting this analysis, we do not claim to have identified a proposed set of OEF adjustments that can be applied mechanistically to the AER's benchmarking models. Nor do we claim to have assessed the full extent of true differences in operating environment factors between the Australian DNSPs, as there are a number of additional OEFs which we were not able to assess within the timeframes for this project (these are briefly discussed in Section 6).

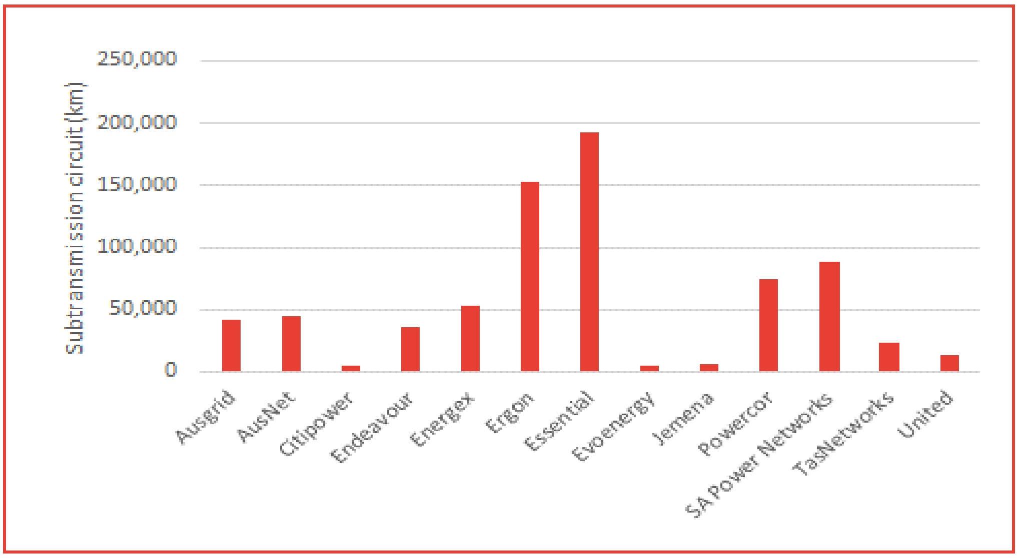
We recommend that our assessment of the OEFs in this report be seen as a starting point for discussion. Our illustrative quantification of OEFs in Sections 2 to 5 can be improved significantly through the process identified in Section 7, in consultation with other DNSPs and stakeholders, and with further data collection and support from the AER. Furthermore, we recommend that with further data collection and time, bespoke methodologies be developed for quantifying the OEFs in Section 6 which are yet to be assessed in detail. Our broader recommendations for the AER are set out in Section 7.

2 Subtransmission

The present day ownership of subtransmission assets by distribution networks in different jurisdictions is to a large extent a legacy of different policy decisions taken when state-level electricity markets were restructured and reformed in the 1990s.[3] This is outside the control of the current management of DNSPs and not accounted for in the AER's preferred econometric benchmarking model.

Figure 2 below shows that Essential Energy and Ergon Energy have significantly more subtransmission circuit than any other DNSP in the NEM. While Essential Energy and Ergon Energy own over 190,000 km and over 150,000 km of subtransmission circuit, respectively, all other DNSPs in the NEM own less than 90,000 km of subtransmission circuit, and some DNSPs, such as CitiPower, own less than 5,000 km of subtransmission circuit.

Figure 1: Subtransmission circuit length by DNSP



Source: Frontier Economics' analysis of 2016 Economic Benchmarking RIN data.
Note: Subtransmission is defined as all overhead lines and underground cables at or above 33kV.

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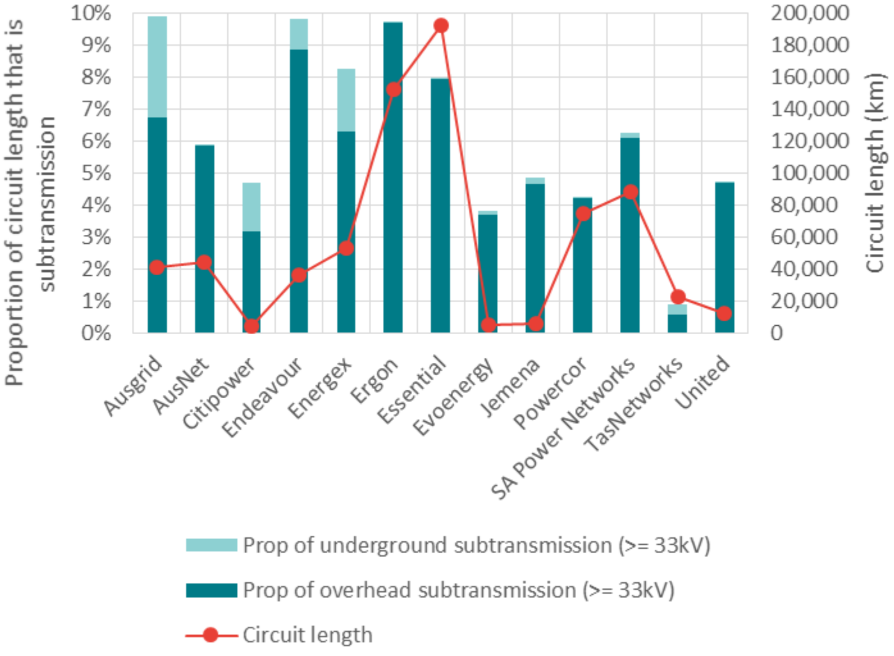
[3] For instance, in NSW, following the market reforms, the issue of whether 132kV assets should be owned by Transgrid (the transmission network operator) or the various distributors was hotly contested in a number of market reviews. The outcomes of those reviews meant that Transgrid took ownership of some 132kV assets, whilst the distributors took ownership of other subtransmission assets. (See, for example: Distribution Review Group, Electricity Distribution Structure Review, August 1995.) In other States, such as Victoria, the ownership of subtransmission assets was less controversial. When the Victorian electricity supply industry was vertically separated during reforms in the early 1990s, five separate distribution networks, and one transmission operator, were established. Network separation occurred according to network functions, and distribution activities were defined as those involving 66kV assets and below (see, for example: Office of the State Owned Enterprises, Department of the Treasury, *Reforming Victoria's Electricity Industry*, December 1994).

Figure 2 below compares the proportion of subtransmission circuit length to total circuit length across DNSPs. It can be seen that the five DNSPs in New South Wales (Ausgrid, Endeavour Energy and Essential Energy) and Queensland (Ergon Energy and Energex) own a significantly higher proportion of subtransmission assets when compared to DNSPs in Tasmania, Victoria and South Australia. For example, while Essential Energy's subtransmission circuit accounts for roughly 8% of its total circuit length, under 1% of TasNetworks' total circuit length is comprised of subtransmission.

Figure 2: Proportion of subtransmission circuit length by DNSP



Source: Frontier Economics' analysis of 2016 Economic Benchmarking RIN data.
Note: Subtransmission is defined as all overhead lines and underground cables at or above 33kV.

Subtransmission assets are more expensive to operate and maintain than distribution assets, and as the extent of subtransmission assets differs vastly across the DNSPs, we consider an OEF adjustment for subtransmission to be important.

We recommend that the AER consider an allowance for an OEF in relation to differences between DNSPs in the total length of subtransmission circuit and the proportion of subtransmission circuit length to total circuit length, as shown in Figure 1 and Figure 2 above. Furthermore, we recommend that the AER's OEF adjustment for subtransmission should have regard to the differences in subtransmission network configuration by feeder type and voltage level, as discussed in Section 2.1 and 2.2 below.

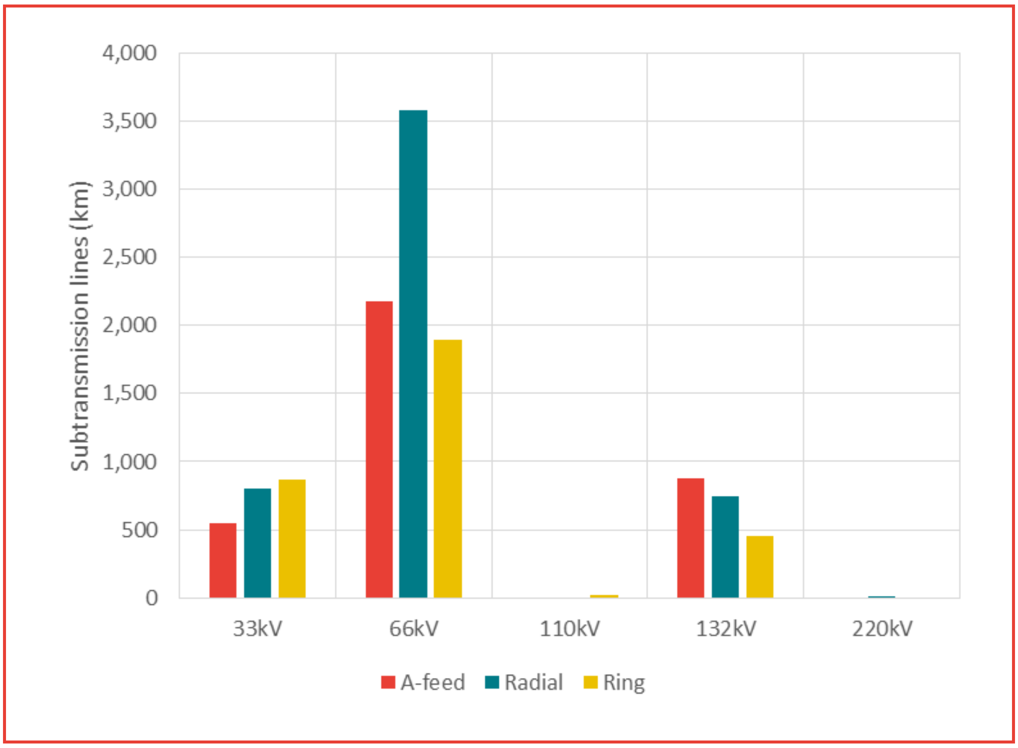
While we have not been able to quantify an OEF for subtransmission with the data that is presently collected and published by the AER, we note that the estimated cost of Essential Energy's radial subtransmission inspection program alone is roughly $1.2m per annum, (roughly 0.3% of Essential Energy's opex), as discussed in Section 2.1.

2.1 Importance of accounting for differences in feeder configuration

The AER's benchmarking and OEF analysis does not account for differences in DNSP feeder configurations, which are influenced by exogenous factors such a differences in population density (customers per square km of service territory). A high population density generally facilitates a more meshed network, whilst a low density results in a radial network design as driven by economics.

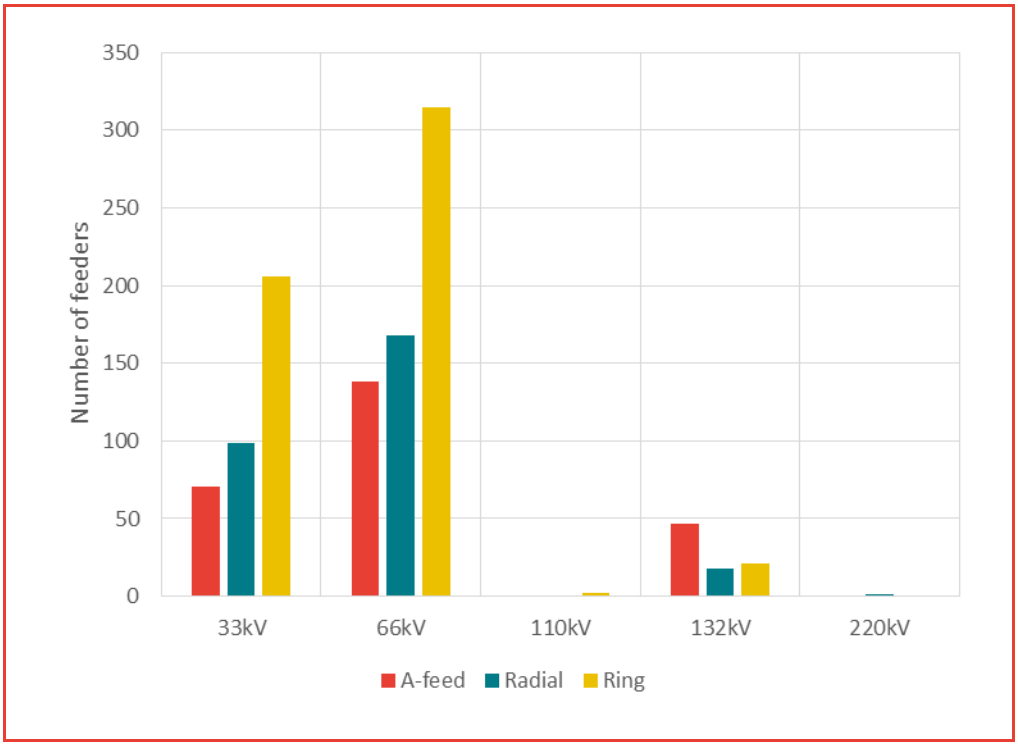
Essential Energy has a subtransmission network that has been designed to service the needs of sparsely distributed customers at the lowest capital cost. This design includes long, radial feeders operating at higher voltage to transport electricity over long distances. This can be seen from Figure 3 and Figure 4 below.

Figure 3: Essential Energy's subtransmission lines by voltage



Source: Frontier Economics' analysis of data provided by Essential Energy.

Figure 4: Essential Energy feeders by configuration type and voltage



Source: Frontier Economics' analysis of data provided by Essential Energy.

The extent of Essential Energy's radial network configuration can be seen in Figure 3 and Figure 4 above.

- Figure 3 shows that 43% of Essential Energy's subtransmission feeder lines (kms) are radial.
- Figure 4 shows that 26% of Essential Energy's subtransmission feeders (numbers) are radial.

We understand from Essential Energy that radial feeders are more expensive to operate as they have no alternative source of supply if there is a fault that causes an outage. This means power on a radial line cannot be re-routed or switched to restore power during supply interruptions. In addition when rectifying defects on radial feeders most utilities will utilise live line techniques which is at a much higher cost. On the other hand, ring feeders can be fed from the same source substation via another feeder or 'loop' of the feeder (hence the term ring), and a fault on an alternate feed feeder (A-feed) can be restored in most instances via an alternate feed from another substation. Furthermore, we understand that it is often difficult to locate and repair radial line faults due to the travel distance involved in locating the fault.

To mitigate the risk of failure on its radial network, we understand that Essential Energy has a separate program of radial subtransmission line inspection in addition to the nominal inspection programs. This separate program is comprised of hi-res photography, live line inspections, drones, and in some cases LiDAR (an airborne 3-D imaging technique). We understand that the cost of this program is approximately $1.2m per annum on average, (roughly 0.3% of Essential Energy's opex).

While we do not have data on the extent of the radial network configuration of the other DNSPs, we understand from Essential Energy that, as radial subtransmission feeders are used by rural utilities to supply sparsely distributed customer bases and to traverse long distances, a radial network design is more prevalent in rural utilities such as Ergon Energy and Essential Energy.

For the reasons outlined above, we recommend that the AER's quantification of an OEF for subtransmission should have regard to both the length of circuit by feeder configuration (which we understand to be a key driver of fault and emergency costs) and the number of feeders by feeder configuration (we understand that the number of assets is a key driver of routine maintenance costs). We recommend that the AER include these two variables in its RIN data collection templates to obtain information on these variables from all DNSPs and facilitate a more meaningful assessment of subtransmission OEFs.

Finally, it can be seen in Figure 3 and Figure 4 above that a significant proportion of Essential Energy's network is designed to operate at higher voltages.

- Figure 3 shows that 0.02%, 17%, 0.2%, 64% and 18% of Essential Energy's subtransmission circuit kms operates at 220kV, 132kV, 110kV, 66kV and 33kV, respectively.
- Figure 4 shows that 0.1%, 8%, 0.2%, 57% and 25% of Essential Energy's subtransmission feeders operate at 220kV, 132kV, 110kV, 66kV and 33kV, respectively.

As we have RIN data on the length of subtransmission cables at difference voltage levels for all DNSPs, we provide a discussion on the need to consider differences in the mix of subtransmission voltages in Section 2.2 below.

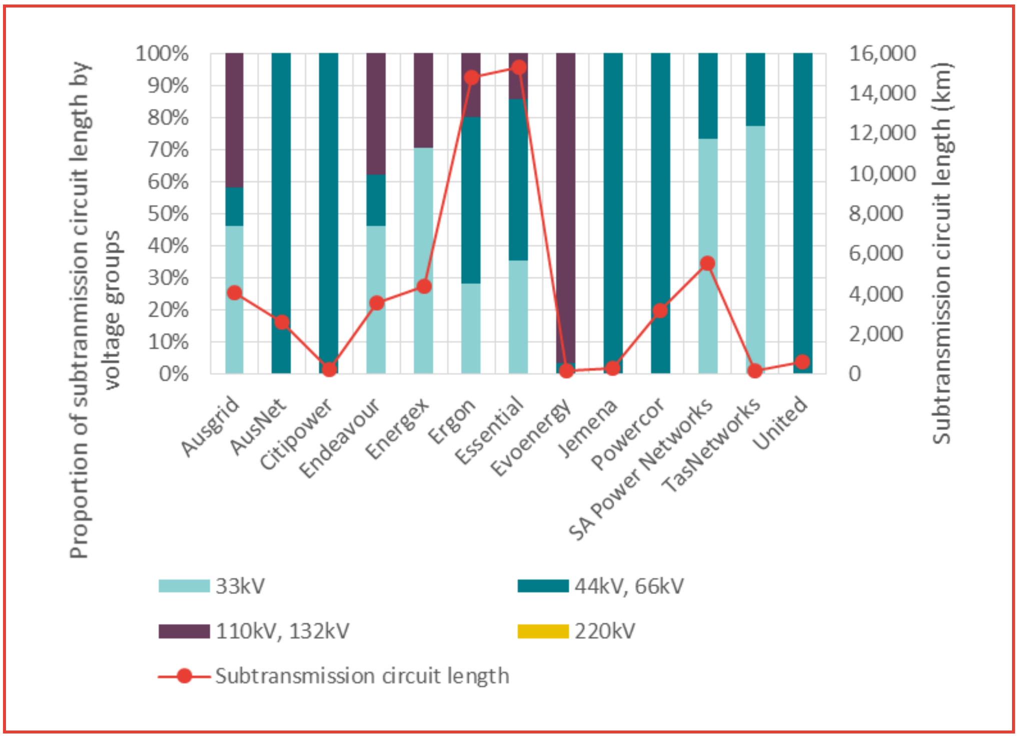
2.2 Importance of accounting for differences in voltage levels

We understand from Essential Energy that as subtransmission voltages increase, the required skill set to manage and maintain these assets becomes more specialised. Figure 5 below shows that the mix of subtransmission assets at different voltage levels varies considerably across DNSPs.

- Essential Energy is the only network with 220kV assets. These assets were constructed by the transmission authority and as such have the same cost base as a transmission asset.

- The ownership of 110kV and 132kV assets is unique to the DNSPs in ACT, NSW and QLD.
- The entire subtransmission networks of Citipower, Powercor, AusNet, Jemena and United operate at 66kV.
- Among the non-Victorian DNSPs, Evoenergy, Ergon Energy and Essential Energy have the lowest proportion of 33kV subtransmission assets, with the majority of their subtransmission network operating at higher voltages.

Figure 5: Subtransmission circuit length by voltage



Source: Frontier Economics' analysis of 2016 Economic Benchmarking RIN data.
Note: Subtransmission is defined as all overhead lines and underground cables at or above 33kV[4].
Essential Energy is the only DNSP that has 220kV subtransmission lines (3km)

Furthermore, we understand from Essential Energy that there are higher costs associated with operating at multiple voltages, owing to multiple tooling requirements, increased complexity and the need for specialised skills at each different voltage level. As can be seen from Figure 5 above, Ausgrid, Endeavour, Essential Energy and Ergon Energy have a more diverse mix of subtransmission assets when compared to the other DNPSs.

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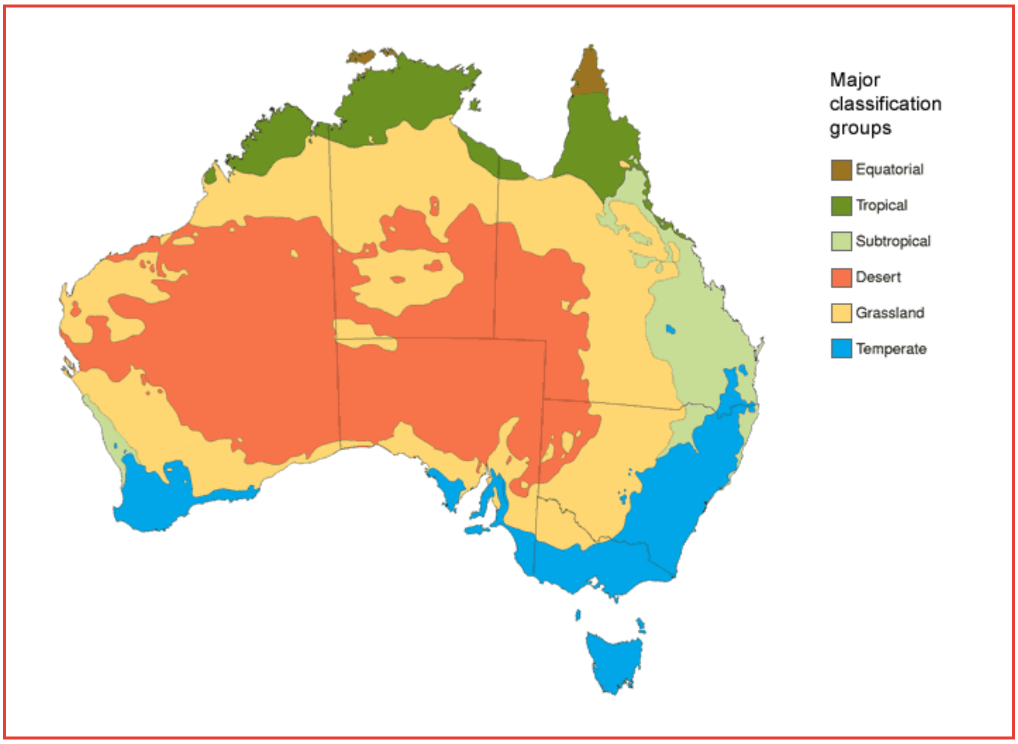
[4] We understand, however, that the AER's definition for subtransmission requires further refinement, as we have been informed that Citipower reports a small proportion of 22kV lines as subtransmission lines and Essential Energy does not use a small proportion of its 33kV lines for subtransmission.

For the reasons outlined above, we recommend that the AER’s quantification of an OEF for subtransmission should have regard to the mix of subtransmission assets at different voltage levels.

3 Diversity of weather

As one of Australia's largest electricity distribution networks covering an expansive service area, Essential Energy's network is exposed to a diverse range of weather-related events. As can be seen from Figure 6 below, Essential Energy's footprint covers subtropical, desert, temperate and grasslands climate zones. As a result, its network is exposed to the effects of a wide variety of weather-related factors such as sub-zero temperatures, extreme high temperatures, lightning, wind, high rainfall, hail and bushfires across its vast service area.

Figure 6: Key climate groups within Australia



Source: Bureau of Meteorology[5]

In the remainder of this section, we estimate the illustrative cost impact of four weather-related factors that Essential Energy considers to be of highest relevance to its network. Our discussion of lightning, wind, heavy rain/floods and bushfires can be found in Sections 3.1, 3.2, 3.3 and 3.4, respectively.

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[5] See: http://www.bom.gov.au/iwk/climate_zones/map_1.shtml

3.1 Lightning

Our analysis in this section demonstrates that lightning strikes are an important candidate OEF.

- Section 3.1.1 below shows that the number of thunder days varies significantly across different parts of Australia.
- Section 3.1.2 summarises Essential Energy's estimates of the number of direct lightning strikes expected to hit each DNSP's network every year; these are based on Essential Energy's publicly available submission to the AER. This summary shows that Essential Energy's network is significantly more exposed to lightning strikes than any other DNSP in the NEM.
- Section 3.1.3 presents our estimate of the average cost per lightning-related outage, using data provided by Essential Energy.
- Section 3.1.4 provides our estimate of the total opex per annum associated with lightning-related outages, using evidence on the estimated number of lightning strikes from Section 3.1.2 and the estimated cost per lightning-related outage from Section 3.1.3.
- Section 3.1.5 summarises our estimated OEF for lightning for each DNSP, which is calculated by dividing our estimate of annual lightning-related opex (Section 3.1.4) by the annual average annual revealed opex over 2006-2016 for each DNSP.

Using the approach described above, our illustrative estimate of the OEF for lightning for Essential Energy is between 2.03% and 3.12%.

3.1.1 Geographic variation in exposure to lightning strikes

Figure 7 below illustrates the average annual number of thunder days experienced in Australia over a ten year period (1990-1999). Using published equations, the relationship between thunder days and lightning strikes can be derived.[6] It can be seen that the number of thunder days varies significantly across different parts of Australia. In particular, the map indicates that the northern parts of Australia are more exposed to lightning than the central, southern, and western parts of Australia. Of the NEM states, Queensland and New South Wales are the most exposed to lightning strikes. This is not surprising given the high storm activity experienced in these states. As the exposure to lightning strikes shows marked variation geographically, the incidence of lightning strikes, and the impact on opex, are likely to vary significantly across DNSPs.

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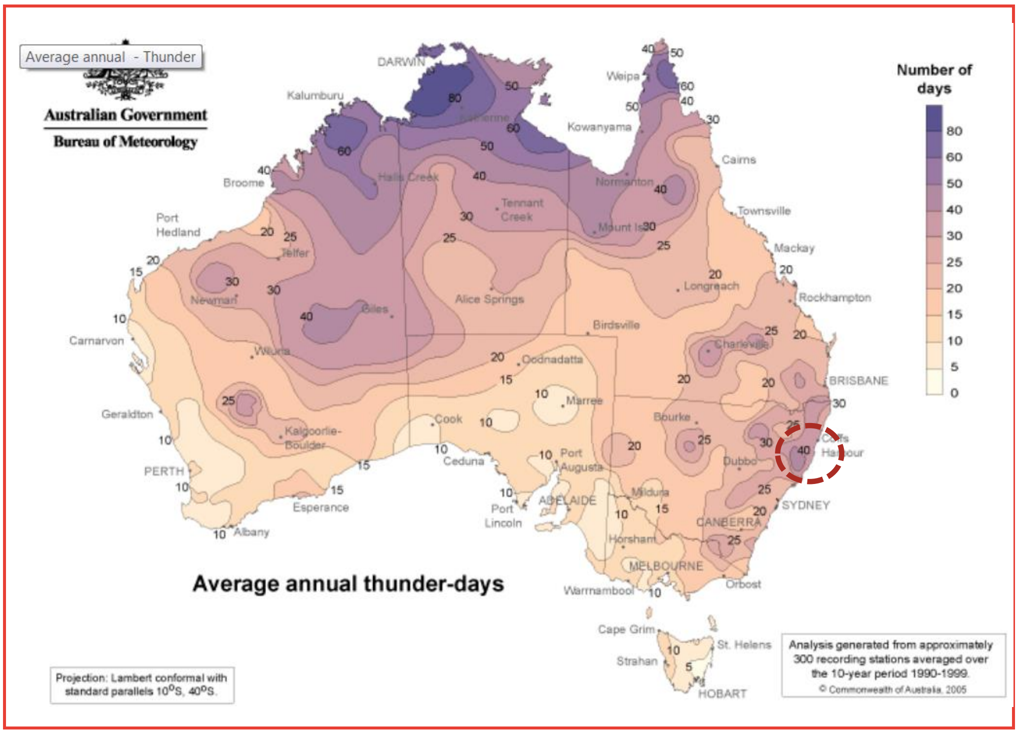
[6] IEC 62305 2012 Protection against lightning

Figure 7: Average annual thunder-days, 1990-1999



Projection: Lambert conformal with standard parallels 10°S, 40°S.

Analysis generated from approximately 300 recording stations averaged over the 10-year period 1990-1999.
© Commonwealth of Australia, 2005

Source: Bureau of Meteorology[7]

3.1.2 Essential Energy's estimate of the number of direct lightning strikes per year, by DNSP

A DNSP's exposure to lightning-related damage depends both on the geographic location of its network and on the volume of assets exposed to lightning. DNSPs with a higher volume of overhead lines located in geographic areas that are more exposed to lightning strikes, are likely to experience a higher number of lightning-related outages. By contrast, DNSPs with fewer assets in geographic areas that are more exposed to lightning strikes are likely to experience a lower number of lightning-related outages.

In its published January 2015 lightning analysis[8] submitted to the AER, Essential Energy showed that, owing to its high customer density on the eastern seaboard, which has the highest annual average thunder days in NSW (40 days,[9] as circled in red in Figure 7 above), its network is significantly more susceptible to lightning strikes than any other DNSP in the NEM. Notwithstanding the high thunder day

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[7] Product code IDCJCM0007 retrieved on 17 April 2018 from http://www.bom.gov.au/jsp/ncc/climate_averages/thunder-lightning/index.jsp

[8] Essential Energy, Attachment 4.2 – STPIS Lightning Analysis, January 2015.

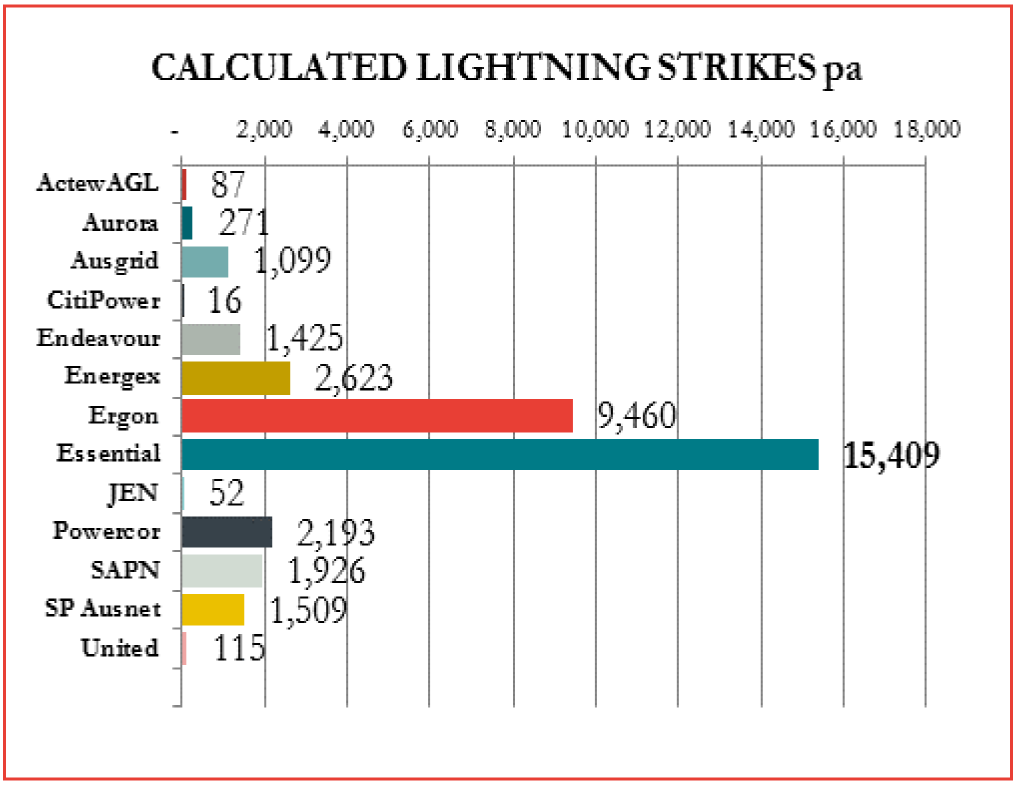
[9] However, we understand that in order to model the entire network, Essential Energy used a conservative average thunder day figure of 25.

figures for the eastern seaboard and the high asset density in this area, Essential Energy used a conservative 25 thunder day average for its entire footprint to estimate the number of direct lightning strikes on its network. Figure 8 below shows Essential Energy's estimate of the number of direct lightning strikes that are expected to hit each DNSP's network every year, based on the average number of thunder days estimated by the Bureau of Meteorology (see Figure 7) and on the circuit length of overhead high voltage lines owned by each DNSP.[10]

As outlined by Essential Energy:[11]

> The analysis shows Essential Energy's footprint is the worst network for lighting strike related outages in the NEM by a significant factor. Essential Energy can expect to have approximately 15,000 lighting strikes per annum, its' nearest peer has approximately 9,000, with the next nearest experiencing approximately 2,600.

Figure 8: Essential Energy's lightning analysis



Source: Essential Energy's lightning analysis.

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[10] Data taken from the Economic Benchmarking RIN database.

[11] Essential Energy, Attachment 4.2 – STPIS Lightning Analysis, January 2015.

3.1.3 Estimate of the average cost per lightning-related outage

In order to quantify an OEF for lightning, we used data provided to us by Essential Energy on roughly 50,000 lightning-related outages that affected its network from 1 July 2013 to 12 March 2018. The data included a mapping by Essential Energy of "Fault and Emergency" (F&E) costs, and associated on-costs and overhead costs, for over 43,000 of these outages.[12] Using this data, we calculated the average cost per lightning-related outage to be $758.9 (real FY2016 AUD).

3.1.4 Estimate of the total opex per annum associated with lightning-related outages

To illustrate the likely cost impact of lightning strikes, we have applied an estimated average cost per lightning-related outage of $758.9 (Section 3.1.3) to two alternative estimates of the number of lightning strikes per annum for each DNSP.

- The first is Essential Energy's estimate of the number of lightning strikes per annum for each DNSP (shown in Figure 8 in Section 3.1.2 above).
- The second is Essential Energy's estimate above, scaled downwards by 35% for all DNSPs. This is to account for the fact that Essential Energy recorded an average of 10,056 lightning-related outages per annum its network in the historical data it provided to Frontier Economics. This is roughly 35% lower than its estimated 15,409 lightning-related outages per annum for its network in Figure 8.[13] We have scaled Essential Energy estimated lightning-related outages for all DNSPs downwards to provide a more conservative lower estimate of likely costs.

Our estimated lightning-related opex per year by DNSP is shown in Figure 9 below. It can be seen that our estimate of lightning-related opex varies considerably across DNSPs. We estimate the lightning-related outage costs to be between $7.6m and $11.7m per annum for Essential Energy, between $4.7m and $7.2m per annum for Ergon Energy, and less than $1m per annum for some other DNSPs including CitiPower.

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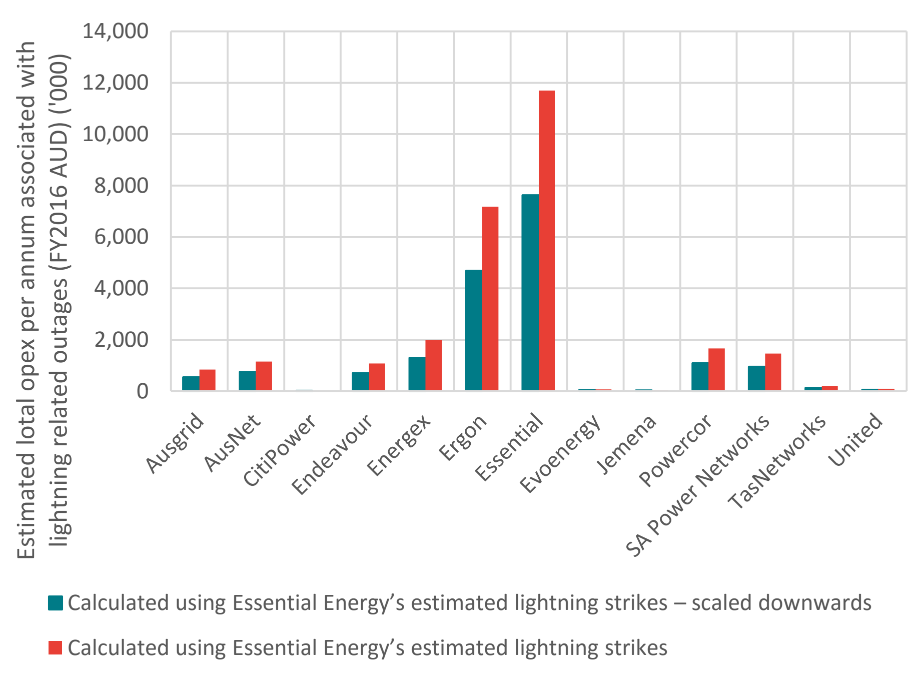
[12] Refer to Appendix A for a detailed description of the dataset used in the analysis and how it was generated.

[13] We understand from Essential Energy that this is due to the fact that, on attendance, field crews cannot always readily identify a lightning instigated outage from other causes.

Figure 9: Estimated lightning-related opex by DNSP

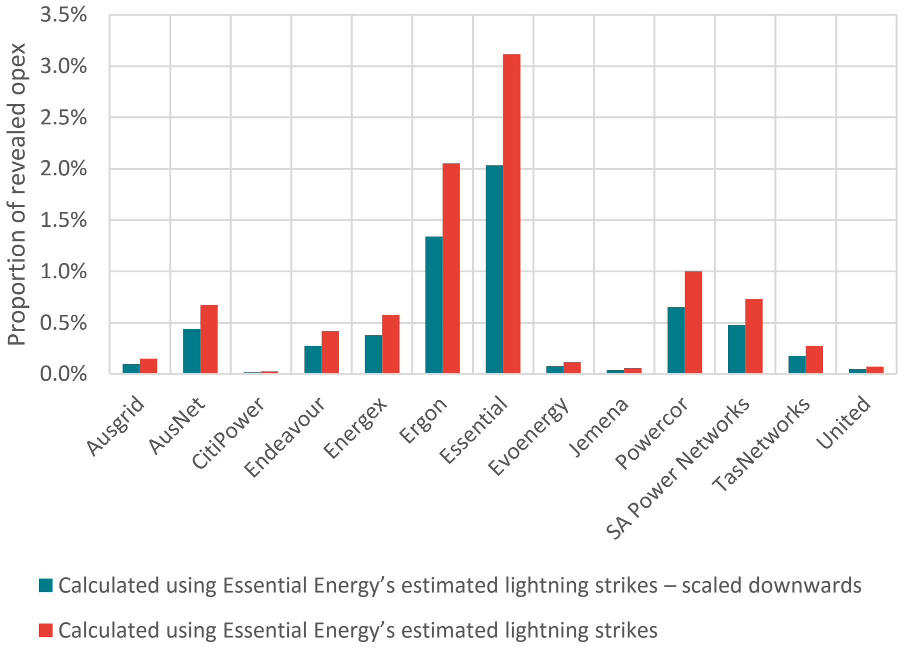


Source: Frontier Economics' analysis of cost data provided by Essential Energy, Essential Energy's lightning analysis, AER/Economic Insights 2017 annual benchmarking RIN dataset.

3.1.5 Estimated OEF for lightning-related outages

To calculate a % OEF for lightning for each DNSP, we have divided our estimates of average lightning-related opex per year (Section 3.1.4) by the average annual revealed opex over the period 2006-2016 for each DNSP. Our estimated % OEFs for lightning are shown in Figure 10 below. Our illustrative estimate of the OEF for lightning for Essential Energy is between 2.03% and 3.12%, for Ergon Energy it is between 1.34% and 2.05%, and for some DNSPs it is as low as 0.02%. On average, Essential Energy incurs higher costs (as a proportion of its opex) than all other DNSPs.

Figure 10: Estimated lightning OEF by DNSP



DNSP	OEF – using Essential Energy's estimated lightning strikes – scaled downwards	OEF – using Essential Energy's estimated lightning strikes
Ausgrid	0.10%	0.15%
AusNet	0.44%	0.67%
CitiPower	0.02%	0.02%
Endeavour	0.27%	0.42%
Energex	0.38%	0.58%
Ergon	1.34%	2.05%
Essential	**2.03%**	**3.12%**
Evoenergy	0.07%	0.11%
Jemena	0.04%	0.06%
Powercor	0.65%	1.00%
SA Power Networks	0.48%	0.73%
TasNetworks	0.18%	0.27%
United	0.05%	0.07%

Source: Frontier Economics' analysis of cost data provided by Essential Energy, Essential Energy's lightning analysis, AER/Economic Insights 2017 annual benchmarking RIN dataset

3.2 Wind

Our analysis in this section demonstrates that exposure to wind is an important candidate OEF.

- Section 3.2.1 shows that exposure to wind varies significantly across DNSPs.
- Section 3.2.2 presents our estimate of the average number of wind-related outages per day per km of overhead lines according to the average maximum wind gust speed.
- Section 3.2.3 presents our estimate of the average number of wind-related outages per year by DNSP, using the estimate of number of outages per day per km from Section 3.2.2 and the exposure to wind from Section 3.2.1. This analysis shows that Essential Energy is the DNSP with the highest number of wind-related outages.
- Section 3.2.4 provides our estimate of the average cost per wind-related outage, using data provided by Essential Energy.
- Section 3.2.5 provides our estimate of the total opex per annum associated with wind-related outages by DNSP, using the estimated number of wind-related outages per year from Section 3.2.3 and the estimate of the cost per outage from Section 3.2.4.
- Section 3.2.6 summarises our estimates of the OEF for wind for each DNSP, which is calculated by dividing, for each DNSP, our estimate of average wind-related opex (Section 3.2.5) by the average annual revealed opex over the period 2006-2016.

Using the approach described above, our illustrative estimate of the OEF for wind for Essential Energy is 0.79%.

3.2.1 Geographic variation in exposure to wind

We understand from Essential Energy that wind can cause system outages either through direct damage, or through debris and tree branches being blown into and onto assets. Wind also causes conductors to clash and places additional load on structures which can lead to premature asset failure.

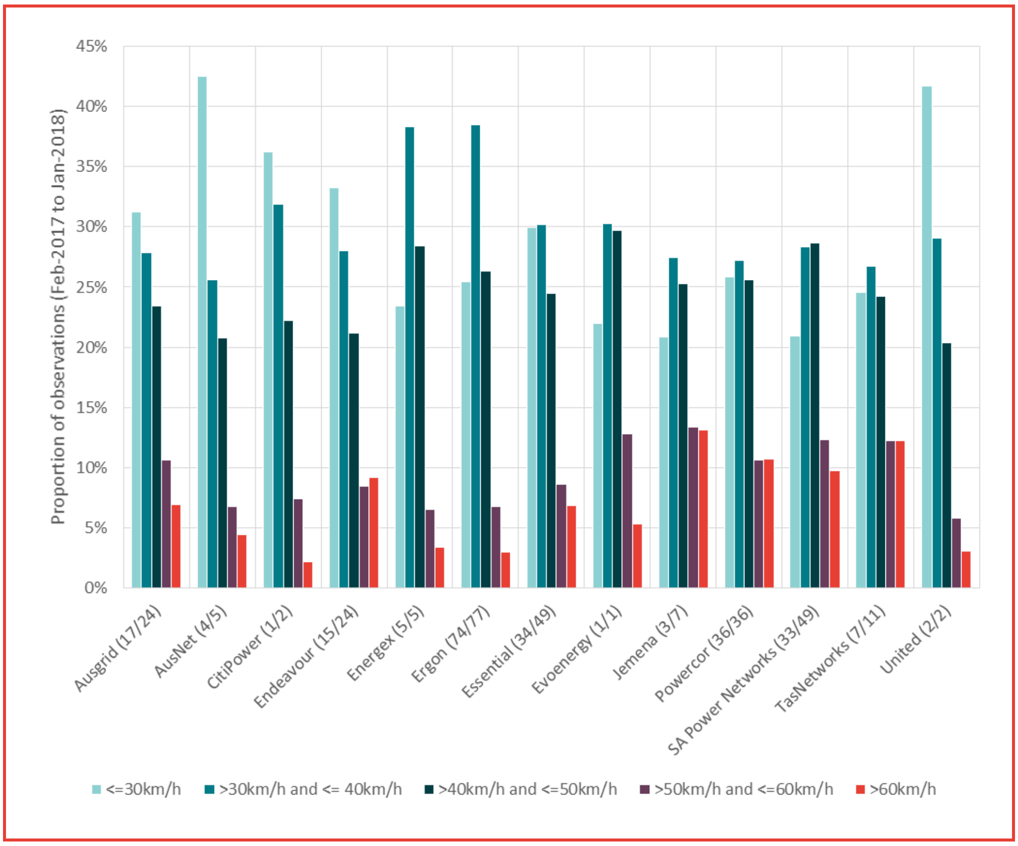
A DNSP's exposure to wind-related damage depends both on the geographic location of its network and on the volume of assets exposed to high wind. DNSPs with a higher volume of overhead lines located in geographic areas that are more exposed to high wind events, are likely to experience a higher number of wind-related outages. By contrast, DNSPs with fewer assets in geographic areas that are exposed to high wind are likely to experience a lower number of wind-related outages. Furthermore, rural networks are more likely to be exposed to the effects of wind than urban networks, which are more shielded by built environments.

To illustrate the DNSPs' geographic variation in exposure to wind, we use daily data from the BOM over the year starting on 1 February 2017 and ending 31 January 2018, for those weather stations indicated by the DNSPs in the Economic Benchmarking RIN as being relevant to the management of their network.

Figure 11 below illustrates, for each DNSP, the proportion of observations for which the recorded maximum wind gust speed is in the following 5 bands.

- Less or equal than 30km/h.
- Between 30km/h and 40km/h, inclusive.
- Between 40km/h and 50km/h, inclusive.
- Between 50km/h and 60km/h, inclusive.
- Greater than 60km/h.

Figure 11: Proportions of observations by wind band



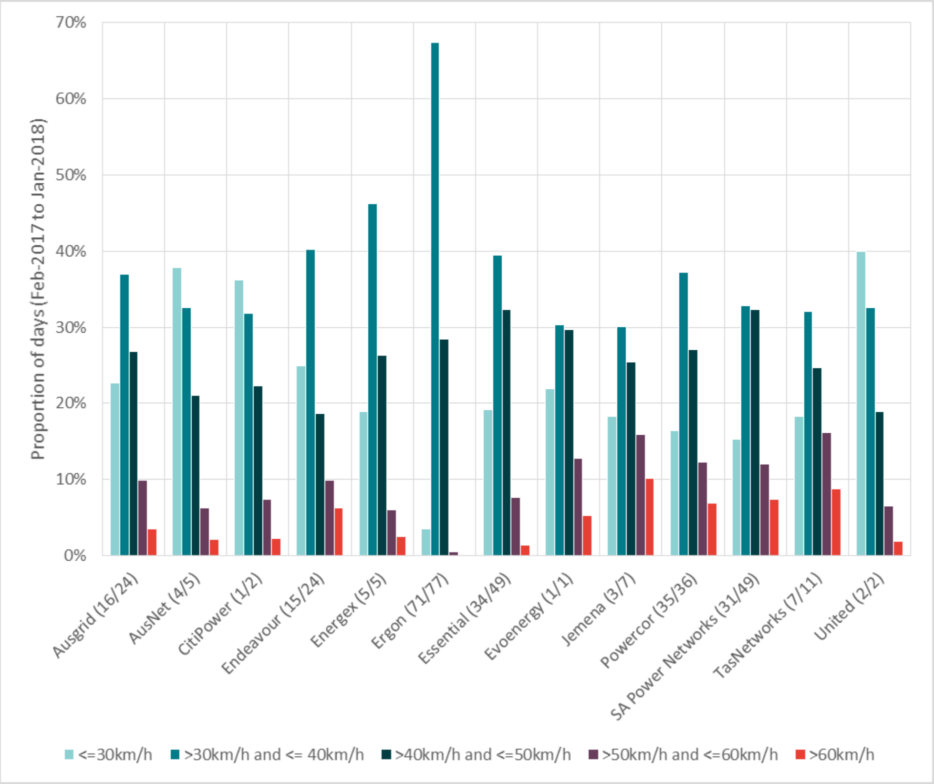
Source: Frontier Economics' analysis of Economic Benchmarking RIN data and BOM daily data.
Note: The numbers in brackets after each DNSP's name indicate the total number of weather stations for which it was possible to retrieve daily data on maximum wind gust speed out of the total number of weather stations indicated as being relevant in the 2014 Economic Benchmarking RIN datase. For example, out of 49 weather stations for Essential in total, 34 weather stations have non-missing

daily data on maximum wind gust speed over the year starting on 1 February 2017 and ending 31 January 2018.

Figure 11 shows that Jemena, TasNetworks, Powercor, and SA Power Networks have the highest proportion of observations in the highest wind speed band (>60km/h). Ergon Energy, Energex, CitiPower and Essential Energy have the highest proportion of observations in the 30-40km/h band.

Another comparison across DNSPs is shown in Figure 12 below, which shows the proportion of daily average maximum wind gust speed in each band, where the average is taken across all the weather stations nominated by each DNSP. When comparing the proportions illustrated in Figure 11 and Figure 12, it can be seen that the proportion of events in the most extreme bands are lower after averaging across weather stations (Figure 12). This is particularly true for the larger DNSPs (Ergon Energy and Essential Energy). In order to develop a conservative estimate of OEFs (and avoid any bias in favour of Essential Energy), we use the proportions presented in Figure 12 as the basis of the remainder of our analysis.

Figure 12: Proportions of observations (daily averages) by wind band



Source: Frontier Economics' analysis of Economic Benchmarking RIN data and BOM daily data.

Note: The numbers in brackets after each DNSP's name indicate the total number of weather stations for which it was possible to retrieve daily data on maximum wind gust speed out of the total number of weather stations indicated as being relevant in the 2014 Economic Benchmarking RIN datase. For example, out of 49 weather stations for Essential in total, 34 weather stations have non-missing *daily data on maximum wind gust speed over the year starting on 1 February 2017 and ending 31 January 2018.*

3.2.2 Estimate of number of wind-related outages per day per km of overhead lines, by average maximum wind gust speed

In order to quantify an OEF for wind, we have used data provided to us by Essential Energy on about 10,000 wind-related outages affecting its network from 1 July 2013 to 12 March 2018.

Using this data we calculated the average number of wind-related outages per day within each of the 5 bands identified in Figure 12 above, by dividing the total number of wind-related outages in that band by the total number of days in that band. The results are summarised in Table 1.

As different DNSPs have a different amount of overhead lines exposed to wind events, in order to quantify an OEF for all DNSPs it is necessary to normalise the estimate of the number of wind-related outages per day by the amount of overhead lines exposed.

Table 1: Estimation of number of wind-related outages by band

Average maximum wind gust speed	Total number of wind-related outages	Total number of days	Total number of wind-related outages per day	Total number of wind-related outages per day per 1000 km of overhead lines
<=30km/h	468	354	1.32	0.007
>30km/h and <=40km/h	2494	756	3.30	0.018
>40km/h and <=50km/h	3705	457	8.11	0.044
>50km/h and <=60km/h	2306	123	18.75	0.102
>60km/h	1438	26	55.31	0.301

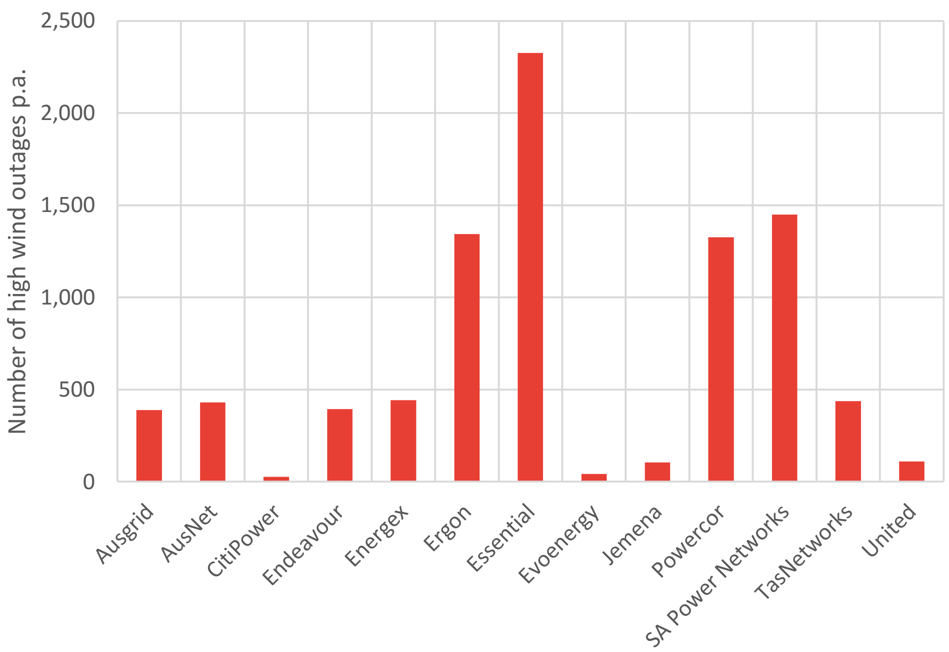
Source; Frontier Economics' analysis of Essential Energy's data.
Note: *Calculation performed over number of outages incurred between 1 July 2013 and 12 March 2018.*

The table above shows that for Essential Energy the number of wind-related outages increases with higher average maximum wind gust speed, going from 1.32 outages per day on days when the average wind gust speed is at or below 30km/h, to 55 outages per day on days when the average maximum wind gust speed is more than 60km/h. The table also shows that, on average, one can expect between 0.007 outages per day per 1,000 km of overhead lines on days with an average maximum wind gust speed at or below 30km/h, and 0.301 outages per day per 1,000 km of overhead lines on days with an average maximum wind gust speed greater than 60km/h.

3.2.3 Estimate of the number of wind-related outages per year, by DNSP

Figure 13 shows the estimated annual average number of wind-related outages over the period 2006-2016 for each DNSP. The estimates were derived by multiplying the total number of wind-related outages per day per 1,000 km of overhead lines, presented in the last column of Table 1, by the length (in 1,000s of km) of overhead lines in each year.

Figure 13: Estimate of number of wind-related outages per year



Source: Frontier Economics' analysis of Essential Energy's dataset, BOM data, and Economic Benchmarking RIN data.

We can see from Figure 13 that, according to these estimates, Essential Energy is the DNSP that experiences by far the most wind-related outages per year – just over 2,000 such instances. Ergon, Powercor, and SA Power Networks are also estimated to experience a considerable number of wind-related outages (1,300 p.a.), while other DNSPs are not affected by many of these events, with an estimate of as few as 26 wind-related outages per year for Citipower.

3.2.4 Estimate of the average cost per wind-related outage

In order to quantify an OEF for wind, we used data provided to us by Essential Energy on about 10,000 wind-related outages that affected its network from 1 July 2013 to 12 March 2018. The data provided included Essential Energy's mapping of F&E costs and associated on-costs and overhead costs for over 9,000 of these outages.[14] Using this data, we calculated the average cost per wind-related outage to be $1,272.85 (real FY2016 AUD).[15]

3.2.5 Estimate of the total opex per annum associated with wind-related outages

In order to illustrate the cost impact of wind-related outages on opex, we have used the estimated number of wind-related outages by DNSP by year (the average over time is shown in Figure 13 above, Section 3.2.3), and applied an estimated average cost per wind-related outage of $1,272.85 (Section 3.2.4). Our estimated average annual wind-related opex for each DNSP over the period 2006-2016 is shown in Figure 9 below. It can be seen that our estimates of wind-related opex vary considerably across DNSPs. We estimate wind-related outage costs to be more than $2.5m per annum for Essential Energy, over $1.5m per annum for Ergon Energy, Powercor, and SA Power Networks, and less than $150k per annum for some of the other DNSPs, including CitiPower, Evoenergy, Jemena, and United.

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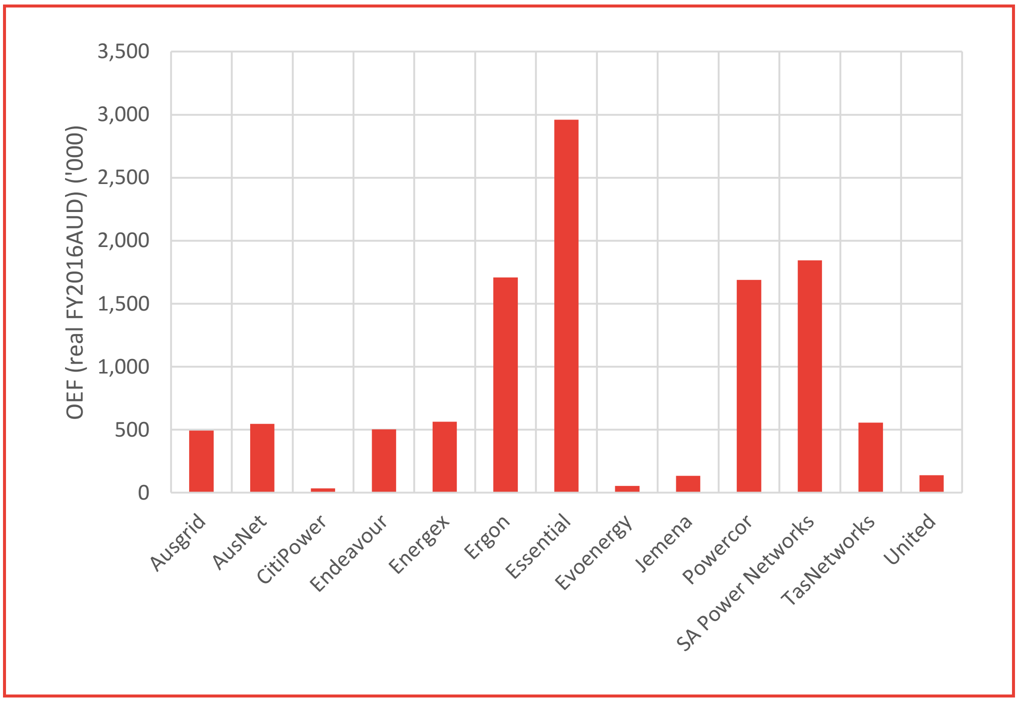
[14] Refer to Appendix A for a detailed description of the dataset used in the analysis and how it was generated.

[15] We use a single average cost per outage for every band of wind gust speed, as the cost per outage does not vary significantly across the bands.

Figure 14: Estimated average annual wind-related opex by DNSP

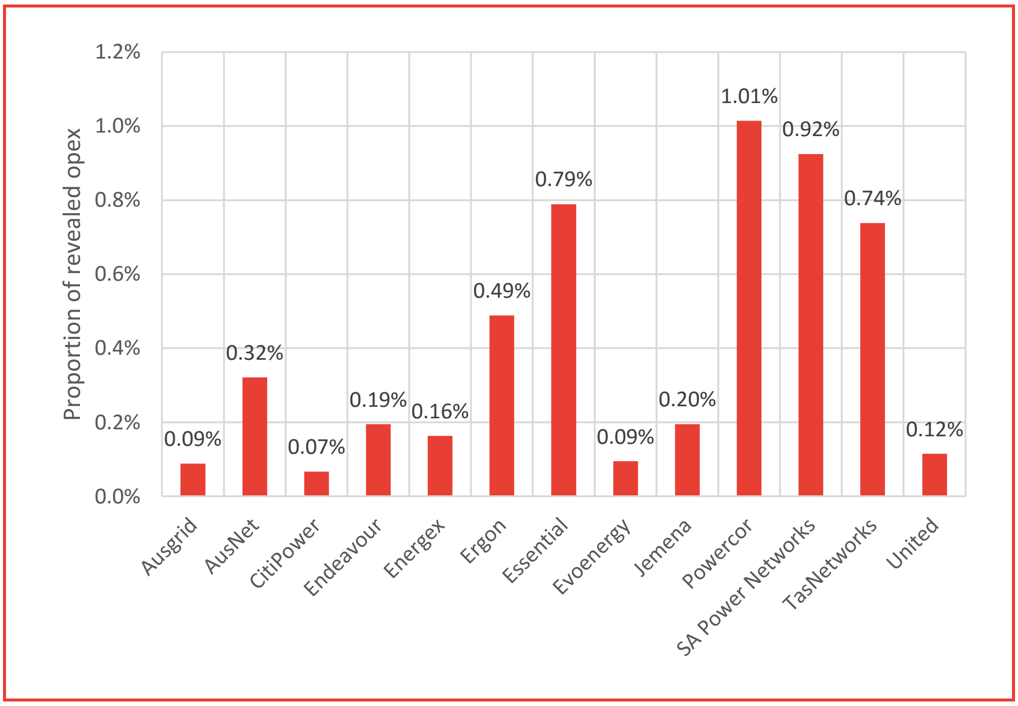


Source: Frontier Economics analysis of Essential Energy's dataset.

3.2.6 Estimated % OEF for wind-related outages

To calculate a % OEF for wind-related outages for each DNSP, we have divided our estimate of average annual wind-related outages opex for each DNSP (Section 3.2.5) by its average annual revealed opex over the period 2006-2016. Our estimated % OEFs for wind-related outages are shown in Figure 10 below. Powercor, SA Power Networks, Essential Energy, and TasNetworks are estimated to incur considerably higher costs per annum on this OEF (as a proportion of their total opex) than all other DNSPs. Our illustrative estimates show that the OEF for wind for Powercor is 1.01%, for SA Power Networks it is 0.92%, and for Essential Energy it is 0.79%. At the other end of the scale is Citipower, for which the wind OEF is estimated to be 0.07%.

Figure 15: Estimated wind OEF



Source: Frontier Economics' analysis of Essential Energy's dataset.

3.3 Heavy rain and floods

Our analysis in this section demonstrates that different DNSPs are exposed to different amounts of rain throughout the year, and that the impact of floods on Essential Energy's costs vary considerably from year to year.

- Section 3.2.1 shows that exposure to rain varies significantly across DNSPs.
- Section 3.3.2 explains how floods affect Essential Energy's network.
- Section 3.3.3 shows the number of heavy rain and flood-related outages for Essential Energy between 1 July 2013 and 12 March 2018.
- Section 3.3.4 provides our estimate of the average cost per heavy rain and flood-related outage, using data provided by Essential Energy.
- Section 3.3.5 provides our estimate of the total opex per annum associated with heavy rain and flood-related outages, using data provided by Essential Energy.
- Section 3.3.6 summarises our estimates of the OEF for heavy rain and floods for Essential Energy over the period 2014-2017. The OEF is calculated by dividing the estimate of opex associated with heavy rain and flood-related outages in each year (Section 3.3.5) by the revealed opex for each year.

Using the approach described above, our illustrative estimate of the OEF for heavy rain and floods for Essential Energy over the period 2014-2017 is between 0.06% in 2014 and 0.32% in 2017.

3.3.1 Geographic variation in exposure to rain

Figure 12 below illustrates, for each DNSP, the proportion of days in a year[16] during which the average daily rainfall (mm)[17] is in any of the following 5 bands based on the average daily rainfall distribution across all days and DNSPs:[18]

- ☐ less than or equal to the median rainfall (0.16mm)
- ☐ between the 50th percentile (0.16mm) and the 75th percentile (1.64mm), inclusive

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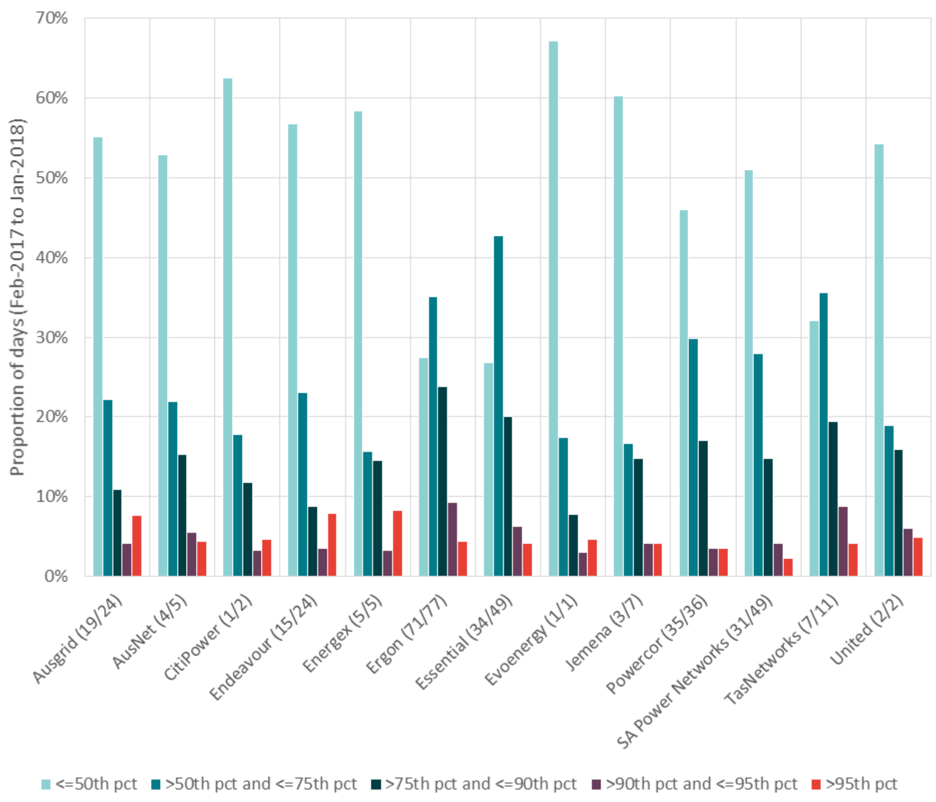
[16] We have used daily data from the BOM over the year starting on 1 February 2017 and ending 31 January 2018.

[17] The average daily rainfall for each day of the year was derived by averaging the daily rainfalls for that day across a set of weather stations. The weather stations considered are those weather stations indicated by the DNSPs in the Economic Benchmarking RIN as being relevant to the management of their network.

[18] For the reasons discussed in Section 3.2.1, we present averages across weather stations in order to avoid any bias in favour of Essential Energy.

- between the 75th percentile (1.64mm) and the 90th percentile(5.85mm), inclusive
- between the 90th percentile (5.85mm) and the 95th percentile (9.75mm), inclusive
- greater than the 95th percentile (9.75mm).

Figure 16: Proportion of days by band of average daily rainfall (mm)



Source: Frontier Economics' analysis of Economic Benchmarking RIN data and BOM daily data.
Note: The numbers in brackets after each DNSP's name indicate the total number of weather stations for which it was possible to retrieve daily data on rainfall out of the total number of weather stations indicated as being relevant in the 2014 Economic Benchmarking RIN dataset.

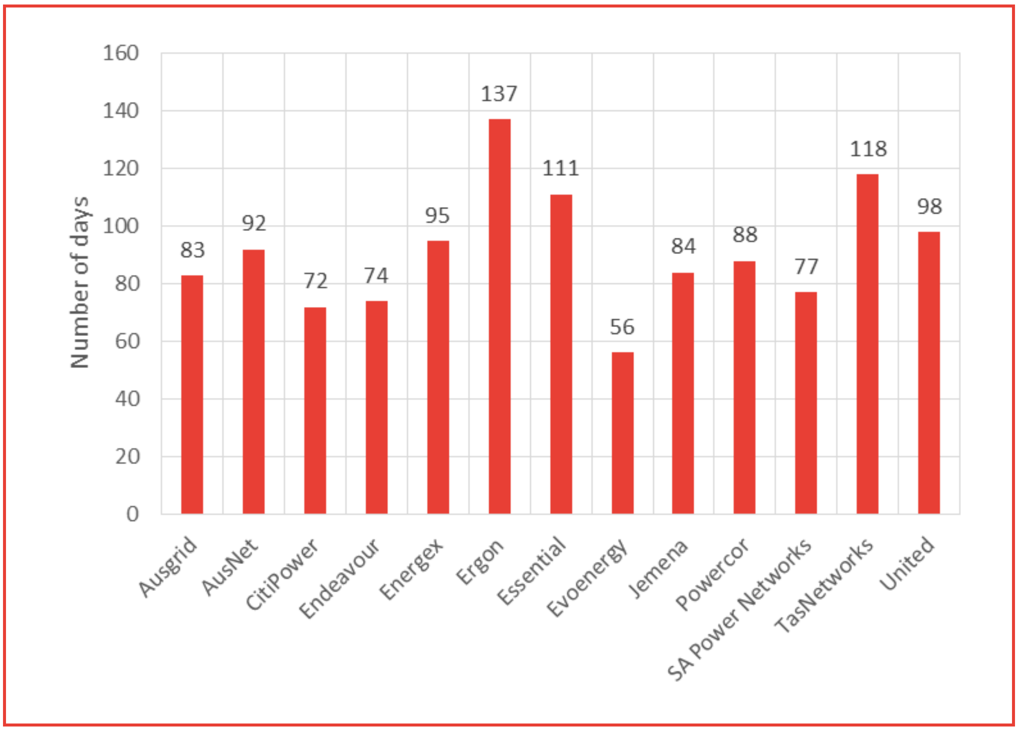
It can be seen that the exposure to rain varies significantly across different DNSPs. For instance, during the year under consideration, Essential Energy was exposed for:

- 73 days to average daily rainfall between the 75th percentile (1.64mm) and the 90th percentile(5.85mm)
- 23 days to average daily rainfall between the 90th percentile (5.85mm) and the 95th percentile (9.75mm); and
- 15 days to average daily rainfall greater than the 95th percentile (9.75mm).

DNSPs with a greater exposure than Essential Energy to average daily rainfall greater than the 95th percentile (9.75mm) include Energex, Endeavour, and Ausgrid, with at least 28 days per year with such events. By contrast, SA Power Network had only 8 days with an average daily rainfall greater than the 95th percentile (9.75mm).

Figure 17 summarises the average number of days per year for which the average daily rainfall exceeds the 75th percentile of 1.64mm per day for each DNSP. It is clear from the chart that Ergon, TasNetworks and Essential are the DNSPs with the greatest exposure to rain above 1.64mm, having at least 111 days per year with an average daily rainfall above 1.64mm.

Figure 17: Days with average daily rainfall in excess of the 75th percentile



Source: Frontier Economics' analysis of Economic Benchmarking RIN data and BOM daily data.

3.3.2 Impact of floods on Essential Energy's network

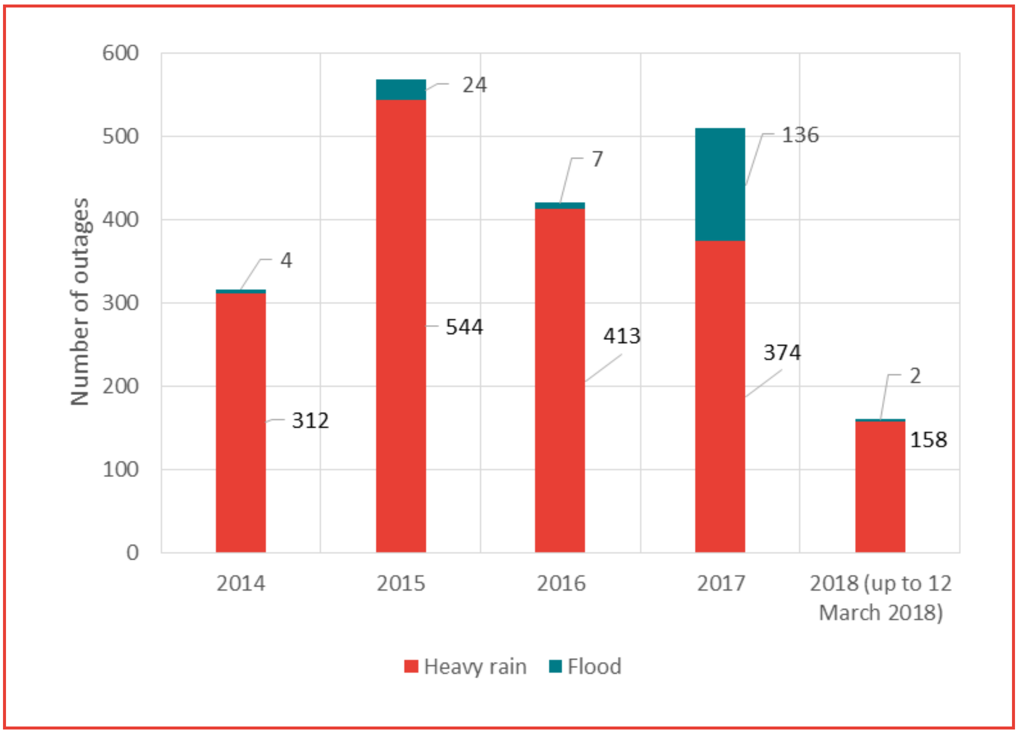
We are informed by Essential Energy that episodes of heavy rain may result in floods, which, within Essential Energy's region, generally occur in populated areas where there is a concentration of underground assets. We understand that flood events have a significant impact on Essential Energy's underground assets. Flood waters can enter underground installations along with mud and debris, and this water can at times be contaminated. Deposited mud and debris can conduct electricity, making the installation unsafe during and after the flood. An installation that has been inundated with flood water requires careful inspection and repair before supply can be restored. Clean-up is often extensive, consuming large amounts of resources to restore supply. Essential Energy, in recognition of the frequency of these events on its network, has a dedicated policy for the restoration of flood-affected underground assets (CEOP2481).

We are advised that while the impact of flooding is smaller on Essential Energy's overhead assets, flood-related erosion can affect pole foundations. Flood waters can also lead to corrosion of electrical connections and significantly increase the risk of connections failing or causing a fire, which could also lead to longer outages.

3.3.3 Number of outages due to heavy rains and floods

Figure 18 summarises the number of outages that Essential Energy reported to be caused by heavy rain and floods between 1 July 2014 and 12 March 2018.[19] The figure below shows that the number of flood-related outages in Essential Energy's network varies considerably over time. For example, while 136 outages were reported to be caused by floods in the year 2017, only 7 flood-related outages were reported in 2016. By contrast, a significantly higher number of outages are reported to be caused by rain in each year (at least 300 outages in each year since 2014), and this is less variable over time.

Figure 18: Number of outages due to heavy rain and floods



Source: Essential Energy's dataset

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[19] By financial year.

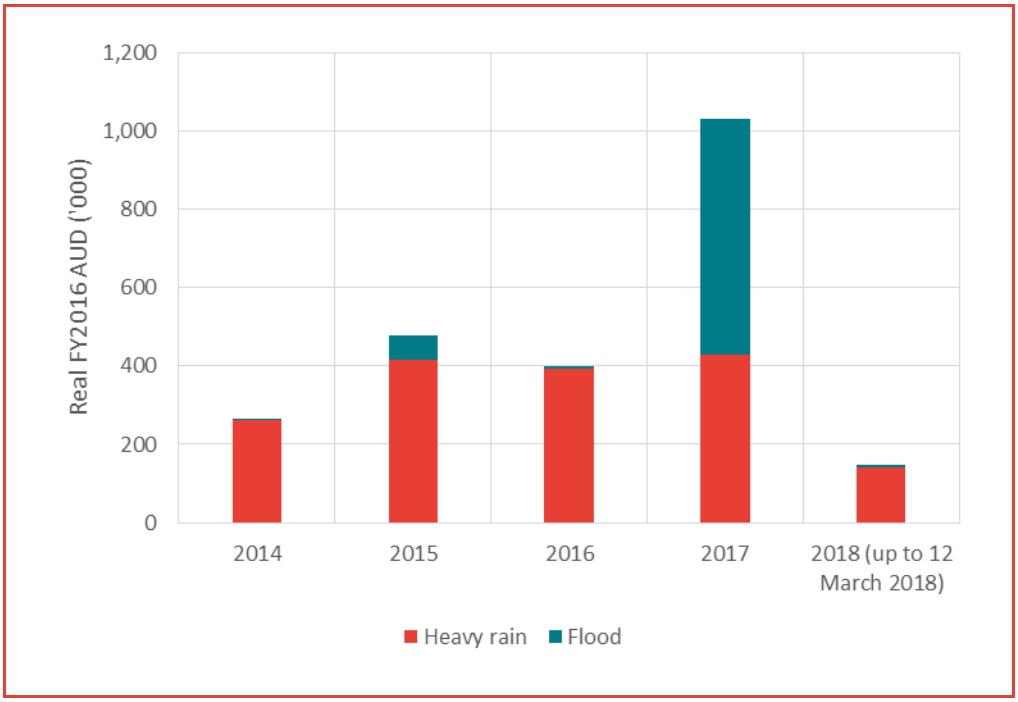
3.3.4 Estimate of the average cost per heavy rain and flood-related outage

In order to estimate the cost per rain and flood event, we use data provided to us by Essential Energy on roughly 1,600 heavy rain-related outages and 160 flood-related outages that affected its network from 1 July 2013 to 12 March 2018, and for which Essential Energy provided a mapping of corresponding "Fault and Emergency" (F&E) costs, including on-costs and overhead costs.[20] Using this data, we calculate the average cost per heavy rain-related outage to be $1,027.10 (real FY2016 AUD) and the average cost per flood-related outage to be $4,312.84 (real FY2016 AUD).

3.3.5 Estimate of the total opex per annum associated with heavy rain and flood-related outages

To illustrate the cost impact of heavy rain and floods we multiply the estimated average costs per outage (Section 3.3.4) by the number of events in each year (3.3.3). Results are reported in Figure 19.

Figure 19: Estimated heavy rain and flood-related opex



Source: Frontier Economics's analysis of Essential Energy's data.

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[20] Refer to Appendix A for a detailed description of the dataset used in the analysis and how it was generated.

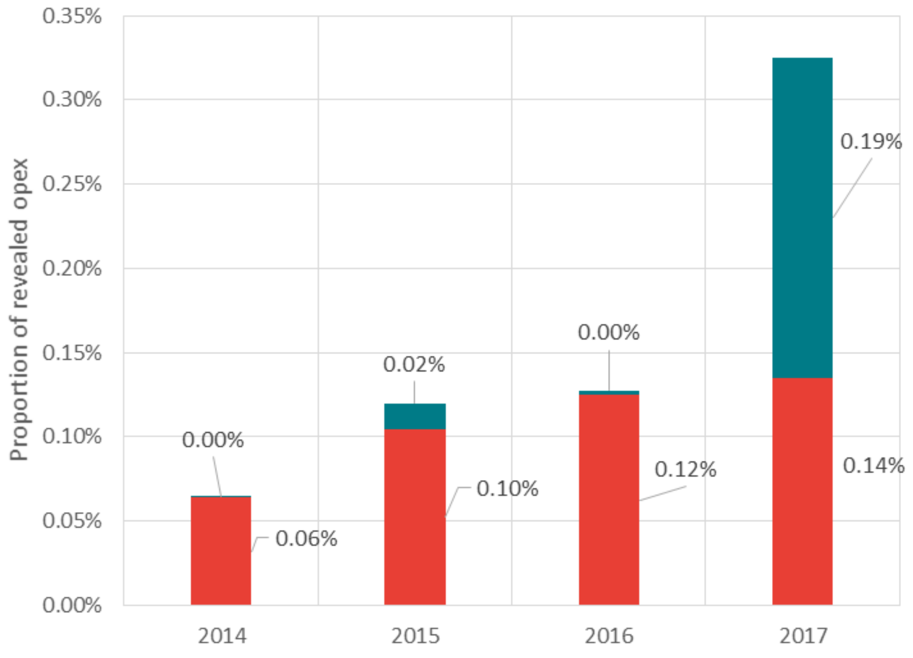
The chart shows that total costs associated with heavy rain do not change considerably over time, at around $400k p.a. By contrast, total costs associated with floods vary significantly over time. Over the period 2014-2017, flood-related costs were as low as $1,000 in 2014 and as high to $601,000 in 2017.

We are advised by Essential Energy that the impact of flood events on costs depends on the amount of underground equipment that needs to be restored and on the concurrence of multiple flood-events which can restrain capacity. For instance, Essential Energy informed us that the 2017 floods occurred in the high density areas of Northern New South Wales and that floods in Lismore and Tweed Heads occurred at the same time.

3.3.6 Estimated OEF for heavy rain and flood-related outages

To calculate a % OEF for heavy rain and flood-related outages for Essential Energy by year, we have divided our estimate of opex associated with heavy rain and flood-related outages (Section 3.3.5) by Essential Energy's revealed opex for each year of the period 2014-2017. Our estimated % OEFs are shown in Figure 20 below.

Figure 20: Estimated heavy rain and flood OEF



Source: Frontier Economics' analysis of Essential Energy's dataset, AER/Economic Insights 2017 annual benchmarking RIN dataset.

Our illustrative estimates show that the combined OEF adjustment for heavy rain and floods vary by year, going from 0.06% of total opex in 2014 to up to 0.32% of total opex in 2017. The yearly variations appear to be mainly driven by costs associated with flood-related outages.

3.4 Bushfire

Bushfire risk, like exposure to lighting, wind and rain, is an exogenous weather-related operating environment factor. However, we note that while costs associated with lightning, wind and rain are predominantly related to the costs of repairing the network following the impact of an outage on assets, the costs associated with bushfires predominantly relate to asset inspection and maintenance in order to prevent bushfires. We understand that the estimated cost of Essential Energy's bushfire mitigation pre-summer inspection program for 2017/18 is $1.4m, which is roughly 0.4% of Essential Energy estimated total opex for the year. We understand that this cost only covers Essential Energy's inspection program. Additional costs associated with bushfires, including defect rectification costs are not included in this estimate.

As outlined in Essential Energy's annual bushfire risk management report 2016/17:[21]

> Essential Energy operates a predominantly rural network generally considered to be bushfire prone environments with different degrees of risk to the public from low to high. The combination of oil-bearing eucalyptus trees, dry grass, low humidity, and hot, gusty winds result in periods of high fire risk. Fires can cause enormous property, livestock and wildlife losses and pose a real threat to human life
>
> Essential Energy has identified locations which are considered to be generally bushfire prone. The bushfire prone lands are further segmented into fire risk classifications based on fire risk modelling. Fire risk priority classifications (P1, P2, P3, P4) are used to determine fire mitigation work priorities, presummer inspection requirements, investment program priorities, and operational procedures.

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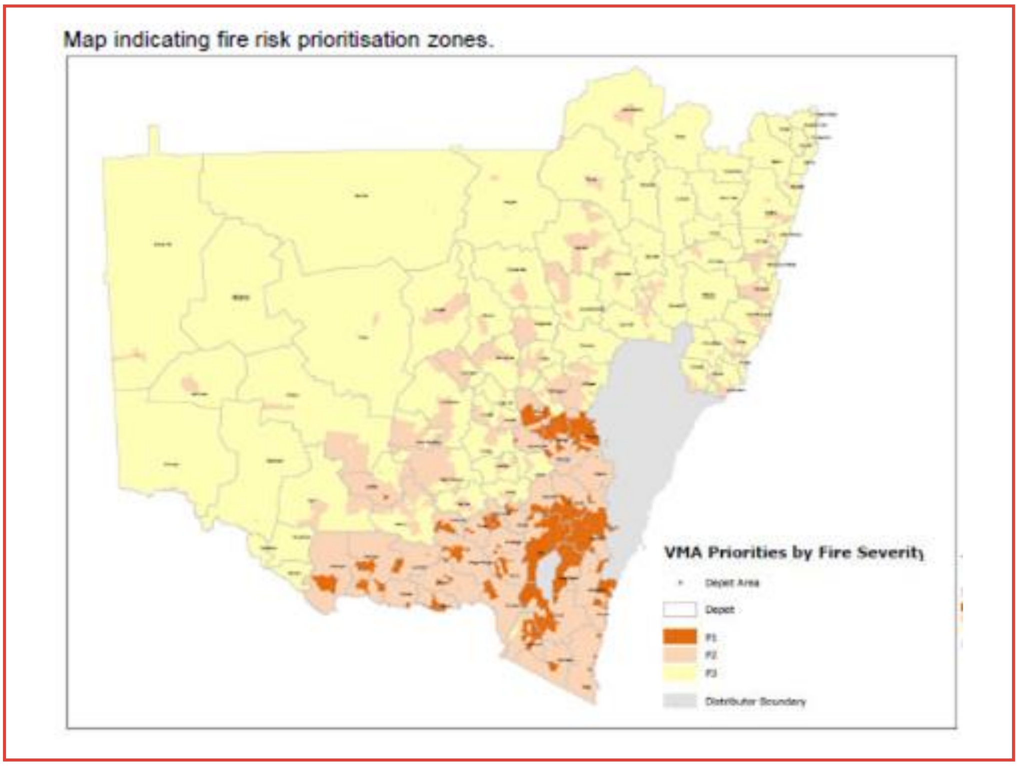
[21] Essential Energy annial bushfire management report (2016/17): This can be found here: file:///C:/Users/sucheta/Downloads/IPART%20Bushfire%20Report%202017.pdf

Figure 21: Essential Energy’s fire risk prioritisation zones



Source: Essential Energy’s annual bushfire risk management report 2016/17

4 Fauna

Our analysis in this section demonstrates that fauna is an important candidate OEF.

- Section 4.1.1 summarises the Category Analysis RIN data on the number of fauna-related outages reported by each DNSP between 2009 and 2016. It can be seen that Essential Energy experienced the second-highest annual average number of fauna-related outages during this period.
- Section 4.1.2 presents our estimate of the average cost per fauna-related outage, using data provided by Essential Energy.
- Section 4.1.3 provides our estimate of the total opex per annum associated with fauna-related outages by DNSP, using the number of fauna-related outages from Section 4.1.1 and the estimated cost per fauna-related outage from Section 4.1.2.
- Section 4.1.4 summarises our estimated OEF for fauna for each DNSP, which is calculated by dividing the estimated annual average fauna-related opex over 2009-2016 (Section 4.1.3) by the average annual revealed opex over 2009-2016 for each DNSP.

Using the approach described above, our illustrative estimate of the OEF for fauna for Essential Energy is 0.65%.

4.1.1 Number of fauna-related outages per year by DNSP

Figure 8 below shows the average number of fauna-related outages reported by DNSPs in the Category Analysis RIN data from 2009 to 2016.[22]

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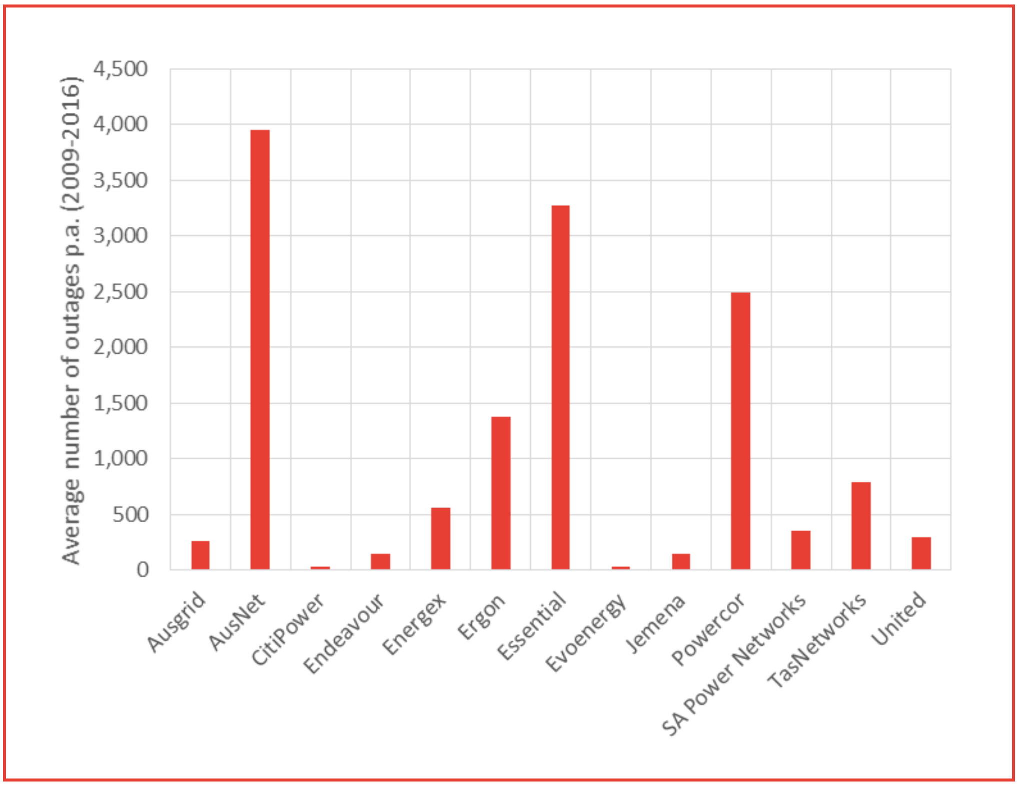
[22] Calendar years for the Victorian DNSPs, financial years for the remaining DNSPs. Category RINs are not available before 2009.

Figure 22: Number of fauna-related outages by DNSP



Source: 2009-2016 Category Analysis RIN datasets.

Figure 8 shows that the number of fauna-related outages varies considerably across DNSPs. It can be seen that, on average, AusNet experienced the highest number of fauna-related outages (roughly 4,000 p.a.) while Evoenergy experienced the lowest number of fauna-related outages (roughly 25 p.a.). Essential Energy experienced the second highest number of fauna-related outages, with over 3,000 outages per year. While we have reported the average number of fauna-related outages per annum in Figure 8, we note that the number of reported fauna-related outrages in the Category Analysis RIN data varies considerably from year to year. We recommend that the AER investigate the reasons for such variations over time and take the variation into account when considering allowances for fauna-relations opex.

4.1.2 Estimate of the average cost per fauna-related outage

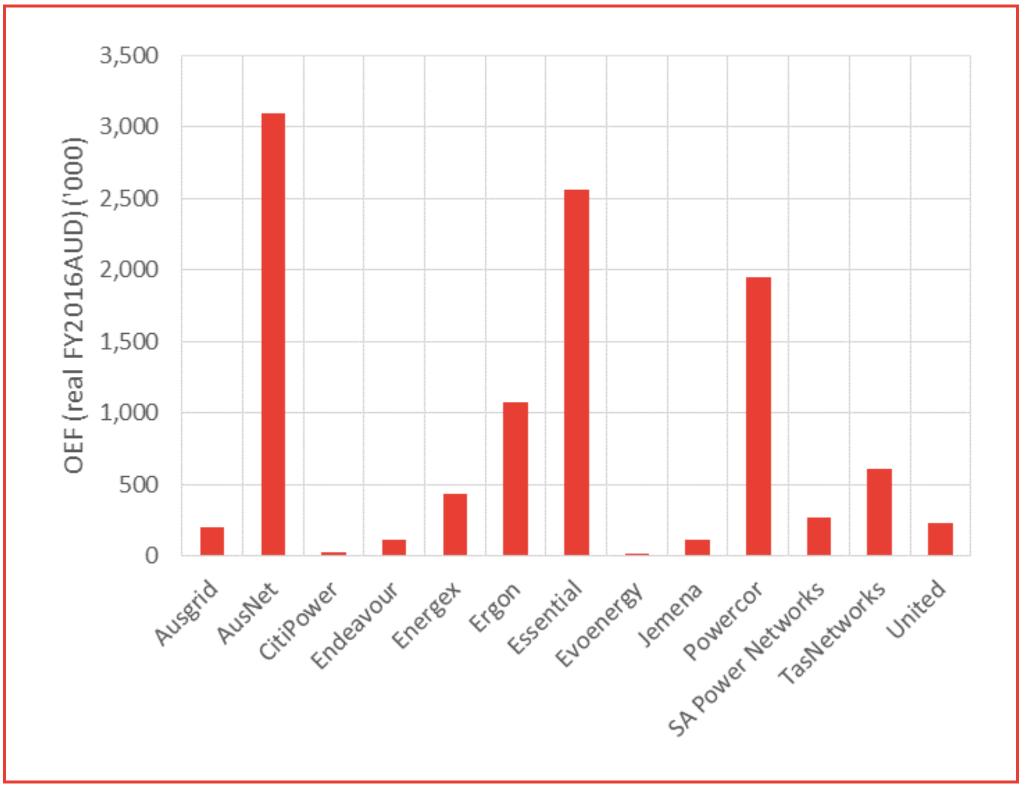
In order to quantify an OEF for fauna, we used data provided to us by Essential Energy on roughly 15,000 fauna-related outages that affected its network from 1 July 2013 to 12 March 2018. The data included a mapping by Essential Energy of "Fault and Emergency" (F&E) costs, and associated on-costs and overhead costs, to about 14,500 of these outages.[23] Using this data, we calculated the average cost per fauna-related outage to be $782.64 (real FY2016 AUD).

4.1.3 Estimate of the total opex per annum associated with fauna-related outages

To illustrate the cost impact of fauna, we have used data on the number of fauna-related outages by year reported by the DNSPs in the Category Analysis RINs (the average number of such outages per year is reported in Figure 8 in Section 4.1.1 above), and applied an estimated average cost per fauna-related outage of $782.64 (Section 4.1.2). Our estimates of average fauna-related opex per year by DNSP are shown in Figure 9 below.

It can be seen that our estimate of fauna-related opex varies considerably across DNSPs. We estimate fauna-related outages to cost AusNet over $3.0m per annum, Essential Energy over $2.5m per annum, Powercor roughly $2.0m per annum, Ergon Energy over $1m per annum in operating expenditures. The cost impact for some DNSPs is as low as less than $100k per annum.

Figure 23: Estimated average fauna-related opex



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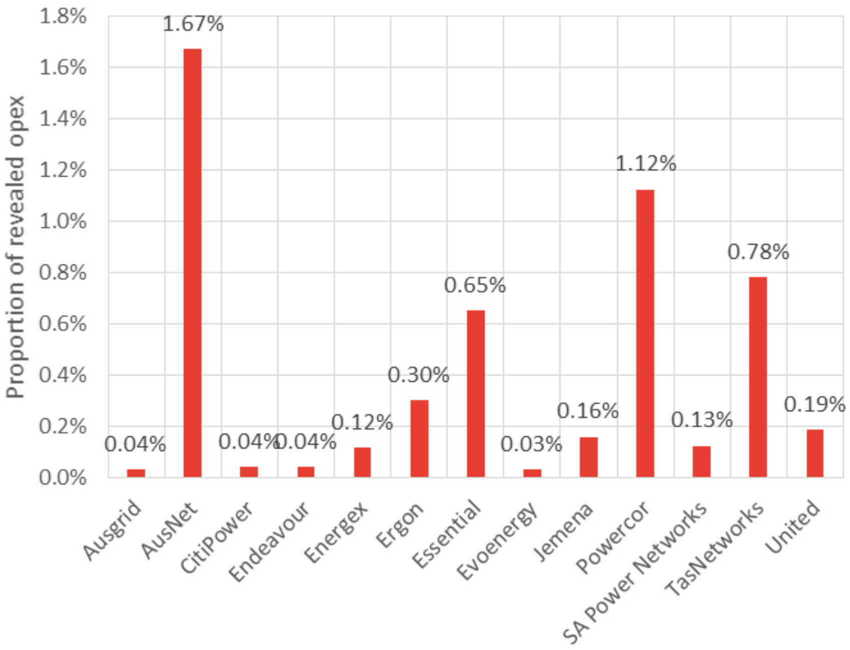
[23] Refer to Appendix A for a detailed description of the dataset used in our analysis and how it was generated.

Source: Frontier Economics' analysis of cost data provided by Essential Energy, 2009-2016 Category RIN datasets.

4.1.4 Estimated OEF for fauna-related outages

To calculate a % OEF for fauna for each DNSP, we have divided our estimate of average annual fauna-related opex over the period 2009-2016 (Section 4.1.3) by the average annual revealed opex over the period 2009-2016 for each DNSP. Our illustrative estimated % OEFs for fauna by DNSP are shown in Figure 10 below. Our illustrative estimate of the OEF for fauna is 1.67% for AusNet, 1.12% for Powercor, 0.65% for Essential Energy, and as low as 0.03% for Evoenergy.

Figure 24: Estimated fauna OEF



Source: Frontier Economics' analysis of cost data provided by Essential Energy, 2009-2016 Category RIN datasets.

5 Proportion of timber poles

Our analysis in this section demonstrates that timber poles are an important candidate OEF.

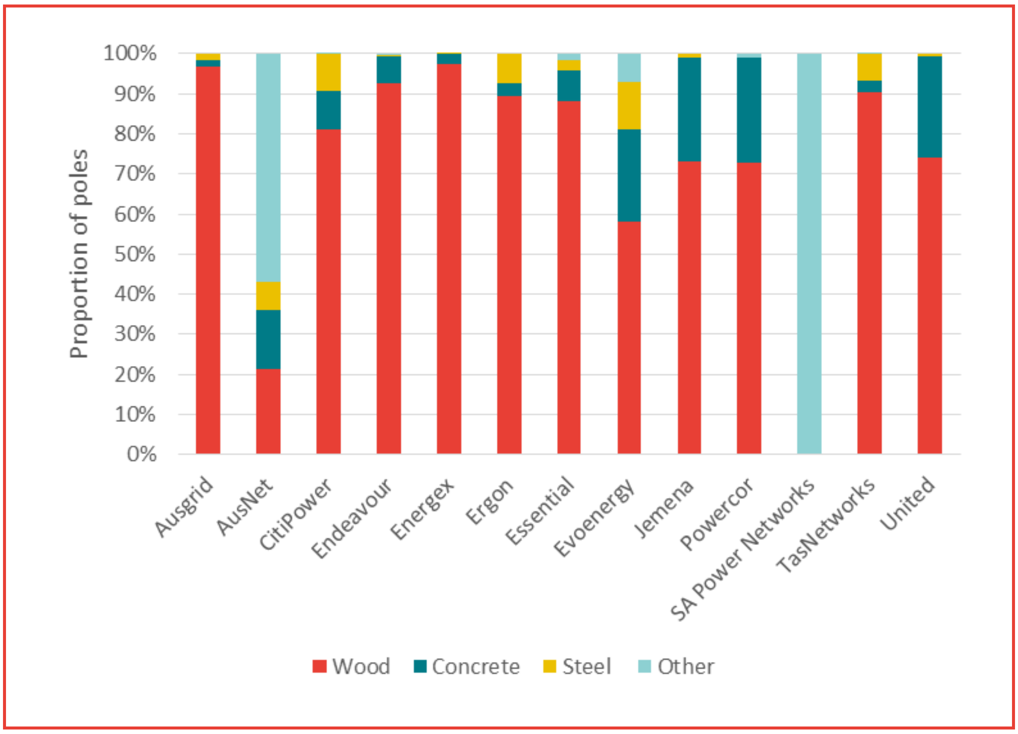
- Section 5.1.1 below shows that there is considerable heterogeneity in the configuration of poles across the Australian DNSPs. It can be seen that Essential Energy has a relatively high proportion of timber poles when compared to the majority other networks.
- Section 5.1.2 summarises evidence from the CSIRO which shows that there is significant geographic variation in the risk of exposure to fungi that cause timber decay. It can be seen that Essential Energy has a larger proportion of its service area in high risk zones for such fungi compared to the majority of other service providers.
- Section 5.1.3 shows that over 23% of Essential Energy’s poles are located in zones where the risk of attack by decay-causing fungi is higher than the timber poles owned by the Victorian DNSPs.
- Section 5.1.4 provides Essential Energy’s estimate of the additional opex per annum, applying its serviceability criteria, associated with the ownership of timber poles compared to non-timber poles.
- Section 5.1.5 summarises our estimated OEF for timber poles for Essential Energy, which is calculated by dividing Essential Energy’s estimate of the additional opex per annum associated with the ownership of timber poles (Section 5.1.4) by the average annual revealed opex over the period 2006-2016 for each DNSP.

Using the approach described above, our illustrative estimate of the OEF for timber poles for Essential Energy is 0.7%.

5.1.1 Variation in proportion for timber poles across DNSPs

Figure 25 summarises the types of poles used by DNSPs in the NEM. It can be seen that there is considerable heterogeneity in the types of poles used across DNSPs, with the six DNSPs in New South Wales, Queensland and Tasmania having a higher proportion of timber poles (close to 90% and above) than DNSPs in Victoria and South Australia.

Figure 25: Proportion of poles by pole type



Source: Frontier Economics' calculations using Category Analysis RIN data. 2015 Category Analysis RIN data for Victorian DNSPs except AusNet, 2014 Category Analysis RIN data for AusNet, and 2016 Category Analysis RIN data for the remaining DNSPs.

5.1.2 Geographic variation in exposure to timber decay fungi

The prevelance of timber decay in a DNSP's network area depends on the proportion of its pole configuration that is timber, the type of timber, and the intensity of factors causing timber decay in its network area. Section 5.1.1 showed that Essential Energy has a relatively high proportion of timber poles when compared to the majority of the other networks. In this section we demonstrate that it is more exposed to the factors causing timber decay than other service providers, with the exception of Energex and Ergon Energy.

Figure 26 below presents CSIRO's hazard map of Australia for the intensity of in-ground timber attack by fungi decay. The map divides Australia into four distinct hazard zones. Zone A is least hazardous, and Zone D is the most hazardous. It can be seen that the area along the NSW coastline, which is serviced by Essential Energy, has been classified by the CSIRO as Zone C, which is the second most hazardous area.

Figure 26: CSIRO hazard zones for timber in-ground

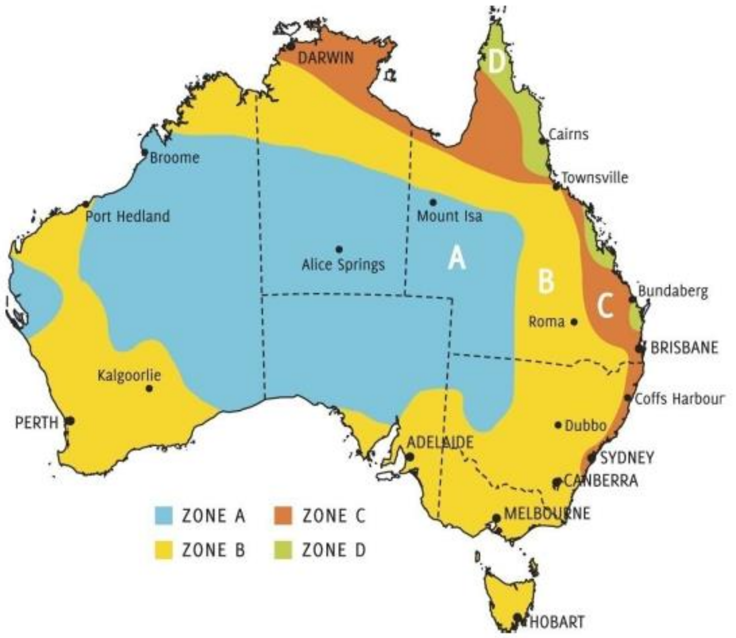


Figure 1.3 A hazard map of Australia for timber in-ground under attack of decay fungi (Zone D is the most hazardous).

Source: CSIRO Forest and Timber Products Australia, Manual 3[24]

Figure 27 below presents CSIRO's hazard map of Australia for attack of above-ground timber by decay fungi, which is applicable to the above-ground timber arms of poles. It can be seen that the area around Tweed Head and Coffs Harbour, which is serviced by Essential Energy, has been classified by the CSIRO as Zone D, which is the most hazardous area.

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[24] See:http://www.fwpa.com.au/images/marketaccess/ManualNo3-IG%20Decay.pdf

Figure 27: CSIRO hazard zones for timber above-ground

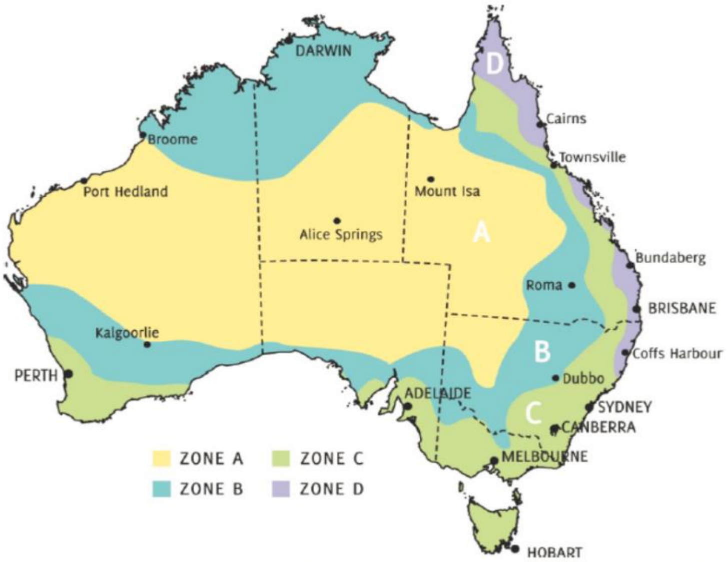

Figure 1.8 A hazard map of Australia for timber above-ground under attack of decay fungi (Zone D is the most hazardous).

Source: CSIRO Forest and Timber Products Australia, Manual 4[25]

5.1.3 Distribution of Essential Energy's timber poles across hazard zones

Essential Energy has provided us with data on the distribution of its timber pole population across CSIRO's timber decay hazard zones A, B, and C shown in Figure 26 above. Figure 28 below shows that almost 280,000 of its timber poles (23.3%) are in CSIRO's Zone C. On the other hand, as can be seen from Figure 26, the entire region serviced by the Victorian DNSPs is classified by the CSIRO as Zone B.

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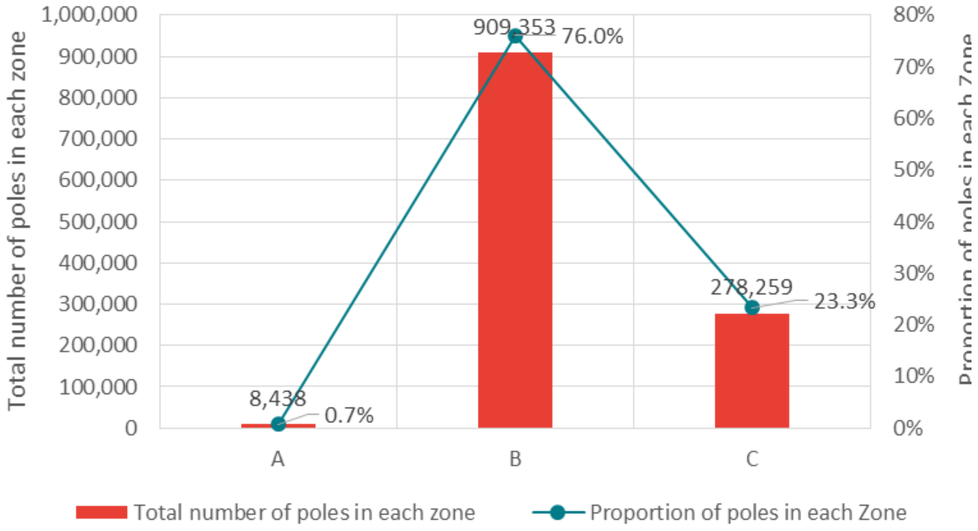
[25] See: http://www.fwpa.com.au/images/marketaccess/ManualNo4-AG%20decay.pdf

Figure 28: Essential Energy’s timber poles classified by CSIRO’s timber in-ground decay hazard zones



Source: Frontier Economics calculations using data provided by Essential Energy

5.1.4 Estimate of the additional opex per annum associated with the ownership of timber poles

Essential Energy has estimated the additional cost per annum associated with its ownership of timber poles (relative to the hypothetical counterfactual scenario of having a 100% non-timber pole population) to be $2.7m (FY2016 AUD).[26]

5.1.5 Estimated OEF for timber poles

To calculate a % OEF for timber poles for Essential Energy, we have divided Essential Energy’s estimate of the additional opex per annum associated with the ownership of timber poles (Section 5.1.4) by the average annual revealed opex over the period 2006-2016. Our estimated % OEF for timber poles is 0.7%.

We understand that Essential Energy’s analysis cannot directly be applied to other DNSPs, as we do not have access to information on the serviceability criteria and timber types of the timber pole population of the other DNSPs. In order to facilitate the calculation of an OEF for timber poles for all DNSPs, we recommend that the AER collect data on these additional factors from all DNSPs.

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[26] Further details can be provided to the AER by Essential Energy upon request.

6 Additional OEFs yet to be assessed in detail

The OEFs that we attempted to assess in detail over the course of our work are set out in Sections 2 to 5 above. We note that there are a number of additional OEFs which may create material differences between the DNSPs and are not accounted for in the AER's econometric benchmarking model. As set out in Section 2.1 of our February 2018 OEFs report, differences in the operating expenditures incurred by the DNSPs can arise from a number of potential sources, including (but not necessarily limited to) differences in:

- core cost drivers (e.g., network scale, demand);
- operating environment (e.g., density, climate, topography, soil properties, vegetation, and the urban/rural nature of certain areas);
- regulatory obligations;
- scope of activities (e.g., sharing of vegetation management roles with local councils);
- input prices (e.g., labour rates);
- cost allocation policies and reporting practices;
- past (legacy) network configuration decisions (e.g., ownership of subtransmission assets, historical choices in the way networks were constructed) and planning constraints that cannot be altered easily or efficiently within a short period of time; and
- current managerial and operating efficiency.

All of these factors can influence (increase or reduce) a DNSP's actual or reported opex compared to other DNSPs. However, for the purposes of determining efficiency adjustments in regulatory proceedings, it is only excess cost due to the last type of underlying difference in the above list – genuine **differences in current managerial and operating efficiency** – that should be measured. Differences in measured performance due to the other factors mentioned above should not be used to justify the imposition of efficiency adjustments.

Of the factors listed above, Essential Energy has attempted to gather evidence in relation to the following.

- Vegetation management
- Jurisdictional differences, such as differences in licence conditions
- Corrosion
- Termites
- Competition from mining
- Sparsity

- Network accessibility
- Cyclones
- Materials availability
- Smart meters
- Backyard reticulation

While some of Essential Energy's work in relation to the above has been shared with Frontier Economics, we have been unable to review and comment on Essential Energy's work in all these areas within the timeframes for this project. We note, however, that evidence from external sources such as the BOM and CSIRO suggests that there is genuine heterogeneity in circumstance in relation to a number of the factors above, warranting their further investigation.

We recommend that the AER allow more time for Essential Energy to make further submissions in relation to additional OEFs that are not discussed in Sections 2 to 5 above. Furthermore, we recommend that with further data collection and time, a bespoke methodology be developed for assessing the OEFs listed above, and any additional OEFs that are considered to be material by the AER, the other DNSPs and relevant stakeholders. The types of bespoke approaches that may be applied are illustrated in our assessment of the OEFs for subtransmission (Section 2), diversity of weather (Section 3), fauna (Section 4) and timber poles (Section 5). Our recommended process for the assessment of such additional OEFs is set out in Section 7 below.

7 Recommendations for the AER

In our February 2018 OEFs report,[27] we set out in detail our proposed framework for accounting for OEFs in the AER's benchmarking. The analysis presented in the present report is our first attempt at developing a bespoke methodology for the quantification of a small subset of OEFs that are relevant for Essential Energy. In the remainder of this section, we summarise the key recommendations for the AER set out in our February 2018 OEFs report, and outline how the analysis presented in this report can be improved in collaboration with the AER, other DNSPs and key stakeholders.

7.1 Need for further consultation

At present, there is little agreement on which OEFs should be accounted for within the benchmarking analysis. Whilst the AER's current consultation process takes a step towards addressing this question, in our view a much more extensive consultation and engagement process (between the AER and relevant stakeholders) is required in order to determine the most important factors that could be driving differences in DNSPs' opex that are not accounted for within the AER's benchmarking models.

Clearly, the factors not accounted for in the AER's benchmarking models will depend on *how* those models are specified. The AER itself has indicated that more work needs to be done to improve its benchmarking models and techniques. Therefore, the question of what OEFs should be quantified and adjusted for cannot be divorced from the process of reviewing and improving the AER's benchmarking models: these two processes need to occur together.

We recommend that efforts to improve the AER's benchmarking analysis and approach to OEFs should not be viewed by DNSPs or the AER as a one-off investment but, rather, as an iterative process that improves gradually the quality of information and analysis available to the regulator, the businesses and consumers as a means of promoting better regulatory outcomes. Our analysis presented in this report should be seen as a preliminary step in this process.

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[27] See Attachment C of Essential Energy's submission to the AER: https://www.aer.gov.au/system/files/Essential%20Energy%20-%20Submission%20on%20review%20of%20Operating%20Environment%20Factors%20for%20Distribution%20Network%20Service%20Providers%20-%2016%20February%202018.pdf

7.2 Need for bespoke methodology for each OEF

Once agreement is reached on the most important OEFs to be accounted for, a process will be required to decide how each of these OEFs should be quantified in a systematic and reliable manner.

As shown from our preliminary analysis in Sections 2 to 5, owing to the wide-ranging characteristics of relevant OEFs, there is unlikely to be a 'standard' approach that can be applied to quantifying all (or even some) OEFs. It is more likely that the quantification of each OEF will require a bespoke calculation. The process for agreeing how each OEF should be quantified would entail:

- developing an appropriate methodology for quantification;
- identifying the data required to apply each method, including the data that can be sourced from preferred third-party sources such as the BOM, CSIRO;
- agreeing on the sources of data that should be used; and
- developing data templates and detailed, standardised data definitions if (as is likely) some of the data are to be collected from DNSPs.

We note that our illustrative quantification of OEFs in Sections 2 to 5 can be improved significantly through the process identified above. Our bespoke methodology for calculating each OEF should and can be improved with further consultation with stakeholders, further data collection, and support from the AER. Furthermore, we believe that analogous to the approaches illustrated in Sections 2 to 5, a bespoke methodology can be developed for quantifying each of the OEFs in Section 6, which we are yet to assess in detail.

7.3 Need for further data collection

There are, at present, major gaps in the data required to quantify and adjust appropriately for the most material OEFs. Reliance on only the data presently available to the AER has two major disadvantages:

- Firstly, the data are limited in their scope and coverage, which in turn may limit considerably and unreasonably the OEFs that the AER can quantify. This could result in important OEFs being omitted from the analysis, or being adjusted for in an *ad hoc* fashion.
- Secondly, as the data currently available to the AER have not been tested thoroughly and corrected for errors, there can be little confidence that the data are reliable or reported consistently (e.g., if some DNSPs have misinterpreted

the data that should be reported).[28] If the data are of poor quality or are unreliable, the resulting OEF adjustments will not provide a true indication of the DNSPs' relative efficiencies.

In order to overcome and avoid these problems, we recommend that the AER work closely with DNSPs to identify the data required, and undertake a rigorous process of checking and improving the veracity of the data, before making OEF adjustments.

Further, we recommend that this data collection and auditing process be undertaken in a collaborative way between the AER and the industry. This would:

- Ensure better consistency of data, as all DNSPs develop a common understanding of the information the AER is seeking and the uses to which it will be put;
- Help the AER to identify early any potential inconsistencies in how data are being reported between DNSPs or over time; and
- Provide the AER with valuable opportunities to learn more about individual businesses and their operations, which would aid its regulatory determinations and its interpretation of the quantitative benchmarking analysis.

7.4 Need to re-consider how OEFs are applied

To date, prior to determining efficiency adjustments in regulatory proceedings, the AER has attempted to account for OEFs only *after* the raw efficiency scores of its benchmarking models have been estimated (i.e., the *ex-post* adjustment approach).

The key disadvantage of the *ex-post* approach is that the data to which the benchmarking model is applied is not made more comparable between DNSPs before the raw efficiency scores are estimated. As a result, the true relationship between the DNSPs' costs and cost drivers will be distorted by the inclusion of non-comparable opex data.[29] As a consequence the estimates of raw relative efficiency (including the efficiency of the comparison point) will be distorted. *Ex-post* adjustments for OEFs do not address the fact that the true cost relationship by the benchmarking model will have been mis-estimated by the inclusion of non-comparable data.

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[28] As discussed in Section **Error! Reference source not found.** of our February 2018 report, Sapere-Merz has expressed reservations about the quality and consistency of the data available to quantify some OEFs.

[29] Technically, the omission of relevant explanatory variables leads to inconsistent estimates of the coefficients of the model. As a result, the raw estimates of efficiency will also be biased.

In Section 3.2 of our February 2018 report, we described a number of alternative approaches that could be considered, which do not suffer from the weakness associated with the application of *ex-post* adjustments. These include the following.

- Including additional explanatory variables in the benchmarking model to control for differences in OEFs.
- Making *ex-ante* adjustments for OEFs to the data, before those data are applied to the benchmarking model.
- Making second-stage adjustments for OEFs after efficiency scores are estimated.

Our recommended approach for the AER is a combination of:

- Investigating the inclusion of some additional cost driver variables in its model, which should become more feasible over time as the sample size increases; and
- Making *ex-ante* adjustments for any costs associated with OEFs that are unexplained, or poorly explained, by the cost driver variables that are included in the model – as Ofgem does.

Second-stage adjustments could be considered as the next available option to account for any additional factors not accounted for through the combination of approaches above. In our view, all three of these approaches are superior to the AER/Sapere-Merz *ex-post* OEF approach.

7.5 Need to interpret benchmarking results with due caution

Finally, we note that even if the AER successfully undertakes a significant program of ongoing improvements to its approach to benchmarking and OEFs, along the lines we recommend, there will still be a need to treat its benchmarking results with appropriate caution. This is because it will never be possible to account perfectly for OEFs due to data and methodological limitations. However, this should not deter the AER from embarking on a program to improve significantly its existing approach to OEFs. It is clear to us that with cooperation between the AER, the DNSPs and other stakeholders, the usefulness of the AER's economic benchmarking analysis can be enhanced greatly.

8 Appendix A: Data provided by Essential Energy

We are advised that Essential Energy's asset management, network operations and financial systems are not fully integrated. In order to provide the data required for our targeted assessment of weather-related and fauna-related OEFs in Sections 3 and 4, respectively, we understand that Essential Energy has amalgamated a number of disparate datasets from different sources. Below is a brief description of Essential Energy's matching of data from different sources, which has been provided to us by Essential Energy. Further details in relation to this data can be provided by Essential Energy to the AER upon request.

Matching of costs to outages

- Data was obtained from three systems to enable matching of outages to costs:
  - Outage data was obtained from Essential Energy's reliability database which captures causes of outages as identified by field staff on site, or by system operators.
  - the Single Point of Contact (SPOC) officers called to engage resources to attend to an outage out of Essential Energy's Distribution Management System; and
  - timesheet data for employees booked to Fault and Emergency tasks out of Essential Energy's finance system.
- For each outage the 'home' depot of the outage was identified as follows
  - Fault and emergency project codes in the finance system are classified to the depot that would normally service that area. However, in fault and emergency situations, staff from different 'home' depots may attend outages in a different depot area. This means the nominal home depot list of employees cannot be used to match to the outage. A separate list of employees mapped to fault and emergency since 2013 was constructed listing the 'home' depot they worked in for outages.
  - The above list was mapped to the outages permitting a mapping between employees who worked in the area since 2013 and any outage.
- Using the above employee mapping, the cost data was mapped to outages as follows for different working times;
  - Ordinary Time: Essential Energy's finance system only captures total hours worked on fault and emergency during normal business hours against the 'home' depot fault and emergency project code. For example, an employee may record 4 hours of fault and emergency work during the day but it is not known what time they worked or on how many outages they worked.

- To match these costs, the 'home' depot of the outage and employees who worked in the 'home' depot for the date of the outage in normal business hours was used to match to the outages on that day. This matching on occasion would result in more than one outage being matched, in these cases the costs were averaged by the number of outages and allocated to the outages accordingly.
- Overtime: In the case of overtime, the start time (punch-in time) and finish time (punch-out time) is recorded in Essential Energy's financial system along with the 'home' depot via the project code. However, it is not known how many outages an employee may have attended in that time. In addition, there is a minimum call out rate of 2 hours paid to all employees[30]. To match these costs to outages, the 'home' depot and employees who worked in these depots were mapped to the outages using the punch-in time. If the punch-in time was between the start time of the outage and the end time of the outage, then the costs were mapped to the outage. For multiple outage hits the costs were averaged using the same method as used for ordinary time.
- Allowances: There are allowance payable on for on-call, or for leading hand, or for meals. These allowances are directly matched to the overtime costs noted above and the matching to outages is identical to the method used for overtime costs.

The match process did not provide costs for all outages, nor were all the costs obtained from the finance system mapped to outages. There are several reasons for this lack of matching. As an example not all outages require field staff attendance, they can be restored remotely.

Allocation of on-costs and overhead costs

The cost matching exercise discussed above was performed using unloaded nominal labour costs to which on costs and overheads need to be applied to reflect total costs incurred by Essential Energy.

On Costs

On costs reflect the costs associated with labour covering superannuation, annual leave, and other employee entitlements such as long service leave valued as mandated by NSW treasury. On cost rates are influenced by the prevailing bond rates during the fiscal year and the adjustments vary accordingly.

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[30] Essential Energy's 2017 Enterprise Agreement introduced a minimum call out pay from 4 hours to 2 hours. To reflect this change, the costs for fault and emergency overtime were recalculated to the 2 hour minimum call out such that the historical data set is reflective of current costs.

Labour On Cost Rates					
	2014	2015	2016	2017	Q3 Fcst 2018
Productive hours – Ordinary Time (%)	56.7%	58.8%	57.7%	48.6%	43.0%
Productive hours – Overtime (%)	10.1%	9.3%	8.6%	10.1%	6.1%

Overheads

Overheads cover the cost of corporate functions such as finance, HR, and management. They also include the costs associated with property, plant and equipment. Overheads are applied to all projects and cost elements in fault and emergency. For the purposes of estimation a low base overhead of 40%[31] was selected to be applied to ordinary time, overtime and allowances.

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[31] A 40% rate was selected as the lowest rate feasible for the historical data set and to also permit comparison across DNSP's using Essential Energy's costs as indicative of other DNSP's.

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