Annual Benchmarking Report

Electricity distribution network service providers

November 2021

AUSTRALIAN ENERGY REGULATOR

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Executive Summary

We report annually on the productivity growth and efficiency of distribution network service providers (DNSPs), individually and as an industry as a whole, in the National Electricity Market (NEM). These service providers operate transformers, poles and wires to deliver electricity from the transmission network to residential and business customers. Distribution network costs typically account for around one-third of what customers pay for their electricity in most jurisdictions (with the remainder covering generation costs, transmission and retailing, as well as regulatory programs).

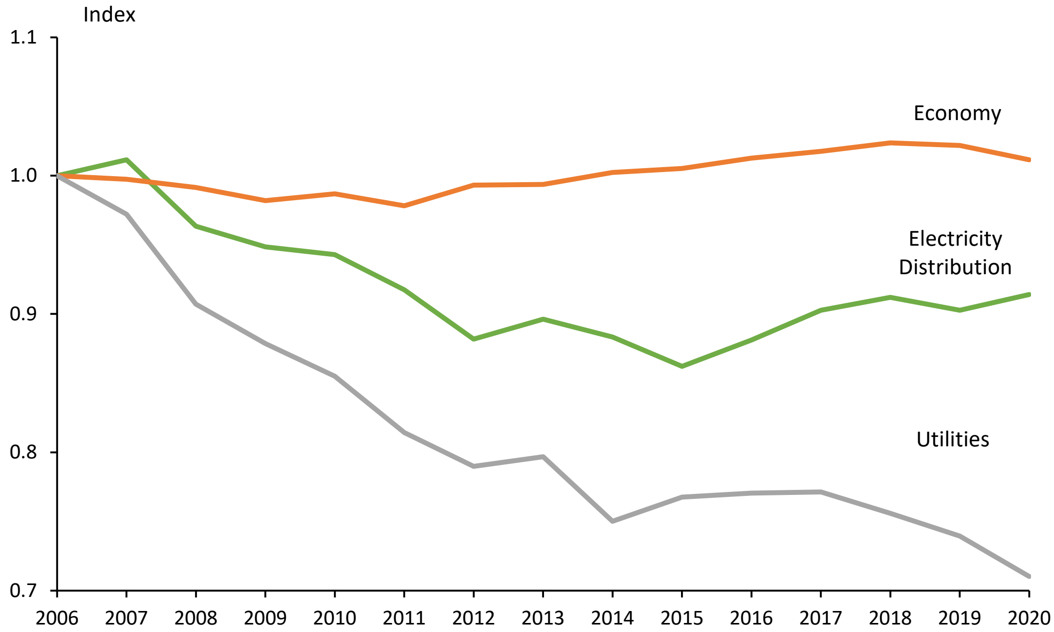
We use economic benchmarking to measure how productively efficient these networks are at delivering electricity distribution services over time and compared with their peers. Where distribution networks become more efficient, customers should benefit through downward pressure on network charges and customer bills. We draw on this analysis when setting the maximum revenues networks can recover from customers.

In preparing this benchmarking report, we have drawn on stakeholder views received through our consultation process.

Distribution network industry productivity has increased in 2020, in line with the general trend since 2015

Electricity distribution productivity as measured by total factor productivity (TFP) increased by 1.2% over 2020. This is consistent with the recent upward trend, which was interrupted by a 1.0% decline in 2019. The increase in distribution network productivity in 2020 is primarily due to reductions in operating expenditure (opex) by most DNSPs. The TFP increase is particularly noteworthy against the backdrop of TFP reductions in the broader utilities sector (electricity, gas, water and waste services (EGWWS)) (-4.0%) and the Australian market economy (-1.0%) over the same period.

Figure 1 Electricity distribution, utility sector, and economy productivity, 2006–20



Source: Economic Insights.

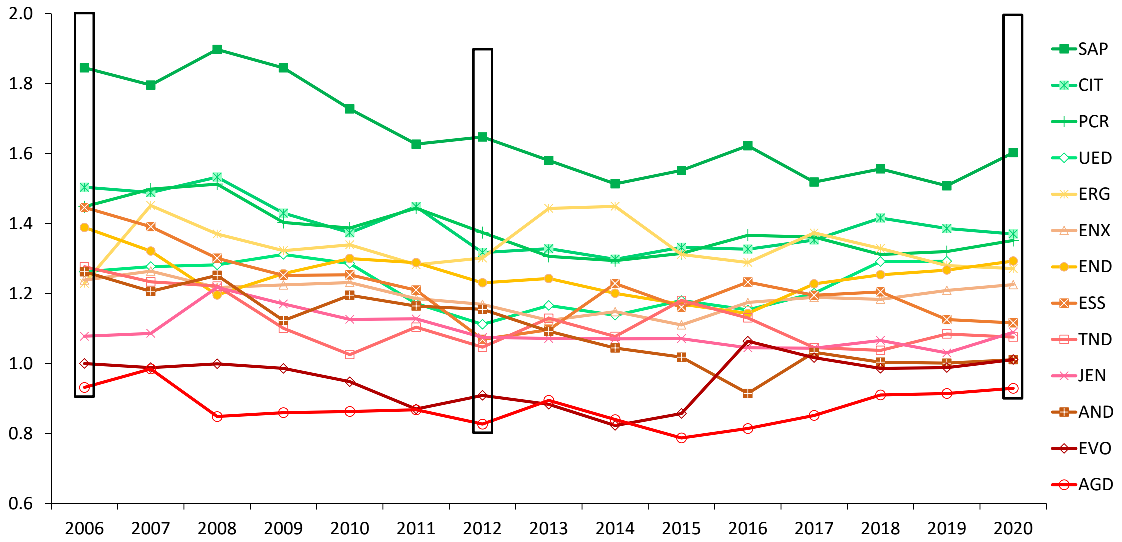
Changes in DNSP productivity over 2020

Over 2020, nine of the 13 DNSPs improved their productivity as measured by multilateral total factor productivity (MTFP).

Jemena and SA Power Networks increased their productivity as measured by MTFP the most, by 5.6% and 6.1% respectively. Powercor, Evoenergy and Endeavour Energy also had strong productivity increases of 2.0% or over. Ausgrid, Energex and AusNet increased their productivity by between 1 and 2%, and United Energy had a very slight productivity increase. Increased opex productivity reflecting lower opex was generally the main source of these productivity improvements.

Over the same period four DNSPs became less productive in terms of their MTFP results. CitiPower had the largest decrease in productivity as measured by MTFP of 1.1%, driven largely by reduced reliability and energy throughput. Three other DNSPs had a reduction in productivity of a similar, but slightly less magnitude: Essential Energy (-0.8%), Ergon Energy (-0.7%), and TasNetworks (-0.8%) experienced small decreases in productivity. Decreased opex productivity, reduced reliability and increased lines/transformers inputs were generally the main sources of the lower productivity of these DNSPs.

Figure 2 Electricity distribution MTFP indexes by DNSP, 2006–2020



Source: Economic Insights, AER analysis.

DNSP productivity levels have converged over time

Since 2006 there has been some convergence in the productivity levels of DNSPs as measured by MTFP. This can be seen from the three equal-sized black columns placed in 2006, 2012 and 2020 in Figure 2. This reflects a number of factors, including:

- Those DNSPs which have been the least productive over time have been improving their performance since 2012. In particular, Ausgrid and Evoenergy have increased their overall productivity, largely as a result of improvements in opex efficiency.

- Several middle-ranked DNSPs have also improved their relative MTFP performance to be closer to the top-ranked DNSPs. In recent years this includes United Energy, Endeavour Energy and Energex, again reflecting improved opex efficiency.
- Further, while Powercor, SA Power Networks and CitiPower have consistently been the most productive DNSPs in the NEM as measured by MTFP, they have also experienced a gradual overall decline in productivity since 2006. As a result, relatively their productivity is now much closer to the DNSPs that are middle-ranked, although SA Power Networks' MTFP rise in 2020 increased its gap to the rest of the DNSPs. This narrowing is primarily due to higher opex, including as a result of new regulatory obligations among other factors. However, since 2014 there has been an improvement in opex productivity for these three DNSPs.

Updates in this year's report

We operate an ongoing transparent program to review and incrementally refine elements of the benchmarking methodology and data. The benchmarking models presented in this report reflect three incremental revisions to the methodology we use to measure productivity. These relate to the methodologies used to calculate the opex price index, the reliability index and the annual user cost of capital.

We are also proposing to undertake further development work. This includes:

- The impact of differences in capitalisation on the benchmarking results and potential options for addressing these differences where material – we have released with this report a paper to commence an external consultation process
- Independently reviewing the non-reliability output weights used in the TFP / MTFP benchmarking – we expect to undertake this over the next 12 months
- Improving, where possible, the performance of the opex econometric cost function models and in particular the reliability performance of the Translog models – we expect work on this to be ongoing over the next 12 months
- Examining whether the model specifications used in the TFP / MTFP and opex econometric benchmarking remain appropriate with the increasing connection of distributed energy resources into the distribution system – we expect to commence consultation on this over the next 12 months.

Contents

1 Our benchmarking report

The National Electricity Rules (NER) require the AER to publish benchmarking results in an annual benchmarking report.[1] This is our eighth benchmarking report for distribution network service providers (DNSPs). This report is informed by expert advice provided by Economic Insights.[2]

National Electricity reporting requirement

6.27 Annual Benchmarking Report

(a) The AER must prepare and publish a network service provider performance report (an annual benchmarking report) the purpose of which is to describe, in reasonably plain language, the relative efficiency of each Distribution Network Service Provider in providing direct control services over a 12 month period

Productivity benchmarking is a quantitative or data driven approach used widely by governments and businesses around the world to measure how efficient firms are at producing outputs over time and compared with their peers.

Our benchmarking report considers the productive efficiency of DNSPs. DNSPs are productively efficient when they produce their goods and services at least possible cost given their operating environments and prevailing input prices. We examine the change in productivity in 2020, compared to 2019, and trends in productivity over the full period of our benchmarking analysis (2006–20).[3]

Our benchmarking report presents results from three types of 'top-down' benchmarking techniques.[4] Each technique uses a different method for relating outputs to inputs to measure and compare DNSP efficiency:

- **Productivity index numbers (PIN)**. These techniques use a mathematical index to measure the relationship between multiple outputs and inputs, enabling comparisons of measured productivity over time and between networks.
- **Econometric operating expenditure (opex) cost function models**. These

[1] NER, cll6.27(a) and 6.27(c).

[2] The supplementary Economic Insights report outlines the full set of results for this year's report, the data we use and our benchmarking techniques. It can be found on the AER's benchmarking website.

[3] Throughout this report references to calendar years for non-Victorian DNSPs refer to financial years (that is, 2020 refers to 2019–20 for non-Victorian DNSPs).

[4] Top-down techniques measure a network's efficiency based on high-level data aggregated to reflect a small number of key outputs and key inputs. They generally take into account any synergies and trade-offs that may exist between input components. Alternative bottom-up benchmarking techniques are much more resource intensive and typically examine very detailed data on a large number of input components. Bottom-up techniques generally do not take into account potential efficiency trade-offs between input components of a DNSP’s operations.

estimate opex (as the input) as a function of outputs and other operating environment factors to measure opex efficiency.

- **Partial performance indicators (PPIs)**. These simple ratio methods relate one input to one output.

Being top-down measures, each benchmarking technique cannot readily incorporate every possible exogenous factor that may affect a DNSP's performance. Therefore, the performance measures are reflective of, but do not precisely represent, the underlying efficiency of DNSPs. For this benchmarking report, our approach is to derive raw benchmarking results and where possible, explain drivers for the performance differences and changes. These include those operating environment factors (OEFs) that may not have been accounted for in the benchmarking modelling.

The PIN techniques we use in this report to measure the productivity performance of individual DNSPs in the NEM are multilateral total factor productivity (MTFP) and multilateral partial factor productivity (MPFP). The indexes allow comparisons of absolute levels and growth rates of the measured productivity. MTFP examines the overall productivity of using all inputs in producing all outputs. MPFP examines the productivity of either opex or capital in isolation. The econometric opex cost function models also examine the productivity of opex in isolation.

As discussed in section 2, the benchmarking report provides important information to stakeholders on the relative efficiency of the electricity networks they use, own and invest in. We make use of benchmarking results in our revenue determinations, where we must ensure that DNSP revenues reflect the efficient cost of provision. We use our top-down benchmarking tools, and other assessment techniques, to test whether DNSPs have been operating efficiently.

This is particularly relevant for examining the opex costs revealed in the most recent years prior to DNSPs' revenue determination processes. Where a DNSP is responsive to the financial incentives under the regulatory framework to make cost reductions, and retain the gains for a period (5 years), actual opex should provide a good estimate of the efficient costs required to operate in a safe and reliable manner and meet relevant regulatory obligations. The benchmarking analysis allows us to test this assumption. The results from the opex econometric cost function models are central in this assessment (as presented in section 5). Importantly, this needs to include consideration and quantification of OEFs that are not directly incorporated into the economic benchmarking models (as presented in section 7). We use the other benchmarking approaches to qualitatively cross-check and confirm the results from the econometric opex cost function models.

What is multilateral total factor productivity

Total factor productivity is a technique that measures the productivity of businesses over time by measuring the relationship between the inputs used and the outputs delivered. Where a business can deliver more outputs for a given level of inputs, this reflects an increase in its productivity. MTFP allows us to extend this to compare productivity levels between networks.

The inputs we measure for DNSPs are:

- Five types of physical capital assets DNSPs invest in to replace, upgrade or expand their networks.
- Opex to operate and maintain the network.

The outputs we measure for DNSPs (and the relative weighting we apply to each) are:

- Customer numbers. The number of customers is a driver of the services a DNSP must provide (about 19% weight).
- Circuit line length. Line length reflects the distances over which DNSPs deliver electricity to their customers (about 39% weight).
- Ratcheted maximum demand (RMD). DNSPs endeavour to meet the demand for energy from their customers when that demand is greatest. RMD recognises the highest maximum demand the DNSP has had to meet up to that point in the time period examined (about 34% weight).
- Energy delivered (MWh). Energy throughput is a measure of the amount of electricity that DNSPs deliver to their customers (about 9% weight).
- Reliability (Minutes off-supply). Reliability measures the extent to which networks can maintain a continuous supply of electricity (customer minutes off-supply enters as a negative output and is weighted by the value of consumer reliability).

The November 2014 Economic Insights report referenced in Appendix A details the rationale for the choice of these inputs and outputs. Economic Insights updated the weights applied to each output in November 2018 and again in November 2020. We also discuss the outputs and inputs used further in Appendix B.

Appendix A provides reference material about the development and application of our economic benchmarking techniques. Appendix B provides more information about the specific models we use and the data required. Our website also contains this year’s benchmarking report from our consultant Economic Insights and the benchmarking data and results.

1.1 Updates in this benchmarking report

This benchmarking report includes three relatively minor incremental updates to the benchmarking methodology relating to:

- *the opex price index* – as with past studies, an opex price index is calculated from published ABS price indexes that approximate components of electricity DNSP costs, and it is used to deflate nominal opex and derive real opex. As applied to individual DNSPs, the approach used in this report is consistent with the previously used approach, where the opex price index differs depending on whether the DNSP reports data in financial or calendar years.[5] For the industry as a whole, this report uses a weighted average regulatory (financial/calendar) year opex price index,[6] whereas previously the financial year opex price index was used for the industry.[7]
- *the reliability index (the value of customer reliability)* – consistent with previous studies, customer minutes off-supply is used as the measure of reliability and is a (negative) output. The weight given to this output depends on the cost of customer minutes off-supply in proportion to a DNSP's total revenue. The cost of customer minutes off-supply depends on the value of customer reliability per minute, which differs for each DNSP. For the industry as a whole, past practice has been to average the value of customer reliability of the DNSPs using customer numbers as weights, and multiply this by total customer minutes off-supply of all DNSPs to obtain the cost of customer minutes off-supply. In this report, we have used customer minutes off-supply as the weight, so that the cost of customer minutes off-supply is calculated as the sum of the cost of customer minutes off-supply for all DNSPs. In addition, in calculating the weight of the reliability output based on the value of customer reliability, we have recognised that the state-based value of customer reliability estimates published by the AER are the September 2019 value,[8] which are adjusted by CPI to the mid-point of each regulatory year of the DNSP.
- *annual user cost of capital (the return on and of capital)* (AUC), which is used to determine the cost (and hence cost shares) of the physical capital asset inputs noted above. We have updated the calculation of the weighted average cost of capital for 2020 to reflect the AER's Rate of Return Instrument 2018.[9] In previous years (2006–2019), the annual user cost of capital calculations broadly reflect the 2013 rate of return guideline.[10]

This report also includes a number of minor updates in the benchmarking data. These updates reflect minor refinements to the historical Australian DNSP dataset, consistent with previous years' benchmarking reports, and are set out in the consolidated

[5] Victorian DNSPs report on a calendar year basis, and all other NEM DNSPs report on a financial year (ending 30 June) basis.

[6] The weights attached to the financial and calendar being based on the opex quantities of each of the DNSPs.

[7] The weighted average opex price index is such that both the sum of all DNSPs' nominal opex equals industry nominal opex and the sum of all DNSPs' real opex equals industry real opex.

[8] AER, *Values of Customer Reliability: Final report on VCR values*, December 2019, p. 71, 88.

[9] AER, *Rate of return instrument*, December 2018, Table 1, column 3 (pages 13–16).

[10] AER, *Rate of return instrument*, December 2018, Table 1, column 2 (pages 13–16).

benchmarking dataset published on our website.[11]

1.2 Benchmarking development program

We seek to progressively review and incrementally refine elements of the benchmarking methodology and data. The aim of this work is to maintain and continually improve the reliability of the benchmarking results we publish and use in our network revenue determinations.

This year we have advanced our thinking around the implications of capitalisation differences, which we consider can be thought of as an OEF, on the benchmarking results. Along with this benchmarking report we have released a paper to commence an external consultation process in relation to these issues. We expect this process will form an input to the 2022 Annual Benchmarking Report.

This year we also considered, with Economic Insights, possible options for improving the performance of the Translog econometric opex cost function models. We discuss this issue and our progress further in section 8.1. We have also progressed our internal thinking in relation to an independent review of the non-reliability output weights used in the TFP / MTFP benchmarking and undertaken preliminary investigations about whether changes may be required to benchmarking to account for distributed energy resources. As set out below, this will enable us to progress these issues and where required engage externally over the next 12 months.

The key issues we consider require further examination and potential development, as informed by submissions we received from DNSPs and other stakeholders, are:

- independently reviewing the non-reliability output weights used in the TFP / MTFP benchmarking following the changes made in the 2020 Annual Benchmarking Report after the identification of an error – we expect to undertake this over the next 12 months
- improving, where possible, the performance of the opex econometric cost function models and specifically the reliability performance of the Translog models, particularly in relation to satisfying the key property that an increase in output can only be achieved with an increase in costs – we expect work on this to be ongoing over the next 12 months
- examining whether the model specifications used in the TFP / MTFP and opex econometric benchmarking remain appropriate with the increasing connection of distributed energy resources into the distribution system – we expect to commence consultation on this over the next 12 months.

In our 2020 benchmarking report we flagged our intention to independently review the non-reliability weights, to improve if possible the reliability performance of the Translog opex econometric cost function models and examine the model specifications given the

[11] Refinements are outlined in the 'Data revisions' sheet of the consolidated benchmarking data file.

increasing connection of distributed energy resources. We have made more limited progress than we would like in advancing these projects because the issues have proved more complex and resource intensive than anticipated. We will progress this work over the next 12 months.

Beyond this, in following years we will examine the choice of benchmarking comparison point when making our opex efficiency assessments and improving and updating the quantification of material OEFs. We will make other incremental improvements such as the way we measure the quantity of lines and cable inputs and considering whether GSL payments should be included in opex for benchmarking.

1.3 Consultation

In developing this report, we have undertaken consultation with external parties in two stages, consistent with the approach we adopted in 2020. This involved consultation in relation to the preliminary benchmarking results prepared by our consultant Economic Insights and then further consultation in relation to the AER's draft of this year's report.[12] We sought submissions from DNSPs and customer representative groups.

Across the consultation process, we received submissions representing ten of the 13 DNSPs, and one from Energy Networks Australia. The major focus of the submissions was on our benchmarking development. Stakeholders were generally supportive of our identified priorities for benchmarking development.[13] However, many respondents expressed concern at the limited progress we have made in recent years, and encouraged the AER to commit to a firmer timetable, including processes for industry consultation.[14] The lack of progress was a particular concern in the context of approaching revenue determinations for the DNSPs in NSW and the ACT. In terms of the specific issues raised by DNSPs, these included:

[12] Economic Insights' final report has addressed issues raised in submissions to the preliminary benchmarking results. For more details, see: Economics Insights, *Economic Benchmarking Results for the Australian Energy Regulator's 2021 DNSP Annual Benchmarking Report*, November 2021, section 1.4, pp. 5–9

[13] Jemena, *Submission on the AER's 2021 draft benchmarking report*, 27 October 2021, p. 1; Ausgrid, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; Evoenergy, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; SA Power Networks, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; Essential Energy, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; Energy Networks Australia, *Submission on the AER's 2021 draft benchmarking report*, 27 October 2021, p. 1.

[14] Ausgrid, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; CitiPower, Powercor, United Energy, *Submission on the AER's 2021 draft benchmarking report*, 27 October 2021, p. 1; AusNet Services, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; Energy Networks Australia, *Submission on the AER's 2021 draft benchmarking report*, 27 October 2021, p. 2; Essential Energy, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; SA Power Networks, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; Evoenergy, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1.

- that differences between DNSPs' cost allocation and capitalisation policies might affect the benchmarking results and should be examined[15]
- questions about the methodology used for deriving the output weights for the MTFP analysis,[16] including further support for our planned independent review of this methodology
- that it would be timely for the AER to reassess the suitability of the current benchmarking methodology, including in light of recent changes and current developments in the power system, e.g. treating distributed energy resource integration as an output[17]
- concerns about the performance of the opex econometric cost function models, in particular in relation to the reliability of the Translog models and how the efficiency scores from these models are reported and applied[18]
- questions about whether, in the AER's use of the output elasticities from the opex econometric models to derive the output weights that we use to calculate the weighted average overall forecast output growth in the context of forecasting opex, it should be using the average elasticities from the sample of Australian DNSPs or

[15] Jemena, *Submission on the AER's 2021 draft benchmarking report*, 27 October 2021, p. 1; Ausgrid, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; Evoenergy, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; SA Power Networks, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; Essential Energy, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; Energy Networks Australia, *Submission on the AER's 2021 draft benchmarking report*, 27 October 2021, p. 2; AusNet Services, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, pp. 1–2.

[16] Jemena, *Submission on the AER's 2021 draft benchmarking report*, 27 October 2021, p. 1; Ausgrid, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; Evoenergy, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; SA Power Networks, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 2; Essential Energy, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; Energy Networks Australia, *Submission on the AER's 2021 draft benchmarking report*, 27 October 2021, p. 1; AusNet Services, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 5; CitiPower, Powercor, United Energy, *Submission on the AER's 2021 draft benchmarking report*, 27 October 2021, p. 1.

[17] Ausgrid, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; Evoenergy, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; SA Power Networks, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 2; Essential Energy, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 2; Energy Networks Australia, *Submission on the AER's 2021 draft benchmarking report*, 27 October 2021, p. 2; AusNet Services, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 4.

[18] Jemena, *Submission on the AER's 2021 draft benchmarking report*, 27 October 2021, pp. 1–3; Ausgrid, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, pp. 1–2; Evoenergy, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; Essential Energy, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1.

using the three-country sample[19]

- further identification and quantification of OEFs,[20] and for our present report to provide further qualification/explanation of the results presented prior to adjustment for a range of material OEFs, including the impact of capitalisation[21]
- suggestions and questions around some of the data and inputs to the benchmarking, including the need to improve the consistency of measures of capacity of lines and cables across DNSPs,[22] that GSL scheme payments should be excluded from opex[23] and that the labour proportion of opex used in deriving the opex price index should use more current data.[24]

We respond to these issues in section 8.

[19] Evoenergy, Response to AER - Preliminary 2021 benchmarking results consultation - stage 1, email received on 17 September 2021.

[20] Evoenergy, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; Essential Energy, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; Energy Networks Australia, *Submission on the AER's 2021 draft benchmarking report*, 27 October 2021, p. 2; AusNet Services, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, pp. 2–3.

[21] AusNet Services, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, pp. 2–4.

[22] Evoenergy, *Response to AER - Preliminary 2021 benchmarking results consultation - stage 1*, email received on 17 September 2021.

[23] SA Power Networks, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; AusNet Services, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 3.

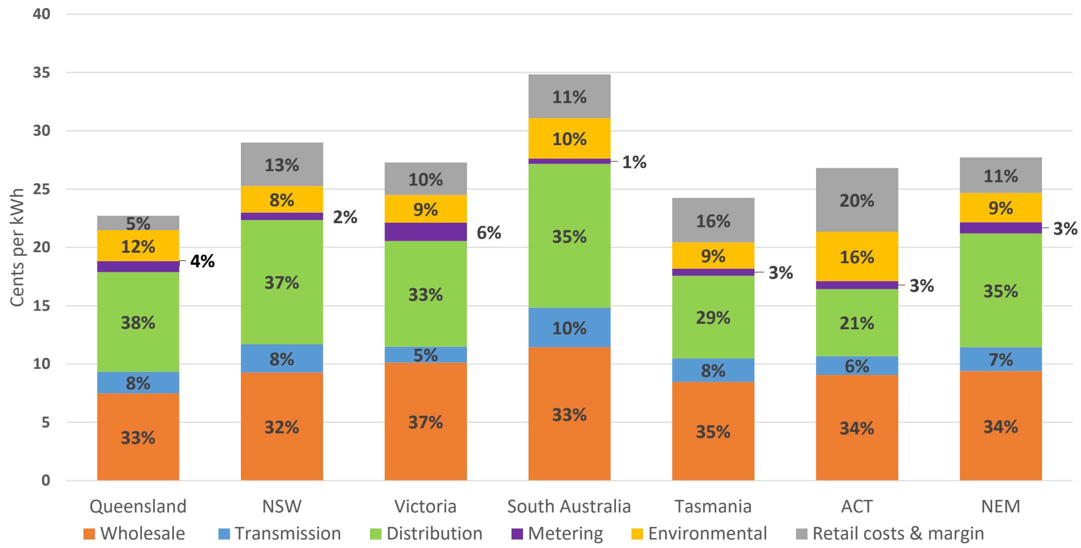
[24] Jemena, *Submission on the AER's 2021 draft benchmarking report*, 27 October 2021, p. 3.

2 Why we benchmark electricity networks

Electricity networks are 'natural monopolies' that do not face the typical commercial pressures experienced by businesses in competitive markets. They do not need to consider how and whether rivals will respond to their prices. Without appropriate regulation, network operators could increase their prices above efficient levels and would face limited pressure to control their operating costs or invest efficiently.

Consumers pay for electricity network costs through their retail electricity bills. Distribution network costs typically account for around one-third of what consumers pay for their electricity in most jurisdictions. The remainder covers the costs of generating, transmitting and retailing electricity, as well as various regulatory programs. Figure 3 provides an overview of the typical electricity retail bill.

Figure 3 Network costs as a proportion of retail electricity bills, 2020



Source: AEMC, *Residential Electricity Price Trends 2020,* Final report, December 2020

Note: Figures may differ slightly from source due to rounding.

Under the National Electricity Law (NEL) and the NER, the AER regulates electricity network revenues with the goal of ensuring that consumers pay no more than necessary for the safe and reliable delivery of electricity services. Because network costs account for such a high proportion of consumers' electricity bills, AER revenue determinations have a significant impact on consumers.

The AER determines the revenues that an efficient and prudent network business require at the start of each five-year regulatory period. The AER determines network revenues through a 'propose-respond' framework.[25] Network businesses propose the costs they believe they need during the regulatory control period to provide safe and reliable electricity and meet predicted demand. The AER responds to the networks' proposals by assessing, and where necessary, amending them to reflect 'efficient' costs.

The NER requires the AER to have regard to network benchmarking results when assessing and amending network capital expenditure (capex) and opex, and to publish the benchmarking results in this annual benchmarking report.[26] The AEMC added these requirements to the NER in 2012 to:

- reduce inefficient capex and opex so that electricity consumers would not pay more than necessary for reliable energy supplies, and
- to provide consumers with useful information about the relative performance of their electricity Network Service Provider (NSP) to help them participate in regulatory determinations and other interactions with their NSP.[27]

Economic benchmarking gives us an important source of information on the efficiency of historical network expenditures (opex and capex) and the appropriateness of using them in forecasts. We also use benchmarking to understand the drivers of trends in network efficiency over time and changes in these trends. This can help us understand why network productivity is increasing or decreasing and where best to target our expenditure reviews.[28] As discussed in section 1, this is particularly relevant for examining the opex costs revealed in the most recent years prior to DNSPs' revenue determination processes.

The benchmarking results also provide network owners and investors with useful information on the relative efficiency of the electricity networks they own and invest in. This information, in conjunction with the financial rewards available to businesses under the regulatory framework, and business profit-maximising incentives, can facilitate reforms to improve network efficiency that can lead to lower network costs and retail prices.

Benchmarking also provides government policy makers (who set regulatory standards and obligations for networks) with information about the impacts of regulation on network costs, productivity and ultimately electricity prices. Additionally, benchmarking can provide information that may contribute to the assessment of the success of the

[25] The AER assesses the expenditure proposal in accordance with the Expenditure Forecast Assessment Guideline which describes the process, techniques and associated data requirements for our approach to setting efficient expenditure forecasts for network businesses, including how the AER assesses a network business's revenue proposal and determines a substitute forecast when required. See: https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/expenditure-forecast-assessment-guideline-2013.

[26] NER, cll. 6.27(a), 6.5.6(e)(4) and 6.5.7(e)(4).

[27] AEMC, Rule Determination, *National Electricity Amendment (Economic Regulation of Network Service Providers) Rule 2012; National Gas Amendment (Price and Revenue Regulation of Gas Services) Rule 2012*, 29 November 2012, p. viii.

[28] AER, *Explanatory Statement Expenditure Forecast Assessment Guideline,* November 2013, pp. 78–79.

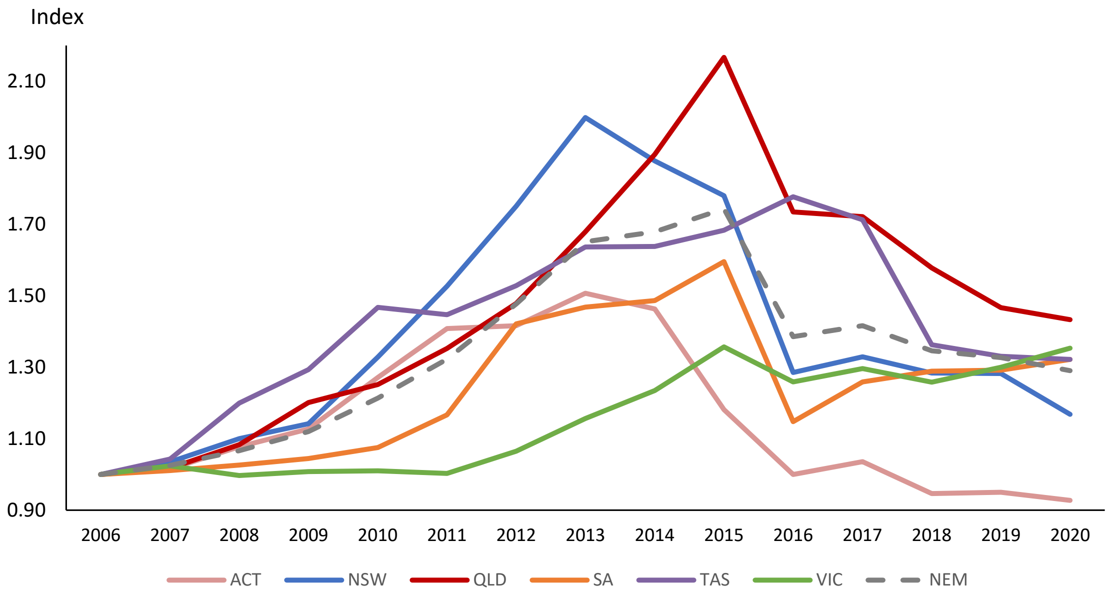
regulatory regime over time.

Finally, benchmarking provides consumers with accessible information about the relative efficiency of the electricity networks they rely on. The breakdown of inputs and outputs driving network productivity allow consumers to better understand what factors are driving network efficiency and network charges that contribute to their energy bill. This helps to inform their participation in our regulatory processes and broader debates about energy policy and regulation.

Since 2014, the AER has used benchmarking in various ways to inform our assessments of network expenditure proposals. Our economic benchmarking analysis has been one contributor to the reductions in network costs and revenues for DNSPs and the retail prices faced by consumers.

Figure 4 shows that distribution network revenues (and consequently network charges paid by consumers) have fallen in all jurisdictions in the NEM since 2015. This reversed the increase seen across the NEM over 2007 to 2013, which contributed to the large increases in retail electricity prices.[29] This highlights the potential impact on retail electricity charges of decreases in network revenues flowing from AER network revenue determinations, including those informed by benchmarking.

Figure 4 Indexes of distribution network revenues by jurisdiction, 2006–20



Source: Economic Benchmarking RIN; AER analysis.

[29] AER, *State of the Energy Market,* 2018, p. 151.

3 The productivity of the electricity distribution industry as a whole

Key points

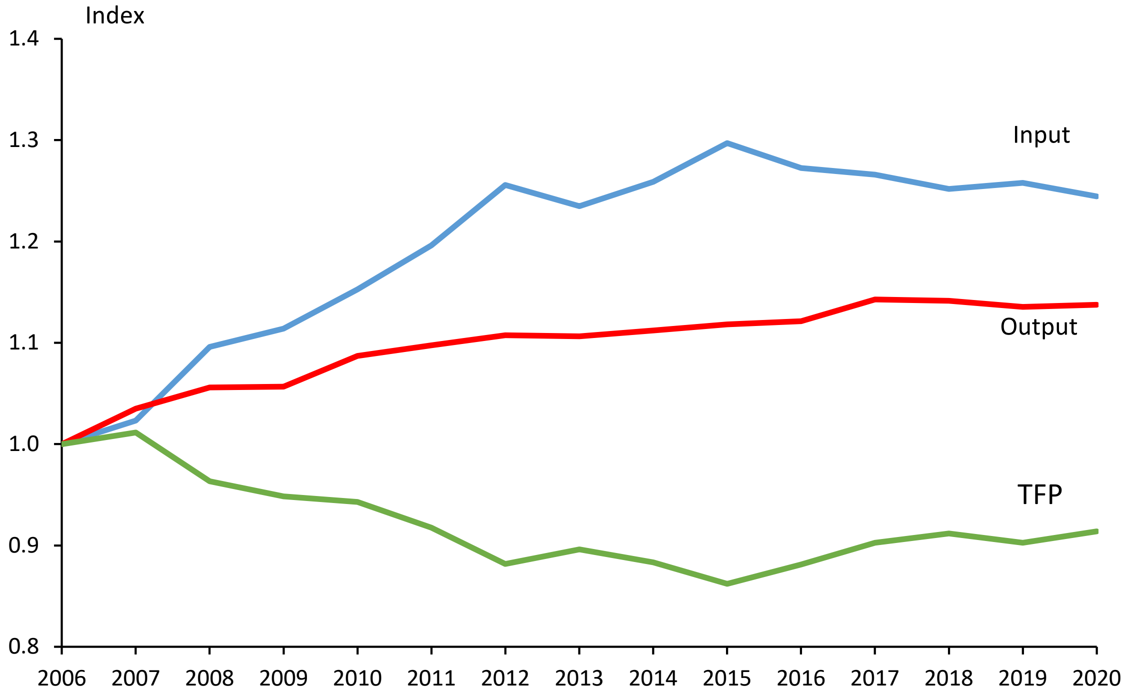
- Productivity in the electricity distribution industry, measured by MTFP, increased by 1.2% in 2020. This was largely driven by ongoing and significant reductions in opex (contributing +1.8 percentage points to TFP growth), with no other input or output individually having a notable impact, but collectively contributing a net negative 0.6%.
- This continues the generally upward trend since 2015 (+1.2% annual average growth), reversing the reduction of 1.0% seen in 2019.
- Distribution sector productivity increased in 2020, while there were reductions in the utilities sector (-4.0%) more broadly and the overall Australian market economy (-1.0%).
- Distribution industry TFP has decreased slightly over the period 2006–20, with the long-term decline in capital partial factor productivity driving this result.

This chapter presents TFP results at the electricity distribution industry level over the 2006–20 period and specifically for the 12-month period of regulatory year 2020. This is our starting point for examining the relative productivity and efficiency of individual DNSPs.

Industry-wide productivity increased by 1.2% in 2020. The result was largely driven by ongoing and significant reductions in opex (contributing +1.8 percentage points to TFP growth), with no other input or output individually having a notable impact, but collectively contributing a net negative 0.6 percentage points. As indicated in Figure 5, this continues the generally upward trend in distribution industry productivity since 2015 (+1.2% annual average growth), reversing the reduction of 1.0% seen in 2019.

Figure 5 also shows that over the 2006–20 period, TFP for the electricity distribution industry declined, by 0.6% per annum on average. Over this 15-year period, input use grew faster (1.6% per year on average) than outputs (0.9% per year on average).

Figure 5 Industry-level distribution input, output and TFP indices, 2006–20

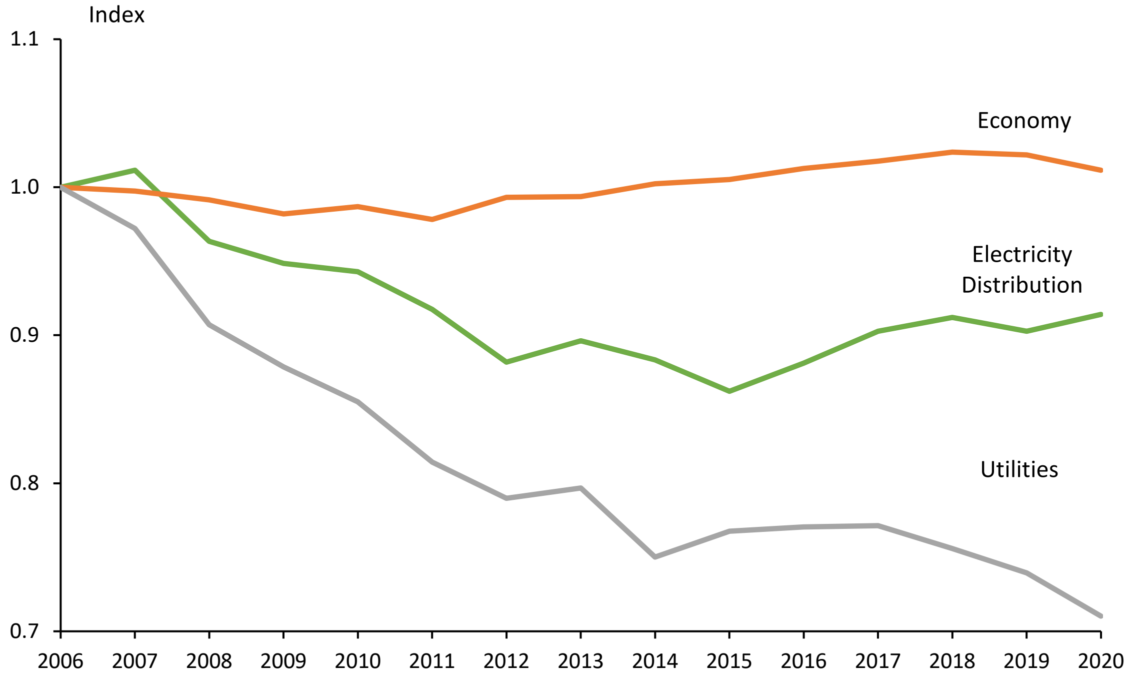


Source: Economic Insights.

Figure 6 compares the TFP of the electricity distribution industry over time relative to estimates of the overall Australian economy and utilities sector.[30] Distribution industry productivity increased in 2020, while there were reductions in the utilities sector (-4.0%) more broadly as well as the Australian market economy (-1.0%). Growth in electricity distribution productivity has been larger on average than that of both the Australian economy and the utilities sector since 2015.

[30] Electricity, gas, water and waste services (EGWWS).

Figure 6 Electricity distribution and economy productivity indices, 2006–20

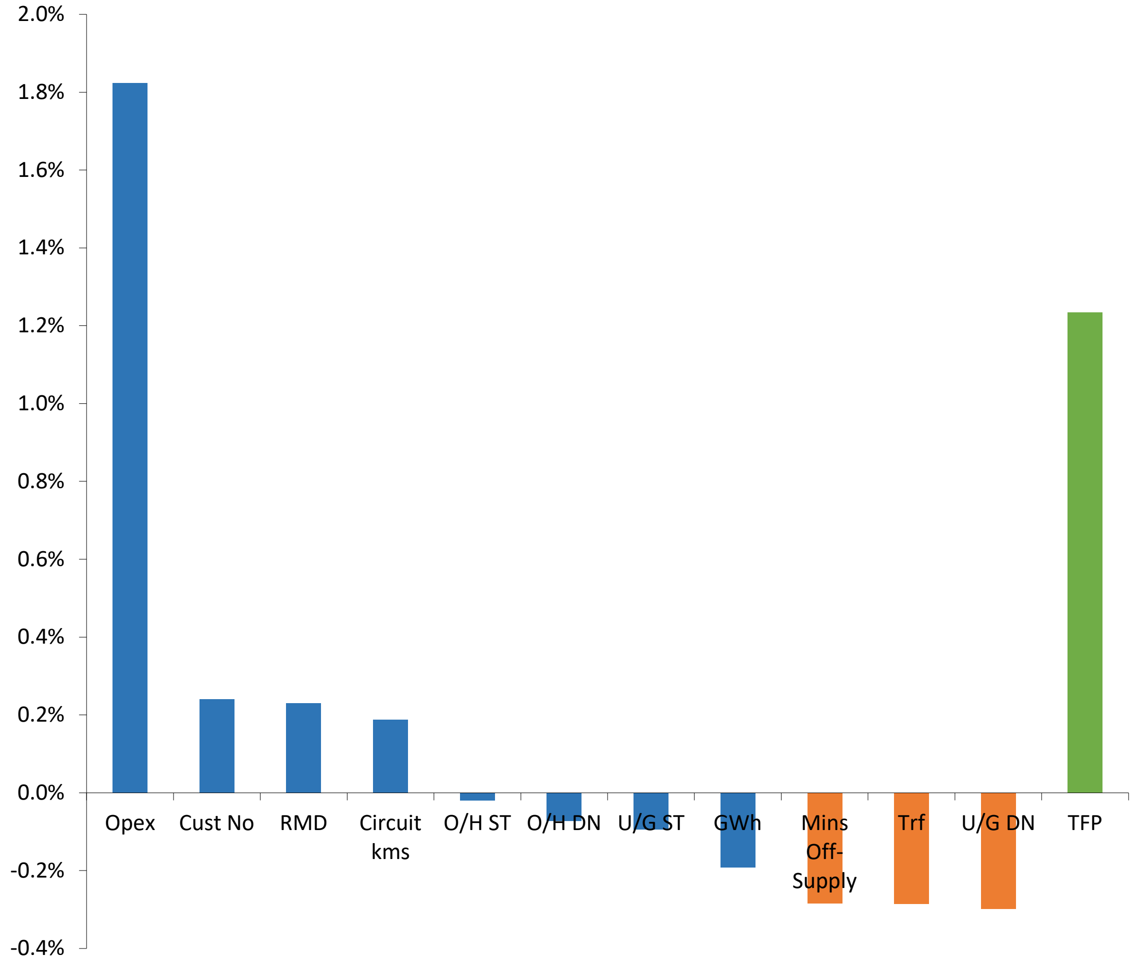


Source: Economic Insights; Australian Bureau of Statistics.

Note: The productivity of the Australian economy and the EGWWS industry is from the ABS indices within 5260.0.55.002 Estimates of Industry Multifactor Productivity, Australia, Table 1: Gross value added based multifactor productivity indexes (a). We have rebased the ABS indices to one in 2006.

Figure 7 helps us understand the drivers of change in electricity distribution productivity over the past 12 months by showing the contributions of each output and each input to the average annual rate of change in TFP in 2020. Outputs consist of customer numbers, circuit length, ratcheted maximum demand, energy throughput and reliability (minutes off-supply), with an increase in output increasing TFP, all else equal. Inputs consist of opex and capital (for example, the length and capacity of overhead distribution lines), with an increase in inputs decreasing TFP, all else equal. Figure 7 shows that the increase in electricity distribution productivity in 2020 was primarily driven by decreases in opex (contributing +1.8 percentage points to TFP growth), with no other input or output individually having a notable impact, but collectively contributing a net negative 0.6 percentage points.

Figure 7 Electricity distribution output and input percentage point contributions to average annual TFP change, 2020



Source: Economic Insights.

Note: The inputs and outputs in this chart are minutes off-supply (mins off-supply), operating expenditure (opex), customer numbers (cust no), ratcheted maximum demand (RMD), circuit line length (circuit kms), overhead distribution lines (O/H DN), energy delivered (GWh), underground sub-transmission cables (U/G ST), overhead sub-transmission lines (O/H ST), transformers (Trf), underground distribution cables (U/G DN).

Opex reductions also played the largest role in driving electricity distribution productivity over the 2012–20 period, contributing 1.0 percentage points on average to the average annual electricity distribution productivity change of 0.45%.[31] The drivers of TFP change in 2020 and in the 2012-20 period are otherwise relatively similar.

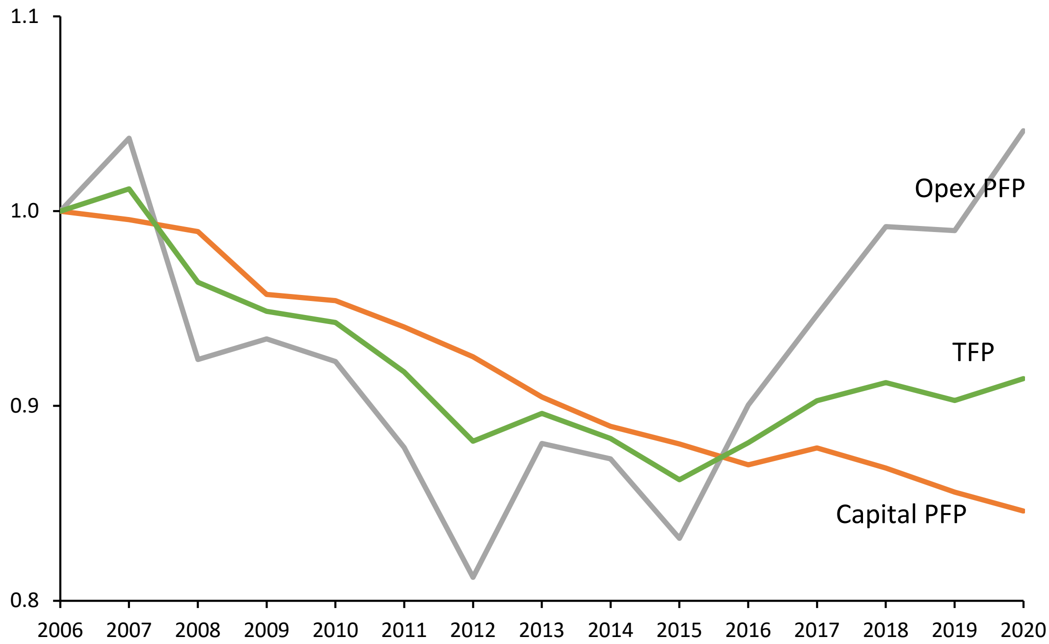
Figure 8 displays TFP, opex PFP and capital PFP in the electricity distribution industry from 2006 to 2020. Consistent with the above observations, since 2012, opex has been the most significant contributor to TFP growth, with opex partial factor productivity increasing on average by 3.1 per cent each year. However, capital PFP has declined

[31] Economic Insights, *Economic Benchmarking Results for the Australian Energy Regulator's 2021 DNSP Annual Benchmarking Report*, November 2021, p. 18.

consistently over time, largely due to network inputs (particularly transformers and underground cables) growing at a faster pace than key outputs such as customers and ratcheted maximum demand as well as energy throughput which slightly fell. We can also see in Figure 8 that, despite reductions in capital PFP in 2020, opex PFP more than offset this decline, leading to growth in TFP. The steadier nature of the trend in capital PFP might be expected given that the capital inputs used in the model are a stock (not a flow) and the largely sunk and long-lived nature of DNSP capital assets. We also note that our outputs may not be fully capturing all of the outputs provided by DNSPs, such as the increasingly prevalent distributed energy resources. We discuss our considerations on incorporating distributed energy resources into the benchmarking outputs in section 8.

While it appears Covid-19 had an impact on some DNSPs in terms of opex and patterns of energy throughput (discussed in section 4.2), the net impact on industry productivity growth in 2020 appears to have been relatively muted.[32] This also reflects capital stock is used as an input in our benchmarking, rather than capex, so any reductions to capex in 2020 as a result of Covid-19 would not have had a material impact.

Figure 8 Electricity distribution, total capital and opex productivity, 2006–20



Source: Economic Insights.

[32] Also see AER, *2021 Electricity Network Performance Report*, September 2021, Section 4, pp. 31–45.

4 The relative productivity of distribution network service providers

Key points

Nine DNSPs became more productive in 2020 as reflected by their MTFP results:

- Jemena (5.6%) and SA Power Networks (6.1%) increased their productivity the most.
- Powercor, Evoenergy and Endeavour Energy also increased their productivity by over 2.0%
- Ausgrid, Energex and AusNet increased their MTFP in 2020 by between 1 and 2% and United Energy had a very slight productivity increase.
- Increased opex partial factor productivity as a result of opex reductions was generally the main driver of increased productivity for these DNSPs.

Four DNSPs became less productive in 2020 as reflected by their MTFP results:

- Essential Energy (-0.8%), Ergon Energy (-0.7%), TasNetworks (-0.8%) and CitiPower (-1.1%) experienced small decreases in productivity.
- Increasing opex and lines/transformers inputs and deteriorating reliability were generally the main drivers of decreased productivity for these DNSPs.
- SA Power Networks, CitiPower and Powercor have consistently been amongst the most productive distributors in the NEM since 2006, although their productivity declined between 2006 and 2020. Endeavour Energy and United Energy have both shown strong increases in productivity since 2016 and became two of the more productive distributors in 2020.
- South Australia had the highest distribution total productivity ranking, as measured by MTFP, in 2020 and over the period 2006 to 2020. In 2020 Queensland was ranked second, followed by NSW, Victoria and Tasmania. Distribution productivity in the ACT was the lowest ranked of the states in 2020.
- The results from the MTFP models do not include the impact of all material OEFs. It is desirable to take into account operating environment conditions not included in the benchmarking models that can affect the benchmarking results. Our benchmarking report includes information about the most material OEFs driving apparent differences in estimated productivity and operating efficiency between the distribution networks in the NEM. These are set out in section 7.

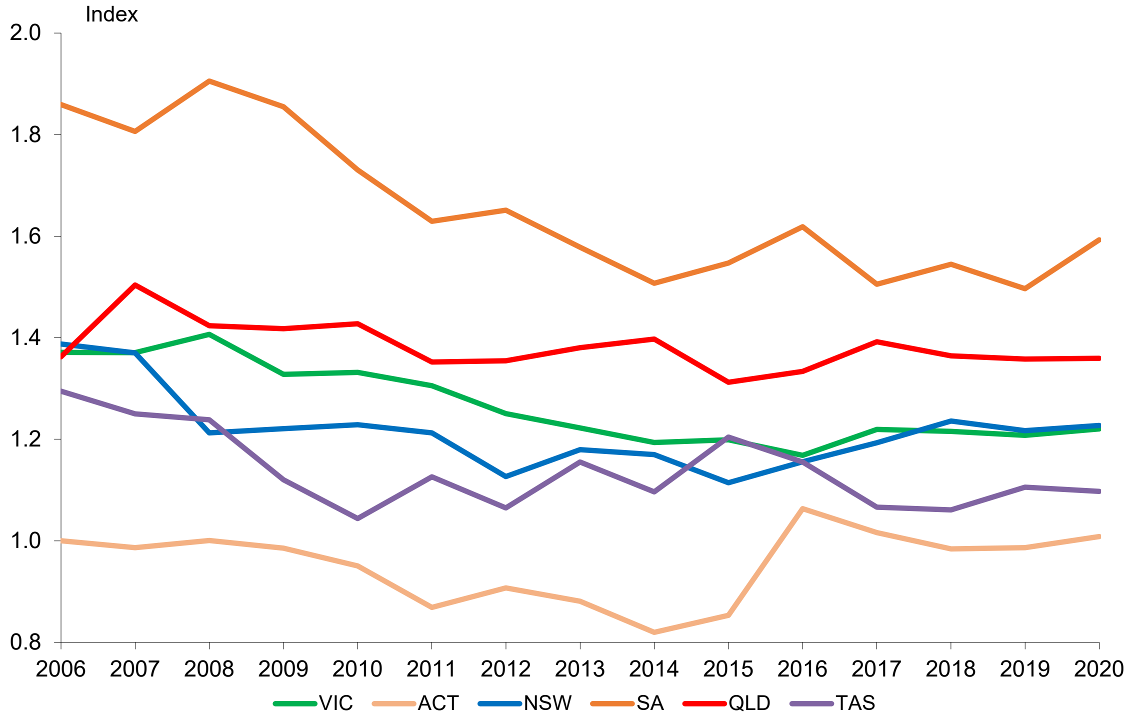
This section presents economic benchmarking results as measured by MTFP (and opex and capex MPFP) at a state and DNSP level and provides our key observations on the reasons for changes in relative productivity of each DNSP in the NEM.

4.1 MTFP productivity results for DNSPs

The MTFP technique allows us to measure and compare the relative total factor productivity of states and individual DNSPs. This is supported by the corresponding partial productivity measures of opex and capital inputs.

Figure 9 presents the relative distribution productivity levels and rankings by state, as measured by MTFP over the period 2006 to 2020. This shows that South Australia is the most productive state in the NEM in both 2020 and over the period 2006 to 2020, although its productivity has declined over this timeframe. In 2020, the next most productive state is Queensland, followed by NSW and Victoria on around the same level. Tasmania[33] is next, with the ACT's distribution total productivity level the lowest of the states in the NEM in 2020, which also reflects its general performance over the period 2006 to 2020. The ACT is the only state/territory that has a higher productivity level in 2020 than in 2006, but only marginally (0.1%). Queensland's productivity in 2020 is slightly lower than in 2006, although it is essentially at the same level.

Figure 9 Electricity distribution MTFP levels by state, 2006–20



[33] TasNetworks could be considered an outlier compared to its peers in terms of system structure. Compared to other DNSPs, TasNetworks operates substantially less high voltage sub-transmission assets and has a comparatively high proportion of lower voltage lines. This disadvantages TasNetworks' MTFP ranking because low voltage assets generally receive the highest capital input weighting under our benchmarking models. Economic Insights advises that some caution is required in interpreting TasNetworks' MTFP score given its comparatively unusual system structure (see Economic Insights, *Memorandum – DNSP MTFP and Opex Cost Function Results*, 13 November 2015, p. 4).

Source: Economic Insights, AER analysis.

Note: These results do not reflect the impact of a range of material OEFs (see section 7).

The remainder of this section examines the relative productivity of individual DNSPs in the NEM. Table 1 presents the MTFP rankings for individual DNSPs in 2020 and 2019, the annual growth in productivity as measured by MTFP in 2020 (column four) and the average annual growth in the 2006–20 and 2012–20 periods (columns five and six).

Table 1 Individual DNSP MTFP rankings and growth rates

DNSP	2020 Rank	2019 Rank	Change (2020)	Change (2006—2020)	Change (2012–2020)
SAP	1	1	6.1%	-1.0%	-0.3%
CIT	2	2	-1.1%	-0.7%	0.5%
PCR	3	3	2.4%	-0.5%	-0.2%
END	4↑	6	2.0%	-0.5%	0.6%
UED	5↓	4	0.0%	0.2%	1.9%
ERG	6↓	5	-0.7%	0.2%	-0.3%
ENX	7	7	1.3%	-0.1%	0.6%
ESS	8	8	-0.8%	-1.8%	0.5%
JEN	9↑	10	5.6%	0.1%	0.2%
TND	10↓	9	-0.8%	-1.2%	0.3%
EVO	11↑	12	2.3%	0.1%	1.3%
AND	12↓	11	1.0%	-1.6%	-1.7%
AGD	13	13	1.6%	0.0%	1.5%

Source: Economic Insights, AER analysis.

Note: All scores are calibrated relative to the 2006 Evoenergy score which is set equal to one. These results do not reflect the impact of a range of material OEFs (see section 7).

We observe relatively minimal change in the rankings, with Endeavour Energy being the only DNSP to change its ranking by more than one place in 2020 (rising two places to 4th). We also note the significant improvements in productivity level in 2020 by SA Power Networks and Jemena. Increasing opex productivity reflecting lower opex was the main driver of these results.

Figure 10 presents MTFP results for each DNSP from 2006 to 2020.

In addition to MTFP, we also present the results of two MPFP indexes:

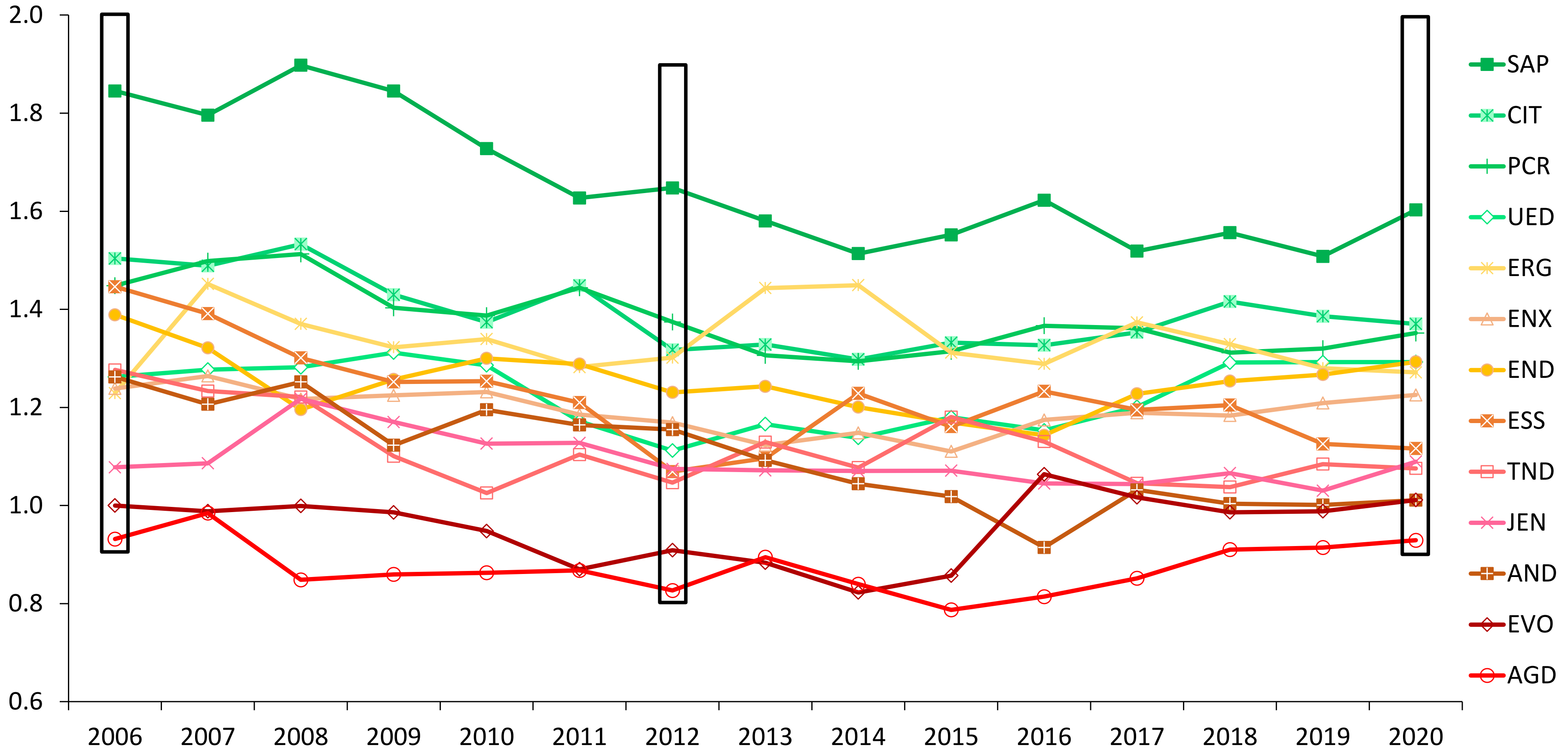
- Opex MPFP is shown in Figure 11. This considers the productivity of the DNSPs' opex.
- Capital MPFP is shown in Figure 12. This considers the productivity of the DNSPs' use of capital inputs, namely overhead lines and underground cables (each split into distribution and sub-transmission components) and transformers.

These partial approaches assist in interpreting the MTFP results by examining the contribution of capital assets and opex to overall productivity. They use the same output specification as MTFP but provide detail about the contribution of the individual components of capital and opex to changes in productivity. However, we note these results do not account for synergies between capital and opex like the MTFP analysis.

Being top-down analysis, these results are only indicative of the DNSPs' relative performance. Importantly, while the analysis accounts for some factors that are beyond a DNSP's control, such as the impact of network density and some system structure factors, additional OEFs can affect a DNSP's costs and benchmarking performance. The differences in MTFP across DNSPs or over time may reflect changes in the OEFs not accounted for in the modelling. Section 7 provides more information about some of these additional factors.

Our observations about these MTFP and MPFP results are discussed in section 4.2.

Figure 10 MTFP indexes by individual DNSP, 2006–20



Source: Economic Insights; AER analysis. Note: These results do not reflect the impact of a range of material OEFs (see Section 7).

Figure 11 DNSP opex multilateral partial factor productivity indexes, 2006–20

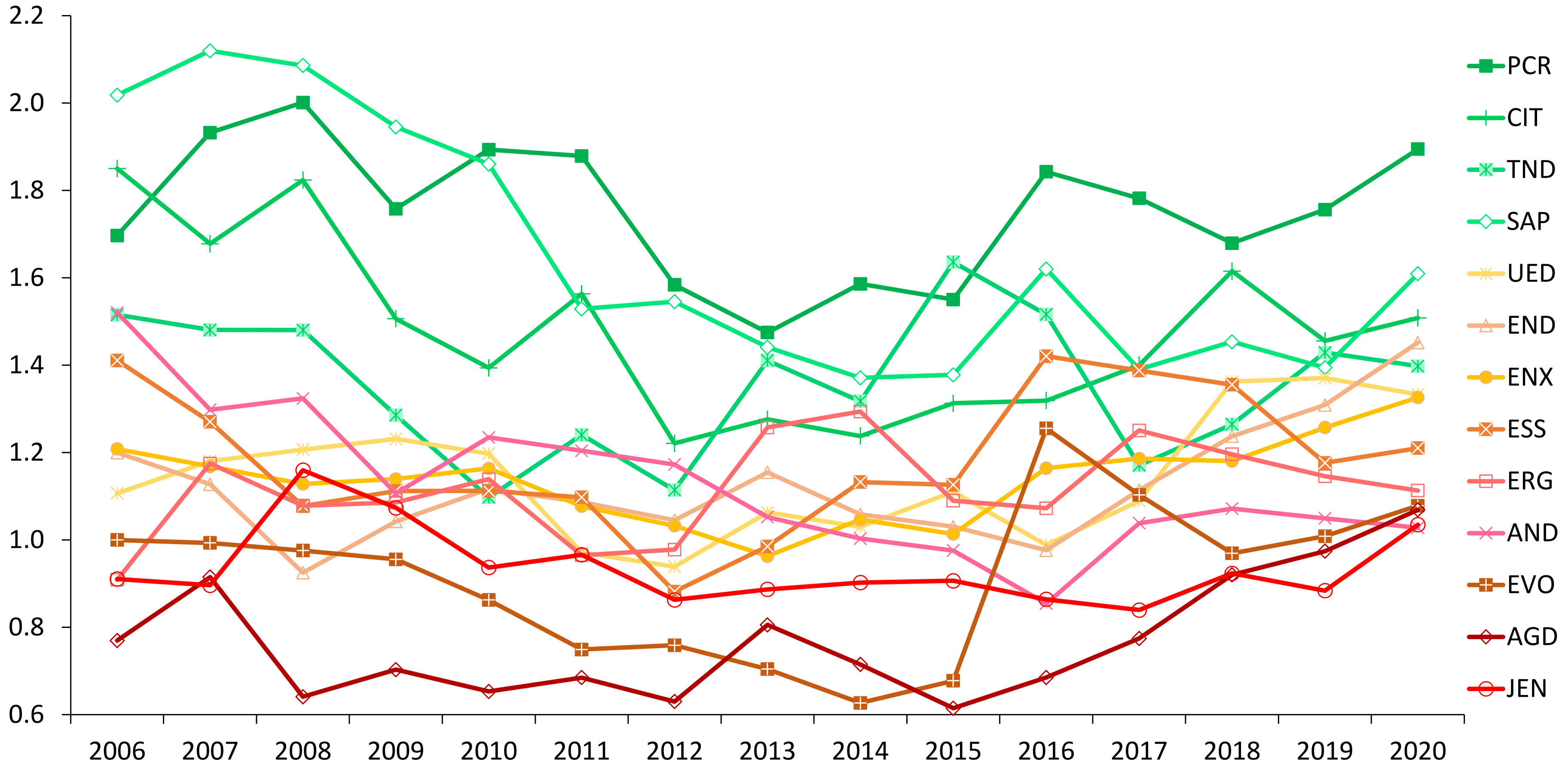
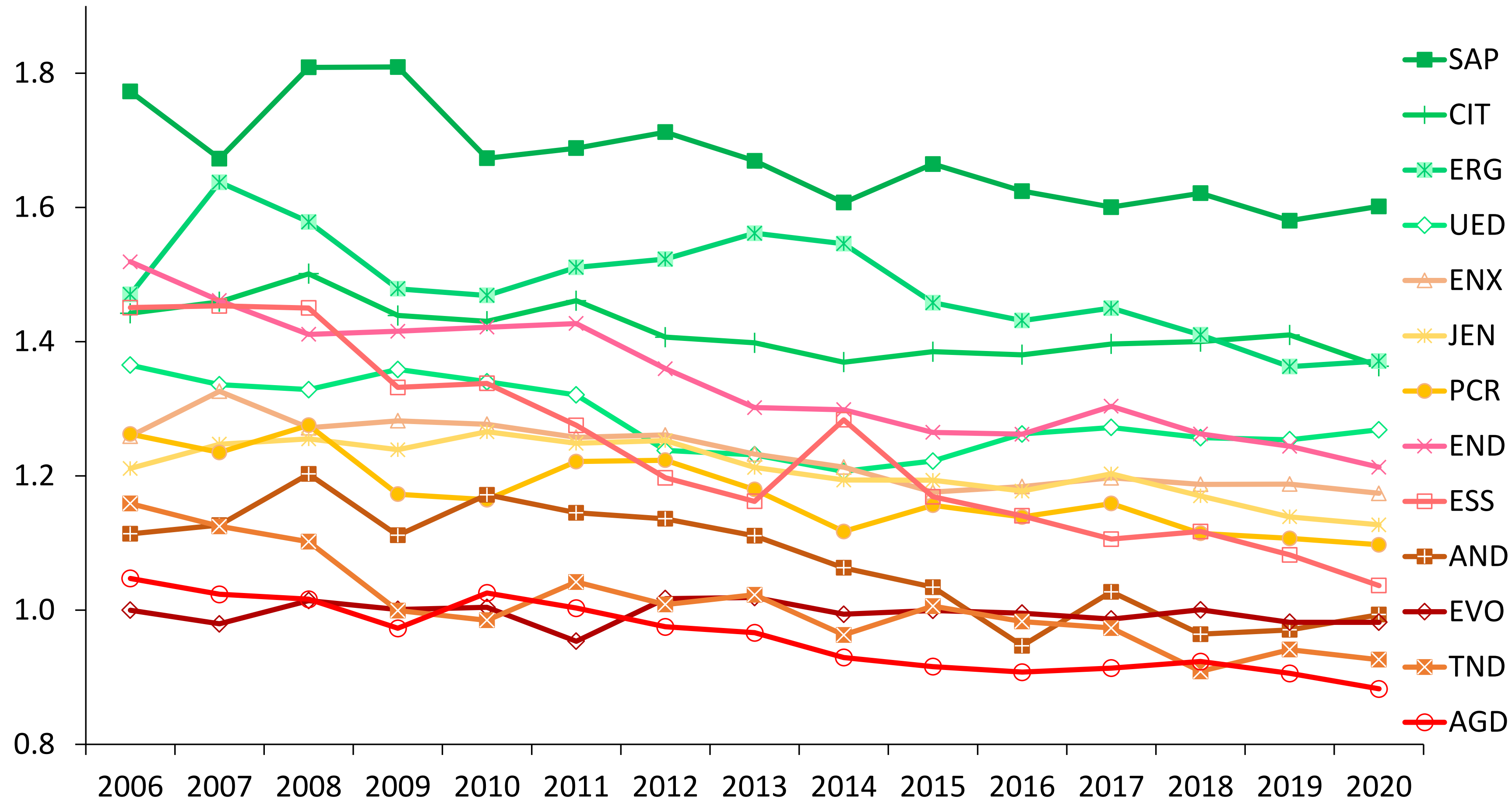


Figure 12 DNSP capital multilateral partial factor productivity indexes, 2006–20



4.2 Key observations about changes in productivity

This section describes some of our key observations about changes in the relative productivity of businesses both for 2020 and recent years, based on the MTFP and MPFP results presented above.

4.2.1 Significant changes in productivity in 2020

Nine DNSPs became more productive in 2020

As can be seen in Figure 10, nine of the 13 DNSPs became more productive in 2020 as reflected by their MTFP results. SA Power Networks and Jemena increased their productivity by 6.1 and 5.6% respectively in 2020, which were the largest increases among the DNSPs in the NEM. Powercor, Evoenergy and Endeavour Energy also had strong productivity increases of over 2.0%. Increasing opex productivity reflecting lower opex was the main driver of these results for these distributors.[34] Ausgrid, Energex and AusNet also increased their productivity, by between 1 and 2%. Again, increasing opex productivity reflecting reductions in opex was generally a key driver for these results, other than for AusNet whose productivity improvements were driven by ratcheted maximum demand growth despite increases in opex.[35] United Energy had a very slight productivity increase in 2020.

Of the DNSPs which had increases in MTFP in 2020, Jemena's and SA Power Networks' opex productivity measured in terms of opex MPFP increased by 15.8% and 14.3% respectively in 2020, the largest increases in the NEM. Five other DNSPs increased their opex productivity in 2020 by more than 5% – Endeavour Energy (10.3%), Ausgrid (9.3%), Powercor (7.6%), Evoenergy (6.7%), and Energex (5.3%). SA Power Networks' opex MPFP ranking rose from 4th place to 2nd in 2020 and Endeavour Energy also rose two places, from 6th to 4th place, while AusNet fell 3 places to 13th. Powercor's increase in opex productivity further consolidated its position as the top ranked distributor in terms of opex MPFP.

Two of these DNSPs which had increases in MTFP in 2020 had decreased opex productivity as measured by opex MPFP in 2020 – AusNet (-2.1%), and United Energy (-2.8%). Significant opex increases were generally the main driver of these reductions in opex MPFP.[36] AusNet cited the cost response to Covid-19 as a factor driving its higher opex in 2020.

For those DNSPs which had increases in MTFP in 2020, AusNet had the largest increase in capital productivity as measured by capital MPFP in the NEM. Its increase of 2.3% was comfortably larger than all other DNSPs, and of the DNSPs which had

[34] Economic Insights, *Economic Benchmarking Results for the Australian Energy Regulator's 2021 DNSP Annual Benchmarking Report*, November 2021, pp. 62, 103, 108, 41, 81.

[35] Economic Insights, *Economic Benchmarking Results for the Australian Energy Regulator's 2021 DNSP Annual Benchmarking Report*, November 2021, pp. 73, 86, 111.

[36] Economic Insights, *Economic Benchmarking Results for the Australian Energy Regulator's 2021 DNSP Annual Benchmarking Report*, November 2021, pp. 111, 116.

increases in MTFP in 2020, only two others had increased capital MPFP in 2020 (SA Power Networks, and United Energy). Endeavour Energy and Ausgrid had decreases of capital MPFP in 2020 of at least 2%. SA Power Networks consolidated its position as the most productive DNSP in terms of capital productivity in the NEM in 2020. Ausgrid maintained last position in terms of capital MPFP, with reduced capital MPFP in 2020. There were few changes in the capital productivity rankings in 2020.

Four DNSPs became less productive in 2020

Four DNSPs became less productive in 2020 as reflected by their MTFP results. Figure 10 shows that CitiPower had the largest decrease in productivity of 1.1%, driven largely by reduced reliability and energy throughput.[37] CitiPower stated that the latter reflects the impact of Covid-19, which is consistent with observations we have made about CitiPower as a predominantly urban/CBD network.[38] In contrast, predominantly regional Powercor cited Covid-19 as a reason for its higher residential consumption in 2020. Essential Energy (-0.8%), Ergon Energy (-0.7%), and TasNetworks (-0.8%) also experienced small decreases in productivity. Increasing opex and lines/transformers inputs and reduced reliability were generally the main drivers of decreased productivity for these DNSPs.[39]

Two of the DNSPs with reduced MTFP in 2020 also had decreased opex productivity as measured by opex MPFP in 2020 – Ergon Energy (-2.9%) and TasNetworks (-2.2%). Opex increases were generally the main driver of these reductions in opex MPFP.[40] TasNetworks' opex MPFP ranking fell from 3rd to 5th.

Of the DNSPs with reduced MTFP in 2020, Essential Energy's capital MPFP decreased by 4.3% in 2020, which was the largest decrease in the NEM. CitiPower also had a decrease in capital MPFP of more than 3%.

Opex input decreased for most DNSPs in 2020

Nine DNSPs had lower levels of opex in 2020, with an average decline across the industry of 4.9 per cent. Eight DNSPs – Evoenergy, Ausgrid, CitiPower, Endeavour Energy, Energex, Jemena, Powercor and SA Power Networks – experienced reductions in opex of greater than 5% in 2020, with Jemena (-15.0%), Ausgrid (-11.9%), SA Power Networks (-11.5%) and Endeavour Energy (-11.3%) decreasing by more than 10%. SA Power Networks cited Covid-19 as one factor driving its opex reduction.

4.2.2 Productivity levels across the industry have converged over time

Since 2006 there has been some convergence in the productivity levels of DNSPs, both at the MTFP level and in opex MPFP. The spread of productivity levels in 2020 is smaller

[37] Economic Insights, *Economic Benchmarking Results for the Australian Energy Regulator's 2021 DNSP Annual Benchmarking Report*, November 2021, p. 76.

[38] AER, *2021 Electricity Network Performance Report*, September 2021, Section 4, pp. 31–45.

[39] Economic Insights, *Economic Benchmarking Results for the Australian Energy Regulator's 2021 DNSP Annual Benchmarking Report*, November 2021, pp. 96, 91, 67 .

[40] Economic Insights, *Economic Benchmarking Results for the Australian Energy Regulator's 2021 DNSP Annual Benchmarking Report*, November 2021, pp. 91, 67.

than in 2012, which was also smaller than in 2006. This can be seen from the three equal-sized black columns placed in 2006, 2012 and 2020 in Figure 10, with a broadly similar pattern observed for opex MPFP in Figure 11.

The convergence is due to a number of factors, some of which are discussed below.

One important factor is that those DNSPs which have been the least productive over time have improved their performance, particularly since 2012. The least productive DNSPs in 2012 as measured by MTFP (Ausgrid and Evoenergy) have increased their productivity at higher rates than some DNSPs with middling productivity. Since 2012, Ausgrid and Evoenergy have increased their overall productivity (MTFP) by 1.5% and 1.3% respectively, compared with the industry average of 0.4%. The growth in productivity of these DNSPs can be largely attributed to improvements in opex efficiency.

In addition to these DNSPs improving their MTFP performance, several middle-ranked DNSPs have also improved their relative MTFP performance to be closer to the top-ranked DNSPs. In recent years this includes United Energy, Endeavour Energy and Energex, again reflecting improved opex efficiency. Since 2012, the NSW and ACT DNSPs have been among the most improved in the NEM in terms of MTFP and opex MPFP performance.

Further, while Powercor, SA Power Networks and CitiPower have consistently been the most productive DNSPs in the NEM as measured by MTFP over the 2006 to 2020 period, they have also experienced a gradual decline in productivity over this period (and from 2012 to 2020 only CitiPower improved MTFP). As a result, their relative productivity is now generally closer to the DNSPs that are middle-ranked, although SA Power Networks' MTFP rise in 2020 increased its gap over the rest of the DNSPs. This narrowing is primarily due to increasing opex, including as a result of new regulatory obligations among other factors. However, there has since been a turnaround in opex productivity for these three DNSPs from 2014. We will monitor this trend.

Changes in opex productivity as measured by opex MPFP is the main driver of productivity convergence in the electricity distribution industry. It has increased since 2012 (as seen in Figure 11) with twelve out of the thirteen (all bar AusNet) DNSPs increasing their opex productivity as measured by opex MPFP. In contrast, capital productivity as measured by capital MPFP has consistently declined since 2006 throughout the NEM and there has been little convergence among DNSPs. All DNSPs have reduced capital MPFP in 2020 as compared to 2006. This is only marginally different when comparing 2020 to 2012, as United Energy is the only DNSP that has increased its capital productivity since then.

4.2.3 Interpreting the results

As noted above and explained further in sections 7and 8, these results should be interpreted with a level of caution. There are inherent limitations with all benchmarking exercises, including with respect to model specification and the specification of outputs and inputs, and data imperfections. In addition, the results for all DNSPs do not reflect the impacts, both positive and negative, on measured productivity of a range of material OEFs, including capitalisation practices. We recognise these limitations in the conservative way we interpret and apply our benchmarking results to particular DNSPs in the context of revenue determinations. However, we consider that the trends over time we observe for measured productivity in the wider industry are consistent with our general expectations.

AusNet submitted that the absence of these OEFs in the MTFP/MPFP results can provide a misleading picture to stakeholders of DNSPs' relative productivity.[41] It encouraged the AER to present some sensitivity analysis of the MTFP and opex MPFP results in charts to illustrate these impacts. AusNet was particularly concerned that the unequal treatment of capitalised overheads is distorting results.[42]

Improving our quantification of material OEFs and examining the impact of capitalisation remain key focuses for our benchmarking development, as discussed in section 8. In relation to the impact of capitalisation more specifically, we have initiated a consultation process on this issue with the release of a paper accompanying this report. We consider that consultation process to be the appropriate context in which to further examine the impact of capitalisation.

AusNet also submitted that inherent differences in DNSPs' outputs also impact the results.[43] AusNet stated that while ratcheted maximum demand and energy throughput are reasonable and intuitive network outputs for the purpose of undertaking productivity benchmarking, these factors are also outside its control and are not material drivers of opex. It considered that its energy and demand density are inherently lower (relative to Powercor) due to the way its customers use its network both because of the much higher proportion of residential customers and higher levels of social disadvantage. As a result, AusNet claimed its measured productivity is negatively affected, and in particular it compares unfavourably to Powercor.

We do not agree with AusNet's submission on this point. As discussed in section 7, OEFs are variables other than outputs and inputs that are exogenous to the benchmarked business and affect its ability to efficiently transform inputs into outputs. We consider our MTFP model accounts for differences in energy use per customer since energy and customer numbers are both included in the output index. By implication, energy density, and similarly customer density, do not need to be used as additional OEFs when interpreting efficiency scores We consider the four outputs measured are material drivers of opex and allow for the difference in customer, energy and demand density across DNSPs (reflecting different customer composition). We also note our benchmarking results have found both predominantly rural and urban networks being in the top, middle and bottom ranked groups.

We also consider that the lower opex MPFP of AusNet relative to Powercor in 2020 is due to their diverging trends in opex input use between 2006 and 2020, and not

[41] AusNet Services, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, pp. 2–5.

[42] AusNet Services, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, pp. 1–2.

[43] AusNet Services, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, pp. 3–4.

explained by comparatively stable factors such as topographical differences or differences in customer mix. As noted in section 8, the differences in the level of opex may also reflect differences in capitalisation practices, which is an issue we are consulting on.

5 Opex econometric models

Key points

- Powercor, CitiPower, SA Power Networks, TasNetworks and United Energy are the most efficient DNSPs in terms of opex efficiency scores, for both the 2006 to 2020 and 2012 to 2020 periods.
- Due to improvements in opex efficiency in recent years, Ausgrid, Endeavour Energy, Essential Energy and Evoenergy as well as Ergon Energy, TasNetworks and Energex are more efficient over the 2012 to 2020 period compared with the 2006 to 2020 period.
- Opex efficiency scores from the opex cost function models are broadly consistent with opex MPFP efficiency scores.
- The opex econometric models take into account some OEFs e.g. relevant density factors and some service classification differences for opex and undergrounding of cables, but do not include other OEFs. It is desirable to further take into account operating environment conditions not included in the benchmarking models that can materially affect the benchmarking results. Our benchmarking report includes information about material OEFs driving apparent differences in estimated productivity and operating efficiency between the distribution networks in the NEM. These are set out in section 7.
- The results from the opex econometric cost function models are central in our assessment of the opex costs revealed in the most recent years prior to a DNSP's revenue determination processes.
- We continue to observe some issues with the reliability of the performance of the Translog models, as noted by many of the submissions to the draft report. This is an area for development that we discuss further in section 8.

This section presents the results of four econometric models that compare the relative opex efficiency of DNSPs in the NEM. These results reflect an average efficiency score for each DNSP over a specified period. The periods we look at are the 2006 to 2020 (long) period and the 2012 to 2020 (short) period. Examining the shorter time period provides a more recent picture of relative efficiency of DNSPs in the NEM and takes into account that it can take some time for more recent improvements in efficiency by previously poorer performing DNSPs to be reflected in period-average efficiency scores.

The four econometric opex cost function models presented in this section represent the combination of two cost functions (Cobb-Douglas and Translog) and two methods of estimation (Least Squares Econometrics (LSE) and Stochastic Frontier Analysis (SFA)), namely:[44]

- Cobb-Douglas Stochastic Frontier Analysis (SFACD)
- Cobb-Douglas Least Squares Econometrics (LSECD)
- Translog Stochastic Frontier Analysis (SFATLG)
- Translog Least Squares Econometrics (LSETLG)

A key economic property required for these econometric opex models is that an increase in output can only be achieved with an increase in inputs.[45] Cobb-Douglas models assume that the response of opex to output changes (output elasticity) is constant across all observations, and so as long as the estimated output coefficients, which reflect the sample-average output elasticity, are positive then this property is satisfied. However, this property may not be held across all the data points for the more flexible Translog models that allow for varying output elasticities.

Before 2018 the results from the Translog SFA model were not presented in our annual reports as this property was not met. In the 2018 Annual Benchmarking Report the Translog SFA model results were included for the short period as this property was largely satisfied for most DNSPs. Then in the 2019 Annual Benchmarking Report the results for this and the long period were included as again this property was largely met for most DNSPs. In the 2020 Annual Benchmarking Report the number of instances where this property was not met became somewhat more prevalent for the models over the short period.

For the current report, the number of instances where this property does not hold in the Translog models has become somewhat more prevalent again. Consistent with last year's report, for the 2006 to 2020 period, the property is satisfied for all of the Australian[46] DNSPs in the Translog SFA model. However, over this period the Translog LSE model has violations of this property for a majority of observations for three DNSPs: CitiPower, Jemena and United Energy.

For the shorter period from 2012 to 2020, the Translog SFA and Translog LSE models both present violations in a majority of observations for most of the Australian DNSPs:

- For the Translog LSE model there are seven DNSPs for whom a majority of their data points do not satisfy this property: Ausgrid, CitiPower, Endeavour Energy, Energex, Jemena, AusNet and United Energy.
- For the Translog SFA model there are nine DNSPs where this property is not

[44] Further details about these econometric models can be found in the Economic Insights 2014 and 2018 reports (full references are provided in Appendix A).

[45] Technically, this is known as the monotonicity property. See Economic Insights' report accompanying this report for further details: Economics Insights, *Economic Benchmarking Results for the Australian Energy Regulator's 2021 DNSP Annual Benchmarking Report*, November 2021, p. 28–29.

[46] As discussed on p. 73–75, we include both the NEM DNSPs and overseas DNSPs in the opex econometric models sample of DNSPs.

satisfied: Ausgrid, CitiPower, Endeavour Energy, Energex, Ergon Energy, Jemena, Powercor, AusNet and United Energy.

Almost all of these cases where the property is not satisfied related specifically to the elasticity of opex with respect to the customer numbers output, and both models estimate negative elasticities of opex with respect to customer numbers on average for Australian DNSPs.

As per the approach used in last year's benchmarking report, where a majority of a DNSP's observations in a given model violate this property (indicated by a hatched pattern in Figure 13 and Figure 14), we exclude that model's efficiency score in calculating that DNSP's model-average score (shown by the horizontal black lines for each DNSP in these figures). However, the issue was so prevalent in the shorter (2012–20) period for both the SFA and LSE Translog models we have decided to exclude their results for the purpose of calculating the average efficiency scores for *all* Australian DNSPs, even though the property is some satisfied for some DNSPs (as shown in Figure 14).

As discussed further in section 8, future consideration will be given to if or how we can improve the performance of these models in relation to this property and whether or not these results are presented or used. We note this was a focus of many submissions to a draft of this report.[47]

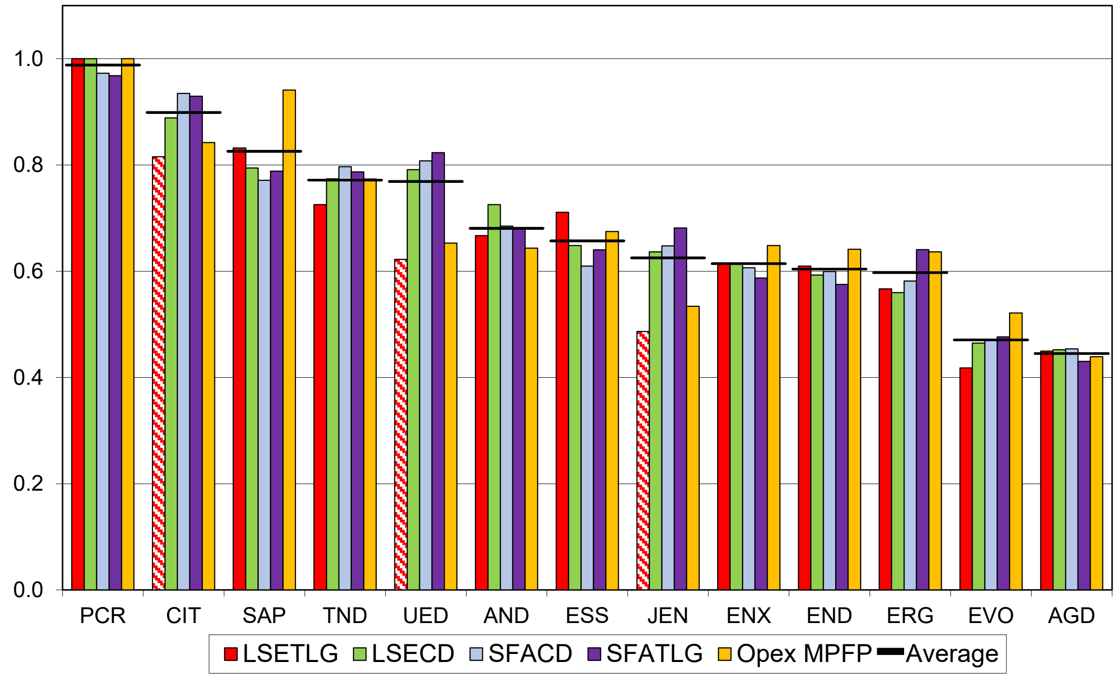
Figure 13 presents average efficiency scores for the above four models (plus opex MPFP) over the long period (2006–2020), ranked from highest to lowest on average.

Powercor and CitiPower have the highest average efficiency scores under the majority of models, followed by SA Power Networks, TasNetworks and United Energy. Ausgrid and Evoenergy have the lowest average opex efficiency scores over this period. As can be seen in Figure 13 the opex MPFP results (in the orange columns) are broadly consistent with the results from these econometric opex cost function models,[48] although the results are somewhat higher for SA Power Networks, Endeavour Energy, Energex and Ergon Energy and somewhat lower for CitiPower, United Energy, AusNet, Jemena and Ausgrid.

[47] Jemena, *Submission on the AER's 2021 draft benchmarking report*, 27 October 2021, pp. 1–3; Ausgrid, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; Evoenergy, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; Essential Energy, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1.

[48] The opex MPFP model has a slightly different combination of outputs than the econometric opex cost function models. See Appendix B and Economic Insights, *Economic Benchmarking Results for the Australian Energy Regulator's 2020 DNSP Annual Benchmarking Report*, 13 October 2020, p. 37.

Figure 13 Opex efficiency scores and opex MPFP, (2006–20 average)



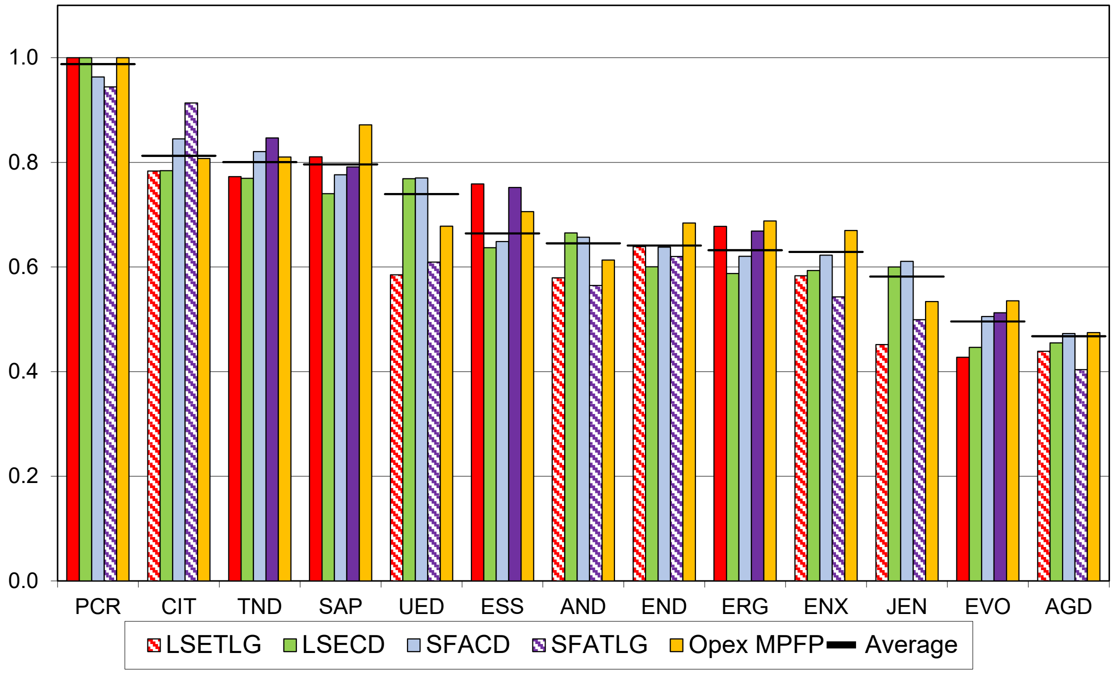
Source: Economic Insights; AER analysis.

Note: Columns with a hatched pattern represent results that violate the key property that an increase in output is achieved with an increase in cost and are not included in the average efficiency score for relevant DNSPs (represented by the black horizontal line). These results do not reflect the impact of a range of material OEFs (see section 7).

Figure 14 presents the average opex efficiency of each DNSP for these four models (plus opex MPFP) over the short period (2012–20). Again, the average (including only those models which satisfy the economic property noted above) is shown by the horizontal black lines for each DNSP. As discussed above, in the case of the shorter period, both Translog models have been excluded for the purpose of calculating the average efficiency scores for all Australian DNSPs. Figure 14 also shows that the corresponding opex MPFP results are broadly consistent with the results from the opex cost function models.

While the average opex efficiency results are similar between the long and short periods, particularly for those DNSPs that have the highest and lowest efficiency scores, there are some changes in average opex efficiency scores of the other DNSPs. Similar to trends observed in section 4, many middle and lower ranked DNSPs in terms of opex efficiency have improved their performance over recent years. This has a more pronounced effect on their opex efficiency scores for the shorter rather than the longer period. Ausgrid, Endeavour Energy, Essential Energy, Evoenergy and Ergon Energy all improved their opex efficiency scores in the shorter period relative to the longer period, and Endeavour Energy (10th to 8th), Essential Energy (7th to 6th), and Ergon Energy (11th to 9th) also have higher rankings in the shorter period than in the longer period. TasNetworks was also able to achieve improved efficiency scores and rankings over the shorter period relative to the longer period.

Figure 14 Opex efficiency scores and opex MPFP, (2012–20 average)



Source: Economic Insights; AER analysis.

Note: Columns with a hatched pattern represent results that violate the key property that an increase in output is achieved with an increase in cost. However, for both the Translog models, as the majority of DNSPs have violations of this property, and as both models estimate negative elasticities of opex with respect to customer numbers on average for Australian DNSPs, we have excluded the efficiency scores of the two Translog models from the average efficiency score calculation for all the DNSPs (represented by the black horizontal line). These results do not reflect the impact of a range of material OEFs (see section 7).

An important limitation of these results is that, apart from relevant density factors, some service classification differences for opex and undergrounding of cables, the opex econometric models do not include the impact of OEFs. It is desirable to take into account operating environment conditions not included in the benchmarking models that can affect the benchmarking results. Section 7 includes information about material OEFs driving apparent differences in estimated productivity and operating efficiency between the distribution networks in the NEM. In summary, these are:

- The higher operating costs of maintaining sub-transmission assets.
- Differences in vegetation management requirements.
- Jurisdictional taxes and levies.
- The costs of planning for, and responding to, cyclones.
- Backyard reticulation (in the ACT only).
- Termite exposure.

We are also considering the impact of differences in capitalisation practices on these benchmarking results and as noted above, and in section 8, we have initiated a consultation on this issue with the release of a paper accompanying this report.

How we use average opex efficiency scores in our revenue determinations to assess relative efficiency of actual opex in a specific year

The econometric models produce average opex efficiency scores for the period over which the models are estimated. The results we are using in this section reflect average opex efficiency over the 2006–20 period and the 2012–20 period. Where there are rapid increases or decreases in opex, it may take some time before the period average efficiency scores reflect these changes, in particular for the longer period. This means that in some circumstances the efficiency scores will not reflect a DNSP's relative efficiency in the most recent year.

To use the econometric results to assess the efficiency of opex in a specific year, particularly in the context of our revenue determination processes, we can estimate the efficient opex of a benchmark efficient service provider operating in the target DNSP's circumstances. We do this by first averaging the DNSP's actual opex (deflated by the opex price index) and calculating its efficiency score over the relevant period. We then compare the DNSP's opex efficiency score against a benchmark comparison score, adjusted for OEFs (see the box in section 7 for further detail on how we apply OEF adjustments). Where the DNSP's efficiency score is below the adjusted benchmark score, we adjust the DNSP's average opex by the difference between the two efficiency scores. This results in an estimate of average opex that is not materially inefficient. We then roll forward this period-average opex to a specific base year using a rate of change that reflects changes in outputs, OEFs and technology between the average year and the specific year. We then compare the DNSP's actual opex in the base year to the rolled forward efficient opex benchmark.

Examples of how we have applied this approach in practice are in the AER's opex final decisions for Jemena and AusNet for the 2021–26 regulatory control period, including the application of material OEFs that we have been able to quantify.[49]

Appendix B provides more information about our econometric models.

[49] See AER, Final Decision, *Jemena distribution determination 2021–26 - Attachment 6 - Operating Expenditure*, April 2021, and AER, *Final Decision, AusNet Services distribution determination 2021–26 - Attachment 6 - Operating Expenditure*, April 2021.

6 Partial performance indicators

Key points

DNSPs with higher customer densities (such as CitiPower, United Energy and Jemena) tend to perform well on 'per customer' metrics. However:

- Powercor (with low customer density) performs more strongly on 'per customer' metrics compared to many DNSPs with higher customer densities.

DNSPs with lower customer densities (such as Essential Energy, Powercor, Ergon Energy and SA Power Networks) tend to perform well on ‘per km’ metrics. However:

- United Energy and Jemena perform well on some 'per km' metrics compared to other DNSPs with lower customer densities.
- Ausgrid (with average customer density) is outperformed on some 'per km' metrics compared to other DNSPs with higher customer densities.

PPI techniques are a simpler form of benchmarking that compare inputs to one output. This contrasts with the MTFP, MPFP and econometric techniques that relate inputs to multiple outputs.

The PPIs used here support the other benchmarking techniques because they provide a general indication of comparative performance of the DNSPs in delivering a specific output. While PPIs do not take into account the interrelationships between outputs (or the interrelationship between inputs), they are informative when used in conjunction with other benchmarking techniques.

On a 'per customer' metric, large rural DNSPs will generally perform poorly relative to DNSPs in suburban and metropolitan areas. Typically, the longer and sparser a DNSP’s network, the more assets it must operate and maintain per customer. The 'per MW' metric exhibits a similar pattern. Conversely, on 'per km' metrics, large rural DNSPs will perform better because their costs are spread over a longer network. Where possible, we have plotted PPIs against customer density,[50] to enable readers to visualise and account for these effects when interpreting the results.

We have updated the PPIs to include 2020 data and present them as an average for the five-year period 2016–20.[51] The results are broadly consistent with those presented in the 2020 Annual Benchmarking Report with no major changes.

[50] Customer density is calculated as the total number of customers divided by the route line length of a DNSP.

[51] The updated PPIs are in dollar values as at the end of December quarter 2020.

6.1 Total cost PPIs

This section presents total cost PPIs averaged over the 2016–20 period. These compare each DNSP's total costs (opex and asset cost) against a number of outputs in turn.[52] Total cost has the advantage of reflecting the opex and assets for which customers are billed on an annual basis. The three total cost PPIs shown here are:

- Total cost per customer
- Total cost per circuit length kilometre
- Total cost per megawatt (MW) of maximum demand.

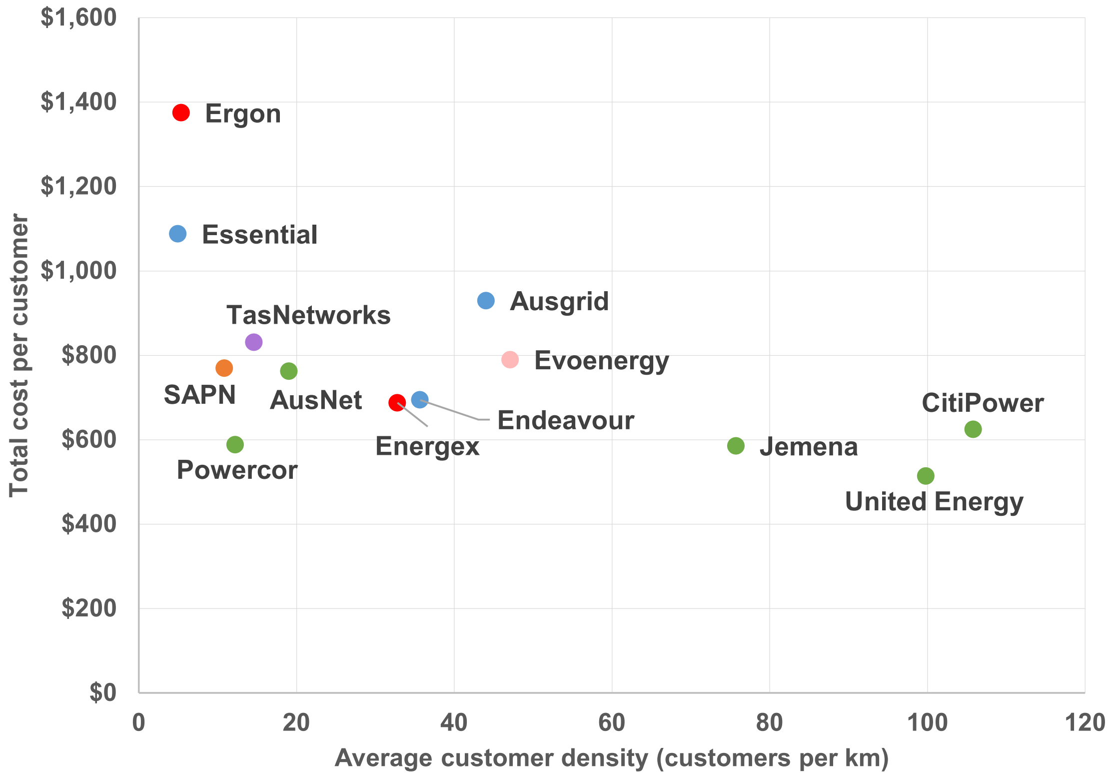
6.1.1 Total cost per customer

Figure 15 shows each DNSP's total cost per customer. Customer numbers are one of the main outputs DNSPs provide. The number of customers connected to the network is one of the factors that influences demand and the infrastructure required to meet that demand.

Broadly, this metric should favour DNSPs with higher customer density because they are able to spread their costs over a larger customer base. However, it is worth noting that there is a large spread of results across the lower customer density networks. Both Ergon Energy and Essential Energy have a relatively higher total cost per customer compared to DNSPs with similar customer densities, including SA Power Networks, Powercor, AusNet and TasNetworks. Ausgrid also has relatively higher costs per customer compared to other networks with similar customer densities and most networks with lower customer densities.

[52] Asset cost is the sum of annual depreciation and return on investment associated with the historical and current capex of a DNSP (as included in its regulatory asset base), using the annual average return on capital. In economic benchmarking studies, it is generally referred to as the annual user cost of capital. We have applied to the PPI calculations the same annual user cost of capital approach we applied to *MTFP and MPFP* analysis. As noted earlier, we have updated the calculation of the annual user cost of capital for the regulatory year 2020 to reflect the AER's Rate of Return Instrument 2018. In previous years the annual user cost of capital calculations broadly reflected the 2013 rate of return guideline. See: https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/rate-of-return-instrument-2018/final-decision.

Figure 15 Total cost per customer ($2020) (average 2016–20)

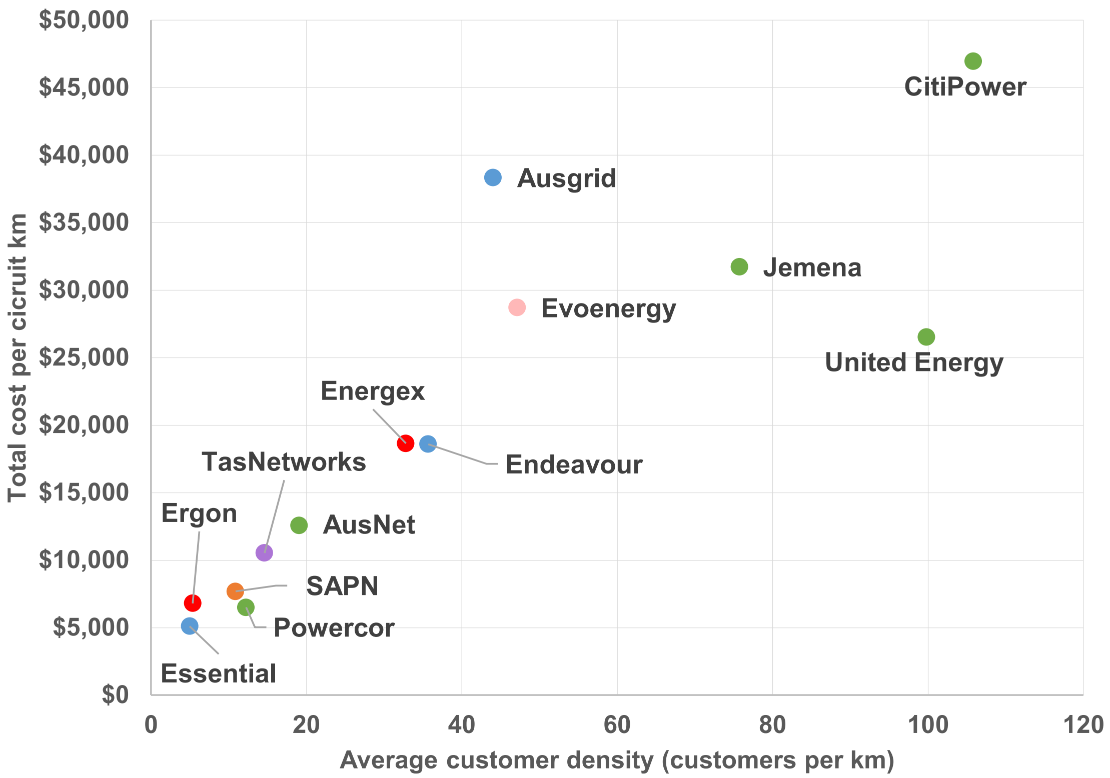


Source: AER analysis; Economic Benchmarking RINs.

6.1.2 Total cost per kilometre of circuit line

Figure 16 presents each DNSP's total cost per km of circuit line length. Circuit line length reflects the distance over which DNSPs must deliver electricity to their customers. CitiPower has the highest total cost per kilometre of circuit line length. As the most customer-dense network in the NEM, this finding must be considered with caution, as 'per km' metrics tend to favour DNSPs with lower customer densities. However, compared to United Energy, which has a similar average customer density, CitiPower performs relatively poorly. Ausgrid reports the second-highest total cost per kilometre of circuit line length in the NEM, and performs worse than some networks with higher customer densities (Evoenergy, Jemena and United Energy).

Figure 16 Total cost per kilometre of circuit line length ($2020) (average 2016–2020)

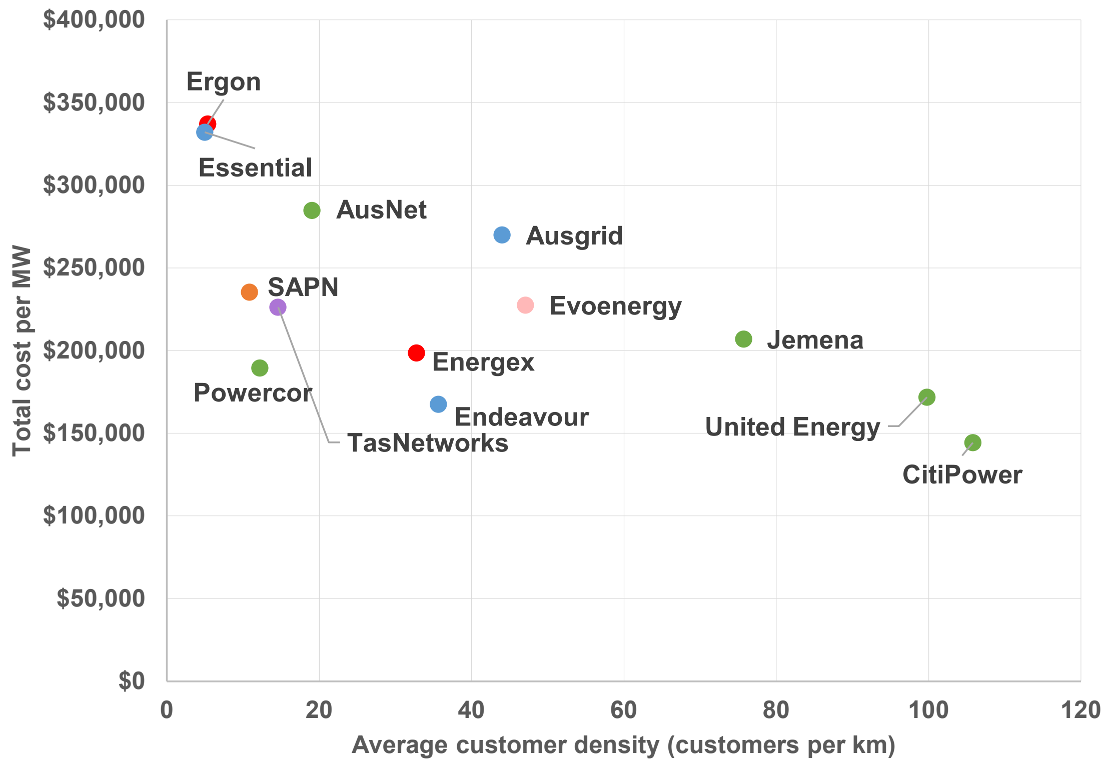


Source: AER analysis; Economic Benchmarking RINs.

6.1.3 Total cost per MW of maximum demand

Figure 17 shows each DNSP's total cost per MW of maximum demand. DNSPs install assets to meet maximum demand. Maximum demand also indirectly influences opex, as installed assets require maintenance (opex). Similar to total cost per customer, the measure of total cost per MW of maximum demand favours DNSPs with higher customer density. However, the spread of results tends to be narrower than that of the other metrics.

Figure 17 Total cost per MW of maximum demand ($2020) (average 2016–20)



Source: AER analysis; Economic Benchmarking RINs.

6.2 Cost category PPIs

This section presents the opex category level cost PPIs averaged over the 2016–20 period. These compare a DNSP's category level opex (vegetation management, maintenance, emergency response) and total overheads against a relevant output.[53] The data for these PPIs are from the category analysis RIN and economic benchmarking RIN reported to the AER.[54]

When used in isolation, these category level PPI results should be interpreted with caution. This is because reporting differences between DNSPs may limit like-for-like category level comparisons. For example, DNSPs may allocate and report opex across categories differently due to different ownership structures and the cost allocation policies it has in place at the time of reporting. There may also be differences in the

[53] We have considered a number of possible output measures such as the length of lines, the energy delivered, the maximum demand and the number of customers served by the service provider. Each of these output measures have advantages and disadvantages. We explain our choice of selected output measure for each of the PPIs below.

[54] We have used the category analysis RIN for category level expenditure data, and the economic benchmarking RIN for non-expenditure data (i.e. route line length, number of interruptions etc.). The expenditure data reported in the category analysis RIN reflects the cost allocation methodology, service classification and reporting requirements in place for each DNSP at the time the RIN was submitted.

interpretation and approaches taken by DNSPs in preparing their RIN data.

We use category level PPIs as supporting benchmarking techniques in our revenue determinations, particularly to identify potential areas of DNSP inefficiency in relation to opex.

6.2.1 Vegetation management

Vegetation management expenditure includes tree trimming, hazard tree clearance, ground clearance, vegetation corridor clearance, inspection, audit, vegetation contractor liaison, and tree replacement costs. We measure vegetation management per kilometre of overhead route line length because overhead line length is the most relevant proxy of vegetation management costs.[55]

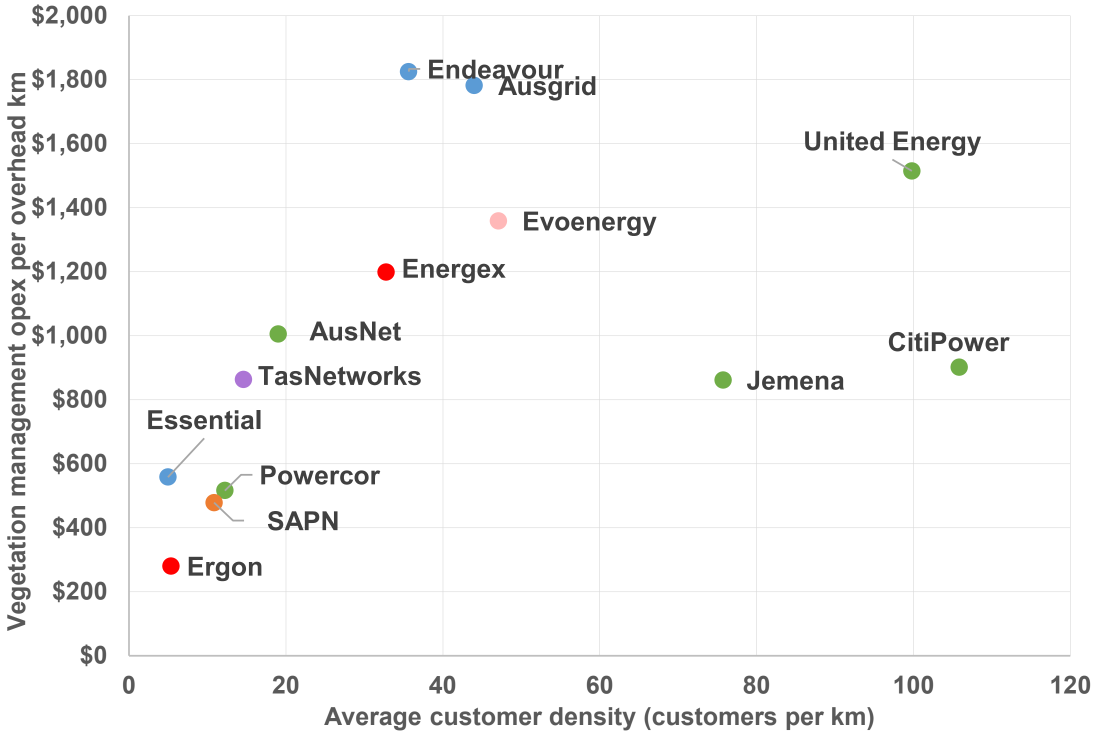
Figure 18 shows that Endeavour Energy, Ausgrid and United Energy have the highest vegetation management expenditure per kilometre of overhead circuit line length relative to other DNSPs in the NEM and relative to DNSPs with similar customer density. In terms of other DNSPs with similar customer density to Endeavour Energy and Ausgrid, Evoenergy benchmarks relatively better despite recent increases in its vegetation management obligations.[56]

In contrast, Ergon Energy, Essential Energy, SA Power Networks and Powercor have the lowest vegetation management expenditure per kilometre of overhead circuit line length in the NEM. As ‘per km’ measures tend to favour networks with smaller customer densities, the relative performance of these DNSPs is somewhat expected.

[55] We note that route line length contains lengths of lines that are not vegetated. Vegetation maintenance spans is a better indicator of the length of vegetated spans. However, we have used overhead route line length instead of vegetation maintenance span length due to DNSPs' estimation assumptions affecting maintenance span length data.

[56] AER, *2020 Annual Benchmarking Report, Electricity distribution network service providers*, November 2020, p 39.

Figure 18 Vegetation management opex per km of overhead circuit length ($2020) (average 2016–20)



Source: AER analysis; Category Analysis RINs; Economic Benchmarking RINs.

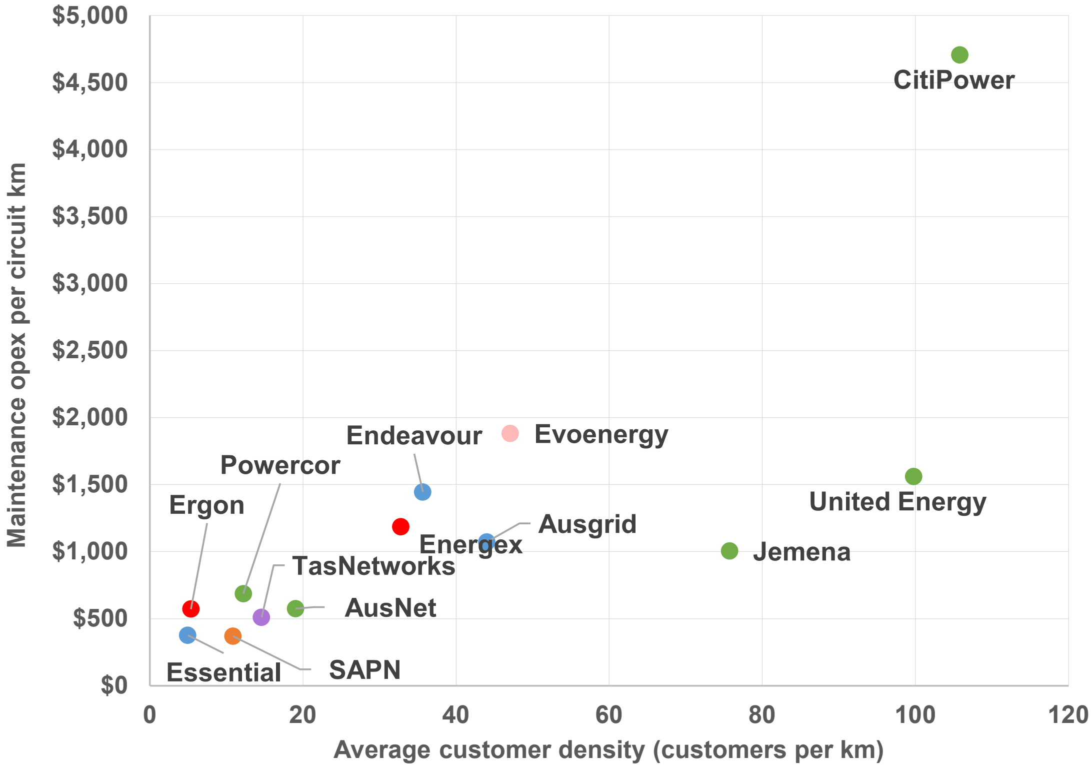
6.2.2 Maintenance

Maintenance expenditure relates to the direct opex incurred in maintaining poles, cables, substations, and protection systems. It excludes vegetation management costs and costs incurred in responding to emergencies. We measure maintenance per circuit kilometre because assets and asset exposure are important drivers of maintenance costs.[57] We used circuit length because it is easily understandable and a more intuitive measure of assets than transformer capacity or circuit capacity.

While CitiPower is one of the best performers in our opex MPFP analysis and econometric benchmarking, Figure 19 shows that it has one of the highest maintenance opex spend per km of circuit length in the NEM. As a high customer density network, CitiPower is likely to be somewhat disadvantaged through the use of 'per km' metrics. However, even compared to other customer-dense networks in the NEM, CitiPower still performs relatively poorly.

[57] Circuit line length includes both overhead and underground cables.

Figure 19 Average maintenance opex spend per circuit km ($2020) (average 2016–20)



Source: AER analysis; Category Analysis RINs; Economic Benchmarking RINs.

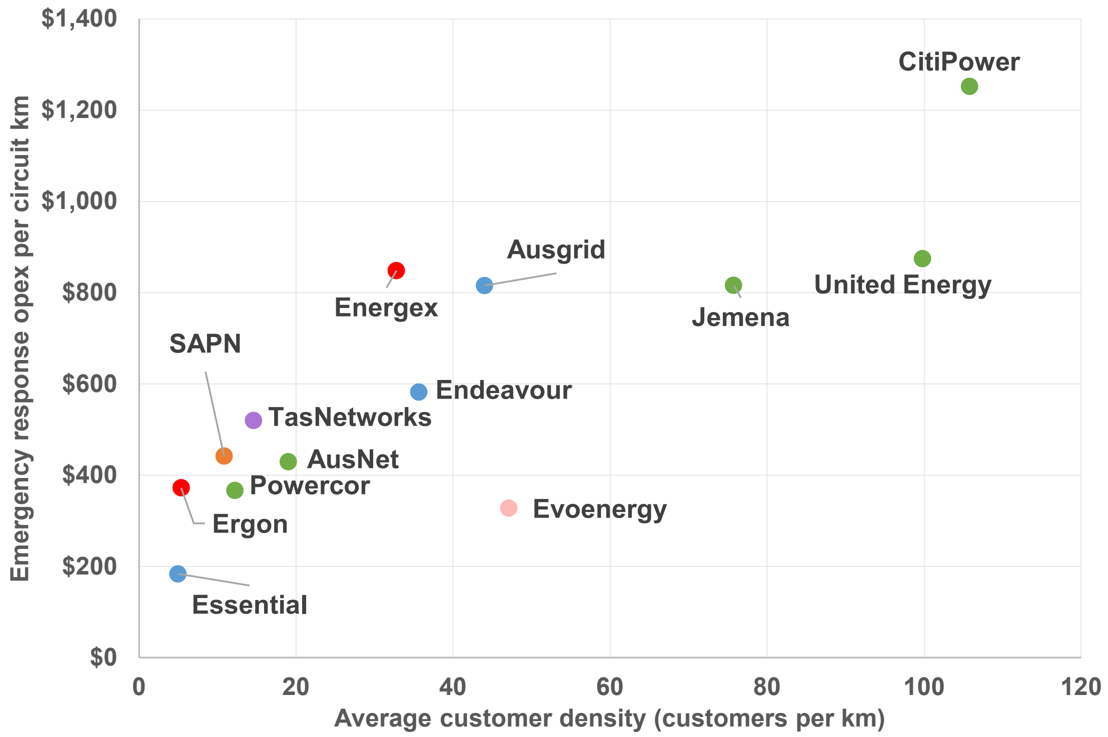
6.2.3 Emergency response

Emergency response expenditure is the direct opex incurred in responding to network emergencies.[58] We measure emergency response costs per circuit km because network emergencies primarily affect powerlines and poles in the field (e.g. due to storms, fires and road accidents leading to network interruptions and loss of power). Using circuit length also allows for comparisons with maintenance opex per km and vegetation management opex per overhead km. The amount of opex spent on maintenance and vegetation management can influence the instances and severity of emergency responses, and in turn there may be trade-offs between maintenance, vegetation management and emergency response.

Figure 20 shows that CitiPower, United Energy, Jemena, Ausgrid and Energex have higher emergency response cost per km relative to other DNSPs of similar customer density, and in the NEM. In comparison, Essential Energy, Ergon Energy, Powercor and Evoenergy have the lowest emergency response costs per km. There may be higher costs associated with responding to emergencies in more customer-dense networks due to the costs of managing congestion (e.g. closing roads and managing traffic).

[58] A future area for examination is the consistency of the emergency response opex reported by DNSPs, as noted in section 8.1.

Figure 20 Average emergency response spend per circuit km ($2020) (average 2016–20)



Source: AER analysis; Category Analysis RINs; Economic Benchmarking RINs.

Note: Jemena's data excludes emergency response opex in 2016. Jemena claimed confidentiality on its emergency response data for these years in its Category Analysis RIN.

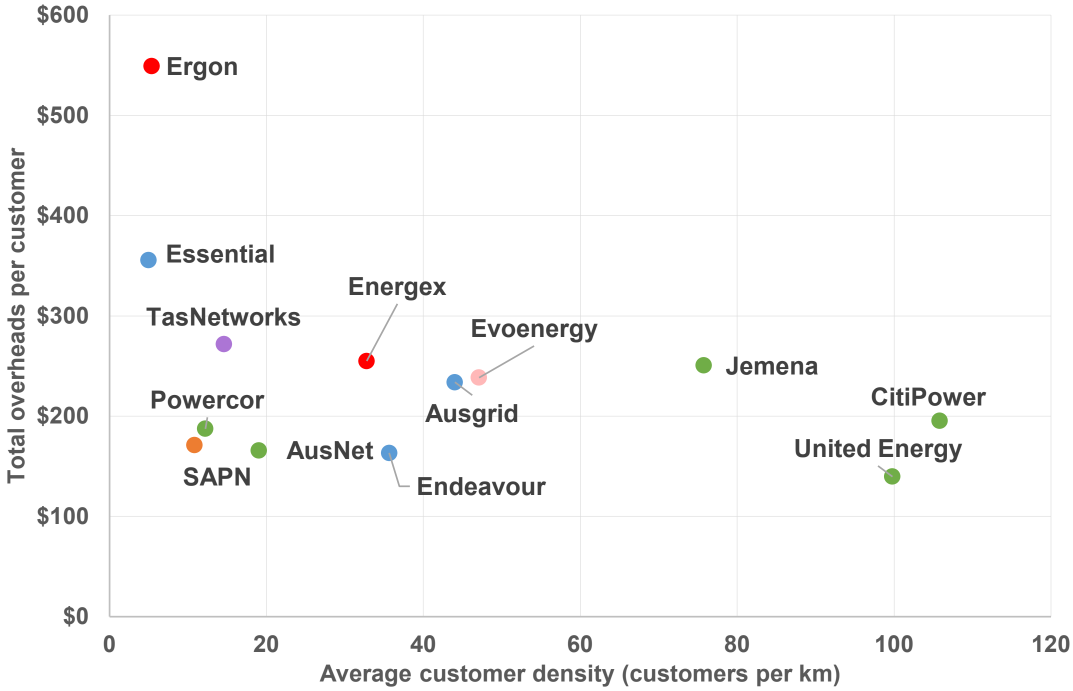
6.2.4 Total overheads

Total overheads are the sum of corporate and network overheads allocated to standard control services. We measure total overheads allocated to both capex and opex to ensure that differences in DNSPs' capitalisation policies do not affect the analysis.[59] It also mitigates the impact of a DNSP's choice in allocating their overheads to corporate or network services.

We have examined total overheads by customer numbers because it is likely to influence overhead costs. Figure 21 shows that Ergon Energy has higher overhead costs compared to all other DNSPs in the NEM, including those DNSPs with similar customer densities. While the 'per customer' measure may favour DNSPs with higher customer density, we do not consider this explains Ergon Energy's relative performance. This is because it has significantly higher costs relative to DNSPs of similar customer densities such as Essential Energy.

[59] By doing this, any differences in capitalisation policy between DNSPs, i.e. whether to expense or capitalise overheads, does not impact the comparison. This is important because there are differences in capitalisation policies between DNSPs, and some DNSPs have changed their polices over time.

Figure 21 Total Overheads per customer ($2020) (average 2016–20)



Source: AER analysis; Category Analysis RINs; Economic Benchmarking RINs.

7 The impact of different operating environments

This section outlines the impact of differences in operating environments not directly included in our benchmarking models. This gives stakeholders more information to interpret the benchmarking results and assess the efficiency of DNSPs. We have also quantified many of the OEFs set out below to include in revenue determinations as a part of our opex efficiency analysis, particularly when using the results from the four opex econometric cost function models. See the box below for more details on how we apply OEF adjustments to the opex econometric benchmarking model efficiency scores.

DNSPs do not all operate under exactly the same operating environments. When undertaking a benchmarking exercise, it is desirable to take into account how OEFs can affect the relative expenditures of each service provider when acting efficiently. This ensures we are comparing like-with-like to the greatest extent possible. By considering these operating conditions, it also helps us determine the extent to which differences in measured performance are affected by exogenous factors outside the control of each business.

Our economic benchmarking techniques account for differences in operating environments to a significant degree. In particular:

- The benchmarking models (excluding the PPIs) account for differences in customer, energy and demand densities through the combined effect of the customer numbers, network length, energy throughput and ratcheted peak demand output variables. These are material sources of differences in operating costs between networks.
- The opex cost function econometric models also include a variable for the proportion of power lines that are underground. DNSPs with more underground cables will, all else equal, face lower maintenance, vegetation management and emergency response costs and fewer outages.
- The opex included in the benchmarking is limited to the network service activities of DNSPs. This excludes costs related to metering, connections, street lighting and other negotiated services, which can differ across jurisdictions or are outside the scope of regulation. This helps us compare networks on a similar basis.
- The capital inputs for MTFP and capital MPFP exclude sub-transmission transformer assets that are involved in the first stage of two-stage transformation from high voltage to distribution voltage, for those DNSPs that have two stages of transformation. These are mostly present in NSW, QLD and SA, and removing them better enables like-for-like comparisons.

However, our benchmarking models do not directly account for differences in legislative or regulatory obligations, climate and geography. These may materially affect the operating costs in different jurisdictions and hence may have an impact on our measures of the relative efficiency of each DNSP in the NEM. As a result, we, and the consultants we engaged to provide us advice on OEFs in 2017, Sapere-Merz, used the following criteria to identify relevant OEFs.[60]

Criteria for identifying relevant OEFs

- Is it outside of the service provider's control? Where the effect of an OEF is within the control of the service provider's management, adjusting for that factor may mask inefficient investment or expenditure.
- Is it material? Where the effect of an OEF is not material, we would generally not provide an adjustment for the factor. Many factors may influence a service provider's ability to convert inputs into outputs.
- Is it accounted for elsewhere? Where the effect of an OEF is accounted for elsewhere (e.g. within the benchmarking output measures), it should not be separately included as an OEF. To do so would be to double count the effect of the OEF.[61]

Sapere-Merz identified a limited number of OEFs that materially affect the relative opex of each DNSP in the NEM, reflecting its (and our) analysis and consultation with the electricity distribution industry.[62] These are:

- The higher operating costs of maintaining sub-transmission assets.
- Differences in vegetation management requirements.
- Jurisdictional taxes and levies.
- The costs of planning for, and responding to, cyclones.
- Backyard reticulation (in the ACT only).
- Termite exposure.

Sapere-Merz's analysis and report also provided:

- preliminary quantification of the incremental opex of each OEF on each DNSP in the NEM, or a method for quantifying these costs

[60] In 2017, we engaged Sapere Research Group and Merz Consulting ('Sapere-Merz') to provide us with advice on material OEFs driving differences in estimated productivity and operating efficiency between DNSPs in the NEM. See its final report Sapere Research Group and Merz Consulting, *Independent review of Operating Environment actors used to adjust efficient operating expenditure for economic benchmarking*, August 2018.

[61] For example, our models capture the effect of line length on opex by using circuit length as an output variable. In this context, an operating environment adjustment for route length would double count the effect of line length on opex. Another example is that we exclude metering services from our economic benchmarking data. In this case, an operating environment adjustment for the metering services is not needed.

[62] The Sapere-Merz report includes more detail about the information and data it used, our consultation with the distribution industry, and the method for identifying and quantifying these OEFs.

- illustration of the effect of each OEF on our measure of the relative efficiency of each DNSP, in percentage terms, using a single year of opex.[63]

A brief overview of each of the material factors follows.

Sub-transmission operating costs (including licence conditions)

Sub-transmission assets relate to the varying amounts of higher voltage assets (such as transformers and cables) DNSPs are responsible for maintaining. The distinction between distribution and sub-transmission assets is primarily due to the differing historical boundaries drawn by state governments when establishing distribution and transmission businesses. In addition, DNSPs in NSW and QLD have historically faced licence conditions that mandated particular levels of redundancy and service standards for network reliability on their sub-transmission assets. DNSPs have little control over these decisions.

Sub-transmission assets cost more to maintain than distribution assets as they are more complex to maintain and higher voltage lines generally require specialised equipment and crews.[64] Our benchmarking techniques do not directly account for these differences in costs. This is because our circuit line length and ratcheted demand output metrics do not capture the incremental costs to service sub-transmission assets compared to distribution assets. It is necessary to consider these relative costs when evaluating the relative efficiency of DNSPs using our benchmarking results.

Sapere-Merz's analysis of sub-transmission costs suggests that most of the NSW and QLD DNSPs require 4–6% more opex to maintain their sub-transmission assets, compared to a reference group of efficient DNSPs. Conversely, TasNetworks requires 4% less opex because it has far fewer sub-transmission assets.[65]

Vegetation management

DNSPs are required to ensure the integrity and safety of overhead lines by maintaining adequate clearances from vegetation, which involves various activities (see section 6.2). Vegetation management expenditure accounts for between 10–20% of total opex for most DNSPs and can differ due to factors outside of their control. Some of these factors include:

- Different climates and geography affect vegetation density and growth rates, which may affect vegetation management costs per overhead line kilometre and the duration of time until subsequent vegetation management is again required

[63] See Sapere Research Group and Merz Consulting, *Independent review of Operating Environment Factors used to adjust efficient operating expenditure for economic benchmarking*, August 2018, p. 35.

[64] Sapere Research Group and Merz Consulting, *Independent review of Operating Environment Factors used to adjust efficient operating expenditure for economic benchmarking*, August 2018, p.48.

[65] Sapere Research Group and Merz Consulting, *Independent review of Operating Environment Factors used to adjust efficient operating expenditure for economic benchmarking*, August 2018, p.55.

- State governments, through enacting statutes, decide whether to impose bushfire safety regulations on DNSPs
- State governments also make laws on how to divide responsibility for vegetation management between DNSPs and other parties.

Sapere-Merz found that variations in vegetation density and growth rates, along with variations in regulation around vegetation management, are likely to be a material and exogenous driver of variations in efficient vegetation management opex. However, under its suggested methods, it could not quantify this OEF based on available data.[66] Sapere-Merz observed that while total vegetation management opex is collected, data about the spans impacted and the density of vegetation needs refinement and consultation with DNSPs to ensure consistency. Sapere-Merz noted that if reliable and consistent data was available, then an OEF could be estimated. It also proposed refinements in relation to regulatory (bushfire regulation and division of responsibility) data.[67]

Recognising this as an area for improvement, in 2020 we undertook some analysis into the quantity and quality of data related to vegetation management. Our main focus was assessment of network characteristic data in the RINs relating to spans, including the total number of vegetation management spans, with a view to calculating an OEF.[68] However, we were not able to develop any clear conclusions from this analysis due to concerns regarding the comparability and consistency of some of the data. For example:

- there may be some inconsistency in DNSPs' definitions of active vegetation management span
- differences in contractual arrangements and vegetation management cycles also raised comparability concerns.

As discussed in section 8, we intend to consult further with DNSPs in refining the data and methodology for calculating this OEF.

While not able to use Sapere-Merz's suggested methodology, or our further work, to quantify the impacts of any differences arising due to vegetation management, in our most recent revenue determinations for Queensland and Victorian DNSPs we included

[66] Sapere Research Group and Merz Consulting, *Independent review of Operating Environment Factors used to adjust efficient operating expenditure for economic benchmarking*, August 2018, pp. 65–66.

[67] Sapere Research Group and Merz Consulting, *Independent review of Operating Environment Factors used to adjust efficient operating expenditure for economic benchmarking*, August 2018, pp. 67–68.

[68] A span refers to the distance between two poles. If a DNSP records poles rather than spans, the number of spans can be calculated as the number of poles less one. Total vegetation management spans refer to the number of spans in a DNSP's network that are subject to active vegetation management practices (i.e. not merely inspection) in the relevant year.

a vegetation management OEF in our benchmarking analysis.[69] This used the same method as in the previous (2015) Queensland determination and involved the summation of two exogenous factors:

- Differences in vegetation management obligations relating to managing bushfire risk
- Differences in the division of responsibility for vegetation clearance with local councils, road authorities and landowners.

As done in 2015, we quantified the differences in the costs related to bushfire obligations by examining the increase in costs faced by Victorian DNSPs following the 2009 Black Saturday bushfires. These reflect an incremental difference in bushfire risk and responsibilities between the Victorian and non-Victorian DNSPs. This quantification was based on forecast costs of step changes and opex pass throughs for the Victorian DNSPs that we approved for the 2011–15 period. The increased opex incurred as a result of these new regulations is used as a proxy for the differences in costs of managing bushfire risks in Victoria compared to other states. We updated the cost estimates for the relevant benchmark periods and new comparator benchmark DNSPs.

We calculated a division of responsibility OEF for Ergon Energy and Energex[70] to reflect the cost disadvantage these DNSPs face in the scale of vegetation management responsibility compared to the benchmark comparator firms in Victoria and South Australia. This is because in Queensland DNSPs are responsible for vegetation clearance from all network assets, whereas other parties such as councils, landowners and roads authorities are responsible for some vegetation clearance in Victoria and South Australia. We derived the OEF adjustment by calculating:

- How much of the vegetated lines in Victoria and South Australia were managed by parties other than the DNSPs (e.g. local councils) in those states, and
- Then multiplying the proportion of opex that relates to vegetation management by the proportionate increase in responsibility the Queensland DNSPs faced relative to the Victorian and South Australian distribution businesses.

Cyclones

Cyclones require a significant operational response including planning, mobilisation, fault rectification and demobilisation. DNSPs in tropical cyclonic regions may also have higher insurance premiums and/or higher non-claimable limits. Ergon Energy is the only DNSP in the NEM that regularly faces cyclones. Sapere-Merz estimated that Ergon Energy requires up to five per cent more opex than other DNSPs in the NEM to account

[69] AER, *Final decision Ergon Energy distribution determination 2020−25 Attachment 6 - Operating expenditure*, June 2020, p. 25; AER, *Draft decision Energex distribution determination 2020−25 Attachment 6 - Operating expenditure*, June 2020, p. 57–79; AER, *Final decision Jemena distribution determination 2021−26 Attachment 6 - Operating expenditure*, April 2021, pp. 29–30; AER, *Final decision AusNet Services distribution determination 2021−26 Attachment 6 - Operating expenditure*, April 2021, pp. 28–29.

[70] This OEF adjustment is by definition zero for any Victorian or South Australian DNSP since the cost disadvantage is calculated by comparison to the division of responsibility applying in Victoria or South Australia.

for the costs of cyclones.[71]

Taxes and levies

A number of jurisdictions require the payment by DNSPs of state taxes and levies such as licence fees and electrical safety levies. As they are state-based, any such taxes or levies could vary between jurisdictions and hence DNSPs. These are outside the control of DNSPs.

Sapere-Merz provided a preliminary quantification of the impact of taxes and levies on each DNSP. This was based on information provided by each DNSP in its RINs and in response to information requests. The impact of differences in taxes and levies generally do not have a significant impact on the relative costs of DNSPs (i.e. beyond 1%). However, Sapere-Merz estimated that TasNetworks requires 5% more opex than other DNSPs due to significant costs imposed by the Tasmanian Electrical Safety Inspection Levy.[72]

Backyard reticulation in the ACT

Historical planning practices in the ACT mean that in some areas overhead distribution lines run along a corridor through backyards rather than the street frontage as is the practice for other DNSPs. Although landowners are theoretically responsible for vegetation management along the majority of these corridors, Evoenergy has a responsibility to ensure public safety, which includes inspecting backyard lines and issuing notices when vegetation trimming is required. Sapere-Merz estimated that Evoenergy requires 1.6% more opex than other DNSPs in the NEM to manage backyard power lines in the ACT.[73]

Termite exposure

DNSPs incur opex when carrying out termite prevention, monitoring, detecting and responding to termite damage to assets. These costs depend on the number of a DNSP's assets that are susceptible to termite damage and the prevalence of termites within the regions where the DNSP's assets are located. Termite exposure is the smallest of the material OEFs identified by Sapere-Merz. Its preliminary analysis suggested that termite exposure primarily affects Ergon Energy and Essential Energy, where they require 1% more opex to manage termites.[74]

[71] Sapere Research Group and Merz Consulting, *Independent review of Operating Environment Factors used to adjust efficient operating expenditure for economic benchmarking*, August 2018, p.77.

[72] Sapere Research Group and Merz Consulting, *Independent review of Operating Environment Factors used to adjust efficient operating expenditure for economic benchmarking*, August 2018, p.72.

[73] Sapere Research Group and Merz Consulting, *Independent review of Operating Environment Factors used to adjust efficient operating expenditure for economic benchmarking*, August 2018, p.80.

[74] Sapere Research Group and Merz Consulting, *Independent review of Operating Environment Factors used to adjust efficient operating expenditure for economic benchmarking*, August 2018, p.74.

Network accessibility

Some DNSPs may incur higher cost of network access to undertake route maintenance (e.g. due to adverse climate and heavy rainfall). In its final report, Sapere-Merz noted that a network accessibility OEF for Power and Water in the Northern Territory would require further data and analysis to determine if it met the OEF criteria.[75]

In our most recent revenue determination for Ergon Energy, we included a network accessibility OEF in our benchmarking analysis.[76] We had included this OEF in our previous (2015) Ergon Energy decision, and considered that the network accessibility circumstances faced by Ergon Energy have likely not changed since our 2015 assessment.[77] We relied on our 2015 assessment approach, with updated data on network without standard vehicle access up to 2018. Where this OEF is relevant and data is satisfactory, we intend to apply this approach.

How we apply OEF adjustments to the benchmarking scores

As discussed at the end of section 5 in relation to the econometric opex cost function models, we use a 0.75 benchmark comparation point to assess the relative operating efficiency of DNSPs (the best possible efficiency score is 1.0.) We adjust the benchmark comparison point for opex impact of material differences in the OEFs between the business and the benchmark comparators that are not already captured in the modelling. The benchmark comparators are those DNSPs that have an econometric model-average efficiency score above the 0.75 benchmark comparison score.

To calculate the adjustment for an OEF for a particular DNSP, the cost of that factor as a percentage of (efficient) opex is compared with the customer-weighted average cost percentage for the comparator DNSPs. Where this difference is positive (negative), indicating a relative cost disadvantage (advantage) for that DNSP, this results in a positive (negative) OEF adjustment. We apply the OEF adjustment by adjusting the 0.75 benchmark comparison point (upwards for negative OEFs, downwards for positive OEFs). This adjusted comparison point is then compared to the business's efficiency score (from the benchmarking models), allowing us to account for potential cost differences due to material OEFs between the business and the benchmark comparison businesses. More detail on the mechanics of our approach is contained in past

[75] Sapere Research Group and Merz Consulting, *Independent review of Operating Environment Factors used to adjust efficient operating expenditure for economic benchmarking*, August 2018, p. 31.

[76] AER, *Final decision Ergon Energy distribution determination 2020−25 Attachment 6 - Operating expenditure*, June 2020, pp. 23–24.

[77] AER, *Preliminary decision Ergon Energy distribution determination 2015−20 Attachment 7 - Operating expenditure*, April 2015, p. 248. We upheld this number in the final decision. See AER, *Final decision Ergon Energy distribution determination 2015−20 Attachment 7 - Operating expenditure*, October 2015, p. 53.

decisions.[78]

[78] AER, *Preliminary Decision, Ergon Energy determination 2015–20, Attachment 7 – Operating Expenditure*, April 2015, pp. 93–138; AER, *Draft Decision, Ausgrid Distribution determination 2019–24, Attachment 6 – Operating Expenditure*, November 2018, pp. 31–33; AER, *Draft Decision, Endeavour Energy Distribution determination 2019–24, Attachment 6 – Operating Expenditure*, November 2018, pp. 27–29.

8 Benchmarking development

We operate an ongoing program to review and incrementally refine elements of the benchmarking methodology and data. The aim of this work is to maintain and continually improve the reliability and applicability of the benchmarking results we publish and use in our network revenue determinations.

We categorise our benchmarking development work as:

- ongoing incremental improvement in data and methods that support our annual benchmarking reporting
- specific issues that have the potential to materially affect the benchmarking results and should involve consultation with affected stakeholders
- changes and improvements in the way that we and other stakeholders use economic benchmarking in decision making.

Our 2019 and 2020 Annual Benchmarking Reports outlined our recent benchmarking improvements and our priorities for future development work.[79] Our future development program has been informed by submissions we received from DNSPs and other stakeholders. This included submissions to our annual benchmarking reports (including the preparation of this report), issues raised throughout revenue determination processes, and specific reviews such as our OEF review. In consulting on a draft of this report there was broad support from stakeholders for progressing the development areas identified below (as outlined in section 1.3). Stakeholders made specific comments in relation to both ongoing incremental improvements to our dataset and methods and the specific issues requiring further investigation, with many noting their readiness to work with the AER and other DNSPs in progressing these issues.

As also noted in section 1.3, in response to the draft report, many DNSPs expressed concern at the lack of progress made in recent years on benchmarking development. Some DNSPs encouraged the AER to outline a firmer timetable and prioritisation of development areas, including processes for industry consultation.

This year we have advanced our thinking around the implications of capitalisation differences on the benchmarking results and with this report we have released a paper to commence an external consultation process. We expect this process will form an input to the 2022 Annual Benchmarking Report.

In addition, building on last year's work, this year we have considered, with Economic Insights, possible further options for improving the reliability performance of the Translog econometric opex cost function models. We have also progressed our internal thinking in relation to an independent review of the non-reliability output weights used in the TFP

[79] AER, *2019 Annual Benchmarking Report, Electricity distribution network service providers*, November 2019, pp. 41–42; AER, *2020 Annual Benchmarking Report, Electricity distribution network service providers*, November 2020, pp. 51–58.

/ MTFP benchmarking and undertaken preliminary investigations about whether changes may be required to benchmarking to account for distributed energy resources. This work will enable us to progress these issues and engage externally over the next 12 months. We expect to be able to undertake the independent review over the next 12 months and begin consideration of possible changes to account for distributed energy resources, although this work and any implementation may be ongoing over the following year.

In our 2020 benchmarking report we flagged our intention to independently review the non-reliability weights, to improve where possible the reliability performance of the Translog opex econometric cost function models and examine the model specifications given the increasing connection of distributed energy resources. We have made more limited progress than we would like in advancing these projects because the issues have proved more complex and resource intensive than anticipated. We will progress this work over the next 12 months.

Beyond this, in following years we will examine other specific issues such as the choice of benchmarking comparison point when making our opex efficiency assessments and progress ongoing incremental improvements such as improving and updating the quantification of material OEFs.

We discuss the areas for incremental improvement and specific issues for investigation in the sections below.

8.1 Ongoing incremental improvement

The key areas for ongoing incremental improvement to our dataset and methods continue to include:

- Continual data refinements in response to our annual review of benchmarking RIN data and data issues identified by stakeholders. For example, emergency response cost data inconsistencies[80] and whether GSL payments should be included in opex for benchmarking purposes.[81] We will also need to consider how to manage the transition of the Victorian DNSPs from a calendar year basis to a financial year basis in the 2022 report. This change in timeframes will be a key data issue for our work over the next twelve months.
- On a specific point in relation to the opex price index, Jemena submitted that audited RIN data should be used to update the labour proportion.[82] Jemena stated that these provide opex in four categories – in–house labour expenditure, labour

[80] Note this issue was raised by Energy Queensland in its submission to the draft 2020 benchmarking report. Energy Queensland, *Submission on the AER's 2020 draft benchmarking report*, 10 November 2020, p. 5.

[81] SA Power Networks, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; AusNet Services, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 3.

[82] Jemena, *Submission on the AER's 2021 draft benchmarking report*, 27 October 2021, p. 3.

expenditure outsourced to related parties, labour expenditure outsourced to unrelated parties, and non-labour expenditure and that the labour proportion can be calculated as the sum of the first three categories divided by total opex.

- We use an opex price index to deflate nominal opex into an 'opex quantity' by removing changes in prices over time. Our opex price index reflects the weighted average movement in the price of labour/non-labour inputs into opex spent by DNSPs. We do not agree with Jemena that we would be able to rely on the RIN information to calculate the labour proportion that we require for the labour/non-labour weights in the calculation of the opex price index. To calculate the labour proportion under our approach, we require data on in–house labour, field services contract labour component and non–field services contract labour component. This data is not available in our RINs. As a result we have needed to collect this data in a separate process.

- Improving the way we measure the quantity of lines and cables inputs. We collect DNSP-specific MVA capacity data for lines and cable by broad voltage category and ask DNSPs to allow for operating constraints. However, DNSPs have adopted a wide range of, and in some cases, frequently changing methods to estimate the constrained MVAs. We plan to explore alternative measures to improve consistency, including ‘nameplate’ capacity of the installed lines and cables. To reduce the data burden on DNSPs, this information could be collected for a ‘snap shot’ year for each DNSP and those values applied to other years for the DNSP.
- Examining the weight allocated to the reliability output in the PIN models and whether it should be capped in some way.
- Improving, where possible, the reliability performance of the Translog econometric opex cost function models, particularly in relation to satisfying the key property that an increase in output can only be achieved with an increase in inputs. This issue is outlined in section 5 and in Economic Insights’ report accompanying this report.[83] We recognise that this issue has generally become more prevalent since 2018. This is reflected in feedback from DNSPs, including in response to Economic Insights’ preliminary results for 2020 and to the draft report.[84] Some DNSPs considered that the current approach creates uncertainty, and that the AER should establish clearer criteria for the inclusion/exclusion of the Translog models. For example, Jemena expressed concern about volatility in the model-average efficiency scores as applied in the efficiency assessments of revenues determinations. This is as a result of the Translog models being included in the average efficiency assessment in one year’s benchmarking report but excluded in another depending on whether the model violates the property in that particular year. Further, Jemena did not consider that

[83] Economic Insights, *Economic Benchmarking Results for the Australian Energy Regulator’s 2021 DNSP Benchmarking Report*, November 2021, pp. 28–34; Appendix C.

[84] Jemena, *Submission on the AER’s 2021 draft benchmarking report*, 27 October 2021, pp. 1–3; Ausgrid, *Submission on the AER’s 2021 draft benchmarking report*, 28 October 2021, p. 1; Evoenergy, *Submission on the AER’s 2021 draft benchmarking report*, 28 October 2021, p. 1; Essential Energy, *Submission on the AER’s 2021 draft benchmarking report*, 28 October 2021, p. 1.

the model-average scores with and without the Translog models are as stable as claimed by Economic Insights, when assessed over various benchmarking periods. Due to these reliability concerns, Jemena considered the Translog models should be excluded from the calculation of model-average efficiency score in the context of resets.[85]

- The Translog functional form is, by design, more flexible than the Cobb-Douglas form, through the addition of 'second-order' terms in the output specification.[86] The downside of this flexibility is that the key property is not necessarily satisfied for all observations in the data sample. We will continue to monitor the performance of the Translog models in future reports, and consider that future possibilities include exploring the suitability of hybrid models (as set out below) as well as not using the results from these models in the future.
- As outlined in Economic Insights' supporting report, it has explored the potential suitability of hybrid models, so named as they are a hybrid of the more restrictive Cobb-Douglas and more flexible Translog functional forms. The rationale for testing hybrid models is that the identified problem is most likely the result of having second-order terms in the more flexible Translog form. By removing some second-order terms while retaining others in this model, the alternative models tested are still more flexible than the Cobb-Douglas three-output models that satisfy the property. The initial results indicate reduced frequency of violations of this property over various different sample periods tested. This provides a possibility for future consideration and we intend to explore the suitability of these models in future benchmarking reports. In response to the draft report, DNSPs were widely supportive of this further investigation, with one DNSP stating that there should be thorough testing and peer review of the hybrid model specifications. We intend to work with Economic Insights to provide a further round of hybrid model specification modelling over the coming 12 months.

- Continuing to improve and update the quantification of material OEFs working with DNSPs. This includes updating the datasets used to quantify individual OEFs and quantifying the impact of OEFs that have not yet been considered. Improving the data and quantification of the vegetation management OEF will be a future focus, as discussed in section 7, e.g. consistency in DNSPs' definitions of active vegetation management span, and understanding differences in DNSP contractual arrangements and vegetation management cycles. We also intend potential refinements to our approach to other OEFs, including GSL and sub-transmission.
  - Several stakeholders also supported our continuing to improve the

[85] Jemena, *Submission on the AER's 2021 draft benchmarking report*, 27 October 2021, pp. 1–3.

[86] In econometric models, first-order terms have a linear relationship to the dependent variable, and second-order terms have a quadratic relationship to the dependent variable. In addition to the Cobb Douglas model's first-order terms, the Translog model also includes quadratic and interaction terms in the outputs.

quantification of material OEFs.[87] In addition, Essential Energy considered that the set of material OEFs should potentially be expanded to include Network Accessibility, weather events (in addition to cyclones) and Fauna.[88] Some stakeholders suggested that the AER examine the feasibility of ex ante adjustments to the benchmarking data.[89]

– We continue to see refinement of OEFs as one of our priority areas. However, we do not envisage we will make any significant progress in the coming 12 months, due to competing priorities. We consider in the meantime our current approach, as outlined in section 7, remains practical in the context of our conservative approach to the application of our benchmarking results.

8.2 Specific issues for investigation

In addition to the above incremental development work, consistent with last year, we consider the following key issues require specific investigation and a degree of consultation with stakeholders:

- The implications of cost allocation and capitalisation differences on the benchmarking results
- Undertaking an independent review of the non-reliability output weights used in the TFP / MTFP benchmarking following the correction of an error in how these were determined in our 2020 Annual Benchmarking Report
- Examining the benchmarking output specifications to determine whether it is appropriate or changes are required to account for distributed energy resources
- The choice of benchmarking comparison point when making our opex efficiency assessments (as explained below)
- If and how Power and Water Corporation should be included in our benchmarking.

These issues are discussed briefly below. As outlined above, the first three issues are areas which we consider should be prioritised and advanced as far as possible over the next 12 months.

8.2.1 Differences in cost allocation and capitalisation approaches

In recent years, we have received submissions and feedback (from AusNet, Ausgrid,

87 Evoenergy, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; Essential Energy, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; Energy Networks Australia, *Submission on the AER's 2021 draft benchmarking report*, 27 October 2021, p. 2; AusNet Services, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, pp. 2–3.

88 Essential Energy, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1.

89 Evoenergy, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1; Essential Energy, *Submission on the AER's 2021 draft benchmarking report*, 28 October 2021, p. 1.

Jemena and SA Power Networks in particular) in relation to the implications of cost allocation and capitalisation differences, and ongoing changes, on the benchmarking results. Some submissions suggest that these differences are leading to differences in benchmarking results that are unrelated to the efficiency of DNSPs and that some DNSPs are disadvantaged due to their cost allocation/capitalisation decisions. Some DNSPs have put forward suggested approaches for how differences in capitalisation practices can be addressed, e.g. benchmarking on the basis of a proportion of overheads that is fixed for all DNSPs or on the basis of a common opex/totex ratio for all DNSPs.[90] We have also observed a number of changes in cost allocation methods by DNSPs since we began benchmarking.

Over the past 12 months, we have made some progress in examining these issues and the implications. We have focused our analysis on capitalisation practices rather than cost allocation more generally, as this has been the consistent focus of stakeholder feedback. Capitalisation practices include both capitalisation policy (which can be changed via a DNSP's Cost Allocation Method) and opex/capital trade-offs.

We have released with this report a consultation paper about the impact of capitalisation differences on the benchmarking results. This paper sets out options and our current views on the various elements of this issue, including how capitalisation differences and their impact on benchmarking should be measured, and how material impacts (if any) on our benchmarking should be addressed. The paper also outlines the process and timeframes for consultation. We note the broad support in stakeholder submissions for this consultation.

Our past considerations and recent analysis are set out in Appendix D of the 2020 Annual Benchmarking Report for distribution, and further extended in the recent opex decision for the Jemena 2021-26 final revenue determination.[91]

We stated in the *2020 Annual Benchmarking Report* that over the next 12 months we intended to further extend and consult on this issue. While we refined our approach in the Jemena 2021-26 final revenue determination, we noted that the approach taken was a pragmatic one that we considered was fit for purpose in the context of Jemena's circumstances. In that decision we considered the optimal method of identifying and adjusting for material differences in capitalisation between DNSPs was an area of ongoing work and is an issue that we intend to explore further and consult on.

8.2.2 Independent review of the non-reliability output weights in the TFP / MTFP benchmarking

In the 2020 Annual Benchmarking Report for distribution we made changes to the non-

[90] For further details on stakeholder submissions, including references, see AER*, 2020 Annual Benchmarking Report, Electricity distribution network service providers*, November 2020, pp. 83–85 and AER, *Final Decision Jemena Distribution Determination 2021 to 2026, Attachment 6 Operating expenditure*, April 2021, pp. 80–85.

[91] AER*, 2020 Annual Benchmarking Report, Electricity distribution network service providers*, November 2020, pp. 83–85 and AER, *Final Decision Jemena Distribution Determination 2021 to 2026, Attachment 6 Operating expenditure*, April 2021, pp. 80–85.

reliability output weights used in the TFP / MTFP benchmarking to correct an error identified in how these weights had been calculated in previous years' reports.[92] Following this, and submissions from stakeholders indicating broad support, we consider it is appropriate to undertake an independent review that will:

- Review whether the data used, and computation undertaken, under the current approach produces the correct non-reliability output weights
- Review the current approach used to produce non-reliability output weights setting out the advantages and disadvantages of this approach
- Explore whether there are any other feasible and / or improved approaches that could be used to determine the non-reliability output weights and the advantages and disadvantages the other feasible approaches.

We consider this is an appropriately targeted and manageable scope. We have begun the process of identifying an independent consultant that is able to undertake this work and anticipate the results of the review will feed into the next benchmarking report. We note the relationship between this and the development work set out below in relation to distributed energy resources and the model specification and will seek to make sure relevant interdependencies are taken into account.

8.2.3 Review of benchmarking modelling to account for distributed energy resources

We have received submissions from some stakeholders about the impact that distributed energy resources is having, or is likely to have, on DNSPs' comparative benchmark performance.[93] DNSPs welcomed our plans to consider the impact of distributed energy resources on benchmarking as noted in section 1.3.

Distributed energy resources include such things as rooftop photovoltaics (e.g. solar panels), batteries and electric vehicles. This is an emerging issue and reflects the evolution of the electricity distribution industry and the expected increase in distributed energy across the NEM. The rollout and penetration of distributed energy resources varies across the NEM and currently affects some DNSPs more than others. This is likely to change as more distributed energy is rolled out. Its increasing importance is reflected by the recent final determination in relation to changes to the NER for access, pricing and incentive arrangements for distributed energy.[94] One requirement of the updated NER is that the AER consult on how it will take into account the changes in the NER relating to distributed energy resources on the annual benchmarking reports by 1 July 2022.

As noted above, in our benchmarking the energy throughput output variable captures

[92] AER, *2020 Annual Benchmarking Report, Electricity distribution network service providers*, November 2020, pp. 3–7.

[93] See, AER, *2020 Annual Benchmarking Report, Electricity distribution network service providers*, November 2020, pp. 55–57.

[94] See, https://www.aemc.gov.au/rule-changes/access-pricing-and-incentive-arrangements-distributed-energy-resources.

the amount of energy delivered to customers over the distribution network as measured at the customer meter. It does not measure energy delivered into the distribution network via distributed energy resources, or that DNSPs are now managing two-way electricity flows. In the extreme, an increase in rooftop solar panels could potentially involve a substitution of different energy sources amongst the same customers without changing the total energy consumed or materially changing the existing network in terms of circuit length or maximum demand. To the extent these two-way flows increase on a DNSP's network, our current output specification would not recognise these as additional outputs. Further, a DNSP may be required to incur higher opex and/or capital to manage the safety and reliability of its network. In this situation there could be a material increase in inputs without a corresponding increase in any or all of the current output measures.

We acknowledge that work is required to assess impacts of this nature. To the extent they are material, it may be appropriate to review the specification of the outputs used in the benchmarking models to appropriately account for the relationship between changes in inputs and growth in distributed energy. Such a review will not be confined to amending certain outputs—it may need to consider whether it is appropriate to add new outputs, as well as revising inputs to better identify inputs relating to the provision of distributed energy resources. It will also need to consider whether distributed energy resources would be better incorporated into our benchmarking analysis as an OEF e.g. initially while there are differences in distributed energy take-up across jurisdictions. A review would also need to consider the data requirements for any new input and output specification or OEFs.

We plan to start a consultation process in relation to this issue in 2022 with a scoping paper that seeks to set out the possible issues. Development work on this issue may be ongoing over the following year particularly in terms of advancing any implementation issues where changes are required.

8.2.4 Benchmarking comparison point

The AER's Consumer Challenge Panel has previously advocated for a review of the selection of the benchmark comparison points that we use in our regulatory decisions.[95] In our opex decisions as a part of the revenue determinations, we draw on the efficiency scores from our econometric opex cost function models (as contained in section 5 of this report) to assess the efficiency of individual DNSPs' historical opex and base year opex. We do this by comparing the efficiency scores of individual DNSPs against a benchmark comparison score of 0.75 (adjusted further for OEFs as set out in section 7), which reflects the upper quartile of possible efficiency scores by DNSPs. The Consumer Challenge Panel has advocated for the raising of our benchmark comparison point and a tightening of the analysis of whether a DNSP is "not materially inefficient".

As we have previously noted, our benchmarking comparison point is conservative and provides a margin for general limitations of the models with respect to the specification of outputs and inputs, data imperfections, other uncertainties when forecasting efficient

[95] See CCP*, Submission to the AER Opex Productivity Growth Forecast Review Draft Decision Paper*, 20 December 2018, p. 13.

opex and quantification of OEFs. We consider that it is appropriate to be conservative while our benchmarking models and OEF assessments are maturing and the underlying data and methods are being refined as set out above. It is also important to provide certainty to industry and other stakeholders because benchmarking is an input into decision making.

We will continue to assess the appropriateness of the current benchmark comparison point in light of the refinements and improvements we make to our benchmarking approaches and metrics over time.

8.2.5 Power and Water Corporation benchmarking

Under section 6.27A of the NER (Northern Territory), Power and Water Corporation ('Power and Water') is a relevant DNSP for our annual benchmarking report. Power and Water transitioned to the NER in 2018 but has not been included in our previous annual benchmarking reports. This is because its benchmarking and regulatory data is relatively immature compared to other DNSPs in the NEM and needs to be examined to ensure it is fit for purpose for benchmarking. We are also mindful of the challenges of Power and Water's potentially unique operating environment in assessing its efficiency relative to the rest of the NEM.

We intend to work with Power and Water to examine its benchmarking data and operating environment, including its size and remoteness, to determine if benchmarking is fit for purpose in its context.

Shortened Forms

Shortened form	Description
AEMC	Australian Energy Market Commission
AER	Australian Energy Regulator
AGD	Ausgrid
AND	AusNet Services (distribution)
Capex	Capital expenditure
CIT	CitiPower
DNSP	Distribution network service provider
END	Endeavour Energy
ENX	Energex
ERG	Ergon Energy
ESS	Essential Energy
EVO	Evoenergy (previously ActewAGL)
JEN	Jemena Electricity Networks
MW	Megawatt
NEL	National Electricity Law
NEM	National Electricity Market
NER	National Electricity Rules
Opex	Operating expenditure
PCR	Powercor
RAB	Regulatory asset base
SAPN	SA Power Networks
TND	TasNetworks (Distribution)
UED	United Energy Distribution

Glossary

Term	Description
Efficiency	A Distribution Network Service Provider's (DNSP) benchmarking results relative to other DNSPs reflect that network's relative efficiency, specifically their cost efficiency. DNSPs are cost efficient when they produce services at least possible cost given their operating environments and prevailing input prices.
Inputs	Inputs are the resources DNSPs use to provide services. The inputs our benchmarking models include are operating expenditure and physical measures of capital assets.
LSE	Least squares econometrics. LSE is an econometric modelling technique that uses 'line of best fit' statistical regression methods to estimate the relationship between inputs and outputs. Because they are statistical models, LSE operating cost function models with firm dummies allow for economies and diseconomies of scale and can distinguish between random variations in the data and systematic differences between DNSPs.
MPFP	Multilateral partial factor productivity. MPFP is a PIN technique that measures the relationship between total output and one input. It allows partial productivity levels as well as growth rates to be compared.
MTFP	Multilateral total factor productivity. MTFP is a PIN technique that measures the relationship between total output and total input. It allows total productivity levels as well as growth rates to be compared between businesses. In this year's annual benchmarking report, we also apply the method to time-series TFP analysis at the industry and State level and for individual DNSP to better capture large customer minutes off supply changes.
Network services opex	Operating expenditure (opex) for network services. It excludes expenditure associated with metering, customer connections, street lighting, ancillary services and solar feed-in tariff payments.
OEFs	Operating environment factors. OEFs are factors beyond a DNSP's control that can affect its costs and benchmarking performance.
Outputs	Outputs are quantitative or qualitative measures that represent the services DNSPs provide.
PIN	Productivity index number. PIN techniques measure aggregated outputs relative to aggregated inputs using a mathematical index.
PPI	Partial performance indicator. PPIs are simple techniques that measure the relationship between one input and one output.
Ratcheted maximum demand	Ratcheted maximum demand is the highest value of maximum demand for each DNSP, observed in the time period up to the year in question. It recognises capacity that has been used to satisfy demand and gives the DNSP credit for this capacity in subsequent years, even though annual maximum demand may be lower in subsequent years.
SFA	Stochastic frontier analysis. SFA is an econometric modelling technique that uses advanced statistical methods to estimate the frontier relationship between inputs and outputs. SFA models allow for economies and diseconomies of scale and directly estimate efficiency for each DNSP relative to the estimated best practice frontier.
TFP	Total factor productivity is a PIN technique that measures the relationship between total output and total input over time. It allows total productivity changes over time or growth rates to be compared across networks. This method was used in previous annual benchmarking reports (up to 2019) to examine productivity change over time at the DNSP level and the industry level.
VCR	Value of Customer Reliability. VCR represents a customer's willingness to pay for the reliable supply of electricity.

A References and further reading

Several sources inform this benchmarking report. These include ACCC/AER research and expert advice provided by Economic Insights.

Economic Insights publications

The following publications explain in detail how Economic Insights developed and applied the economic benchmarking techniques used by the AER.

- Economic Insights, Economic Benchmarking Results for the Australian Energy Regulator's 2021 DNSP Benchmarking Report, November 2021
- Economic Insights, Economic Benchmarking Results for the Australian Energy Regulator's 2020 DNSP Benchmarking Report, 13 October 2020
- Economic Insights, AER Memo Revised files for 2019 DNSP Economic Benchmarking Report, 24 August 2020
- Economic Insights, Economic Benchmarking Results for the Australian Energy Regulator's 2019 DNSP Benchmarking Report, 5 September 2019
- Economic Insights, Economic Benchmarking Results for the Australian Energy Regulator's 2018 DNSP Benchmarking Report, 9 November 2018
- Economic Insights, Economic Benchmarking Results for the Australian Energy Regulator's 2017 DNSP Benchmarking Report, 31 October 2017
- Economic Insights, *Memorandum – DNSP Economic Benchmarking Results Report*, 4 November 2016
- Economic Insights, *Memorandum – DNSP MTFP and Opex Cost Function Results*, 13 November 2015
- Economic Insights, *Response to Consultants' Reports on Economic Benchmarking of Electricity DNSPs*, 22 April 2015 (link)
- Economic Insights, *Economic Benchmarking Assessment of Operating Expenditure for NSW and ACT Electricity DNSPs*, 17 November 2014 (link)
- Economic Insights, Economic Benchmarking of Electricity Network Service Providers, 25 June 2013.

ACCC/AER publications

These publications provide a comprehensive overview of the benchmarking approaches used by overseas regulators.

- ACCC/AER, *Benchmarking Opex and Capex in Energy Networks – Working Paper no. 6*, May 2012 (link)
- ACCC/AER, *Regulatory Practices in Other Countries – Benchmarking opex and capex in energy networks*, May 2012 (link)
- WIK Consult, *Cost Benchmarking in Energy Regulation in European Countries*, 14 December 2011 (link).

AER distribution determinations

The AER applies economic benchmarking to assess the efficiency of total forecast opex as proposed by distribution network service providers. These decisions provide examples of how the AER has applied benchmarking in its decision making:

- AER, Final Decision, *Jemena distribution determination 2021–26 - Attachment 6 - Operating Expenditure*, April 2021 (link)
- AER, Final Decision, *AusNet Services distribution determination 2021–26 - Attachment 6 - Operating Expenditure*, April 2021 (link)
- AER, Draft Decision, *Jemena distribution determination 2021–26 - Attachment 6 - Operating Expenditure*, September 2020 (link)
- AER, Draft Decision, *AusNet Services distribution determination 2021–26 - Attachment 6 - Operating Expenditure*, September 2020 (link)
- AER, Draft Decision, *Ergon Energy distribution determination 2020–21 to 2024–25 - Attachment 6 - Operating Expenditure,* October 2019 (link)
- AER, Draft Decision, *SA Power Networks distribution determination 2020–21 to 2024–25 - Attachment 6 - Operating Expenditure*, October 2019 (link)
- AER, Draft Decision, *Ausgrid distribution determination 2019–20 to 2023–24 - Attachment 6 - Operating Expenditure*, November 2018 (link)
- AER, *Ausgrid distribution determination 2014–15 to 2018–19,* January 2019 (link)
- AER, *Jemena distribution determination 2016 to 2020 - Attachment 7 - Operating Expenditure*, May 2016, p. 7–22 (link)
- AER, *Endeavour Energy distribution determination 2015–16 to 2018–19 - Attachment 7 - Operating Expenditure*, April 2015 (link)
- AER, Preliminary decision, *Energex determination 2015–16 to 2019–20 - Attachment 7 - Operating Expenditure*, April 2015 (link)
- AER, *Preliminary decision, Ergon Energy determination 2015–16 to 2019–20 - Attachment 7 - Operating Expenditure*, April 2015 (link).

B Benchmarking models and data

This appendix contains further information on our economic benchmarking models and techniques, as well as the output and input data used in the benchmarking techniques.

Benchmarking techniques

This report presents results from three types of 'top-down' benchmarking techniques.

PIN. These techniques use a mathematical index to measure outputs relative to inputs, enabling comparison of productivity levels and trends over time.

- TFP relates total inputs to total outputs and provides a measure of overall productivity growth for a single entity (a network or the whole industry). It allows total productivity growth rates to be compared across networks but does not allow productivity levels to be compared across networks. It can be used to decompose productivity change into its constituent input and output parts.
- MTFP relates total inputs (opex and capital) to total outputs and can provide a measure of overall network efficiency. It allows total productivity levels to be compared between networks and over time,[96] when it is applied to combined time-series, cross-section (or 'panel') data.
- MPFP is a partial efficiency measure, which uses the same output specification as MTFP but separately examines the productivity of opex and capital inputs against total output.

Econometric opex cost function models. These model the relationship between opex (as the input) and outputs, and so measure opex efficiency. The report presents two types of econometric opex models — Least Squares Econometrics (LSE) and Stochastic Frontier Analysis (SFA) – and uses two types of functional form for each model – Cobb-Douglas and Translog.

PPIs. These techniques, also partial efficiency measures, relate one input to one output (contrasting with the above techniques that relate one or all inputs to total outputs). PPIs measure the average amount of an input (such as total cost or opex category costs) used to produce one unit of a given output (such as total customer numbers, megawatts of maximum electricity demand or kilometres of circuit length).

There are a number of important differences across the various models. In particular:

- OEFs. The productivity index and econometric models include allowance for the key network density differences (e.g. customer density, maximum demand density). The econometric models also account for the degree of network undergrounding.
- Output variables. The econometric models include three outputs whereas the productivity index models include five outputs (the three outputs in the econometric models plus energy delivered and reliability). The PPIs include only one output variable per indicator.

[96] There may be minor differences in MTFP and TFP growth rates for a particular firm due to differences in the sample means used in the calculations.

- Estimation technique:
  - The MTFP model uses a non-parametric method.
  - Unlike the non-parametric index-based MTFP methods, econometric opex cost function models allow for statistical noise in the data and produce confidence intervals. For the econometric models, two alternative methods of identifying firm-specific inefficiency are used. One method, LSE, uses a variant of ordinary least squares (OLS) regression, incorporating dummy variables for 12 of the 13 Australian DNSPs.[97] The estimated coefficients with these DNSP-specific dummy variables are then transformed as measures of comparative efficiency among these DNSPs.
  - The other method uses stochastic frontier analysis (SFA) that assumes an inefficiency term (with truncated normal distribution) in addition to the random error term. In the SFA models opex efficiency scores are estimated relative to the estimated frontier.
  - The econometric models also estimate two different types of functional form — Cobb-Douglas and Translog. The combination of these two estimation methods and two functional forms gives four econometric models.
- Data. The productivity index models and the PPIs use Australian data only, whereas the econometric opex models use Australian data and overseas data.

Notwithstanding the differences in the features and data requirements of each model, the opex efficiency results of each model are broadly consistent with each other (although there is some variation in individual DNSP results and the relative rankings of DNSPs). The broad similarity between the results from the opex MPFP model and the opex econometric models is particularly noteworthy, given the very different approaches. This reinforces the confidence in the results from each model.[98]

Economic Insights' 2021 report provides more detail on the econometric methodology and modelling results. The Economic Insights November 2014 report referenced in Appendix A also provides more information about each model, and the rationale supporting the choice of input and output specifications used in this report.

Benchmarking data

This section of the appendix contains further information about the benchmarking data used in the benchmarking techniques (specifically the outputs and inputs data).

Inputs include a mix of the infrastructure assets needed to distribute electricity to customers and the network opex to run and maintain the network. DNSPs primarily exist to provide customers with access to a safe and reliable supply of electricity and a range of outputs have

[97] That is, one DNSP is treated as the 'base' and the estimated coefficients on the dummy variables for other Australian DNSPs represent their systematic variation against the base. Overseas DNSPs do not have individual dummy variables, but rather a country-specific dummy variable (with Australia as the 'base country', and hence no dummy variable to avoid dummy variable trap). It does not matter which DNSP is chosen as the base since comparative efficiency measures are subsequently scaled against the DNSP with greatest efficiency.

[98] Economic Insights, *Economic benchmarking assessment of operating expenditure for NSW and ACT electricity DNSPs*, 17 November 2014, pp. 46–47.

been selected to reflect this goal.[99]

Categories of inputs and outputs used in benchmarking

Inputs:

- Capital stock (assets) is the physical assets DNSPs invest in to replace, upgrade or expand their networks. Electricity distribution assets provide useful service over a number of years or even several decades. We split capital into:

  - overhead distribution (below 33kV) lines

  - overhead sub-transmission (33kV and above) lines

  - underground distribution cables (below 33kV)

  - underground sub-transmission (33kV and above) cables

  - transformers and other capital.

- Operating expenditure (opex) is expenditure needed to operate and maintain a network. Opex is an immediate input into providing services and is fully consumed within the reporting year.

Outputs:

- Customer numbers. The number of customers is a measure of the scale of the DNSP and the services a DNSP must provide. We measure the number of customers as the number of active connections on a network, represented by each energised national metering identifier.
- Circuit length. This reflects the distances over which DNSPs deliver electricity to their customers.
- Ratcheted maximum demand (RMD). DNSPs endeavour to meet the demand for energy from their customers when that demand is greatest. This means that they must build and operate their networks with sufficient capacity to meet the expected peak demand for electricity.[100]
- Energy delivered (MWh). Energy throughput is a measure of the amount of electricity that DNSPs deliver to their customers. This output is included only in the PIN models, not in the econometric models.
- Reliability (Minutes off-supply). Reliability measures the extent to which networks are able to maintain a continuous supply of electricity. Minutes off-supply enters as a negative output and is weighted by the value of consumer reliability. This output is included only in the PIN models, not in the econometric models.
- Share of undergrounding: The opex cost function econometric models also include a

[99] The 17 November 2014 Economic Insights report referenced in Appendix A details the input and output weights applied to constructing the productivity index numbers. The 9 November 2018 Economic Insights report contains further information on the updated output weights, while the 13 October 2020 Economic Insights report contains detail on a correction to these weights due to a coding error.

[100] The economic benchmarking techniques use 'ratcheted' maximum demand as an output rather than observed maximum demand. Ratcheted maximum demand is the highest value of peak demand observed in the time period up to the year in question for each DNSP. It recognises capacity that has been used to satisfy demand and gives the DNSP credit for this capacity in subsequent years, even though annual maximum demand may be lower in subsequent years.

variable for the proportion of a DNSP's total circuit length that are underground. DNSPs with more underground cables will, all else equal, face less maintenance and vegetation management costs and fewer outages.

- The November 2014 Economic Insights referenced in Appendix A details the rationale for the choice of these inputs and outputs.

The econometric modelling differs from the other benchmarking techniques in that it uses Australian and overseas data. The lack of variability in the Australian DNSP data means that sufficiently robust results cannot be produced with Australian DNSP data alone using econometric methods. Economic Insights incorporated comparable data from electricity DNSPs in Ontario and New Zealand to increase the size of the dataset and enable more robust estimation of the opex cost function models. Sensitivity analysis of the econometric opex benchmarking results (using cost functions generated with and without the overseas data) indicates that the addition of the overseas data improves the robustness of the econometric opex models (by allowing better estimation of the opex cost function parameters) without distorting the estimation of individual DNSP's efficiency results. Appendix A contains references to further reading on how Economic Insights incorporated overseas data into the econometric models and the sensitivity analyses.

To prepare this year's report, each DNSP provided the AER with input and output data from their businesses as defined in standardised economic benchmarking regulatory information notices (EB RINs). The EB RINs require all DNSPs to provide a consistent set of data, which is verified by each DNSP's chief executive officer and independently audited. We separately tested and validated the data provided by the networks. Economic Insights prepared the benchmarking results using the set of agreed benchmarking techniques.[101] We provided the DNSPs with a draft version of the benchmarking report to allow each network to provide feedback on the results before we publicly release the final benchmarking report.[102]

The complete data sets for all inputs and outputs from 2006 to 2020, along with the Basis of Preparation provided by each DNSP, are published on our website.[103]

Outputs

The techniques in this report measure output using some or all of customer numbers, circuit line length, maximum demand, energy throughput and reliability.

Customer numbers

The primary function of a distribution network is providing its customers with access to electricity. Regardless of how much electricity a customer consumes, infrastructure is required to connect every customer to the network. The number of customers, therefore, is a measure of the services a DNSP provides.[104]

Figure B.1 shows the average customer numbers of each DNSP over the five-year period from

[101] The Economic Insights report outlining the results for this year's report and the data and benchmarking techniques used can be found on the AER's benchmarking website.

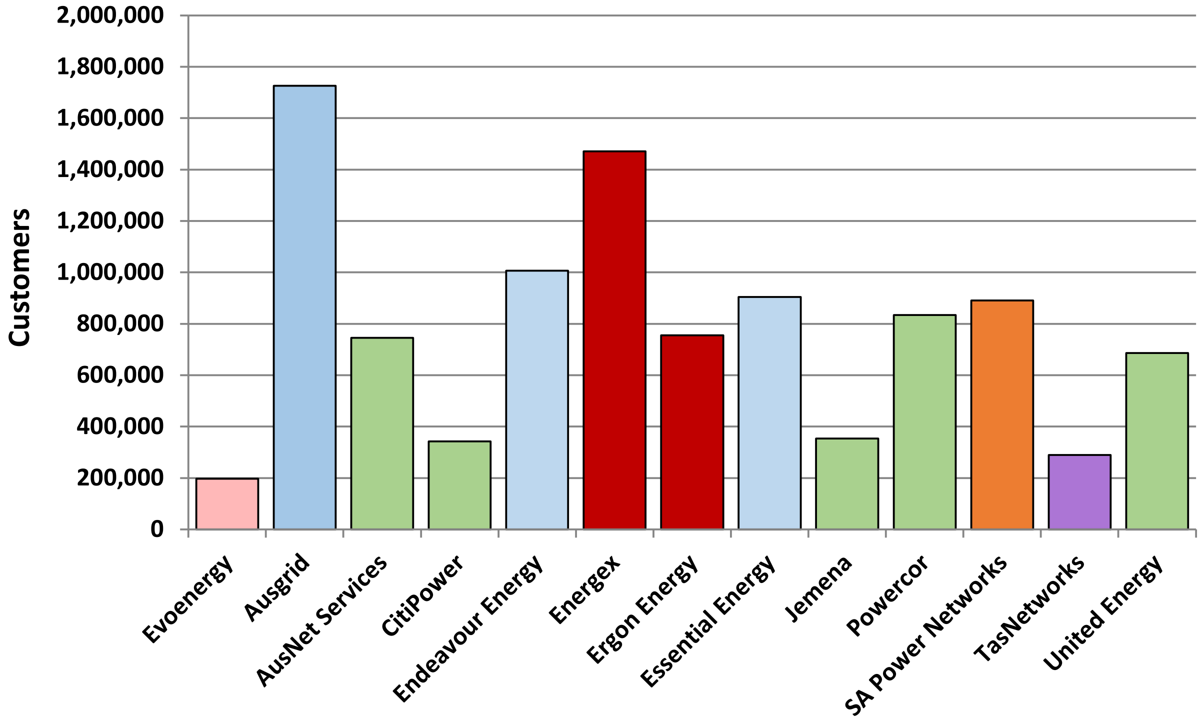
[102] NER, cll. 8.7.4(c)(1) and 8.7.4(c)(2).

[103] This dataset is available at www.aer.gov.au/networks-pipelines/performance-reporting.

[104] We measure the number of customers as the number of active connections on a network, represented by each energised national metering identifier.

2016 to 2020.

Figure B.1 Five-year average customer numbers by DNSP (2016–20)



Source: Economic Benchmarking RIN.

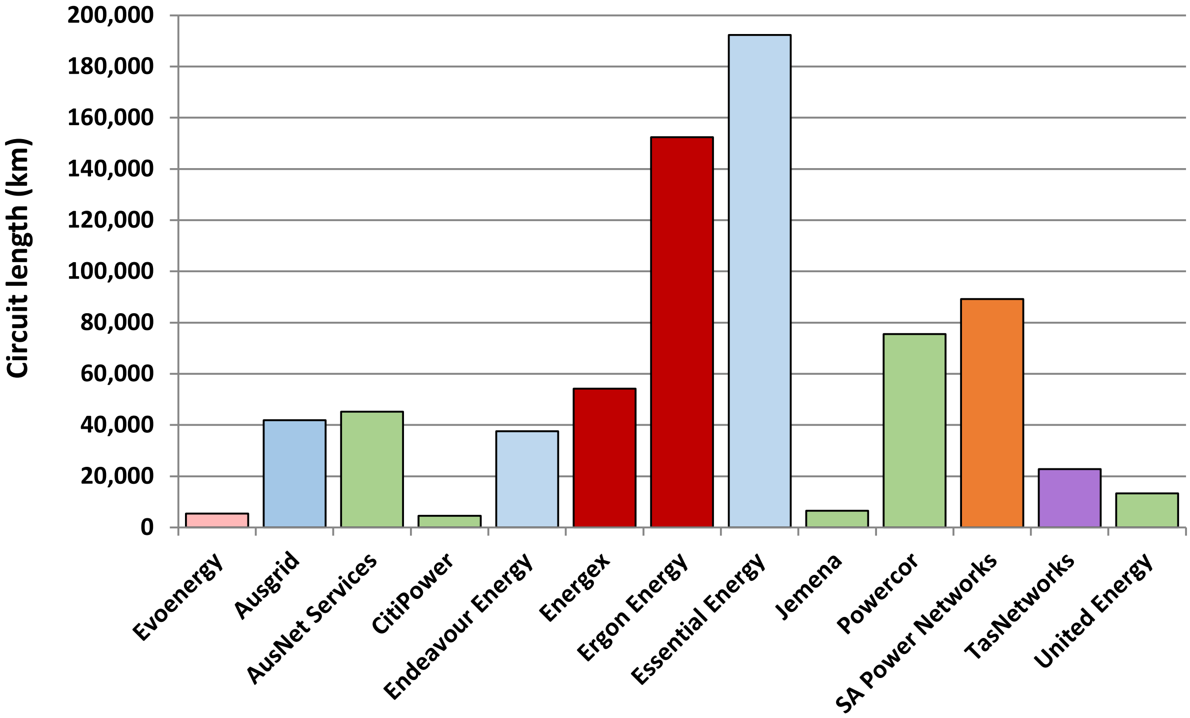
Circuit line length

Line length reflects the distances over which DNSPs deliver electricity to their customers. To provide their customers with access to electricity, DNSPs must transport electricity from the transmission network to their customers' premises. DNSPs will typically operate networks that transport electricity over thousands of kilometres.

In addition to measuring network size, circuit length also approximates the line length dimension of system capacity. System capacity represents the amount of network assets a DNSP must install and maintain to supply consumers with the quantity of electricity demanded at the places where they are located.

Figure B.2 shows each DNSP's circuit length, on average, over the five years from 2016 to 2020.

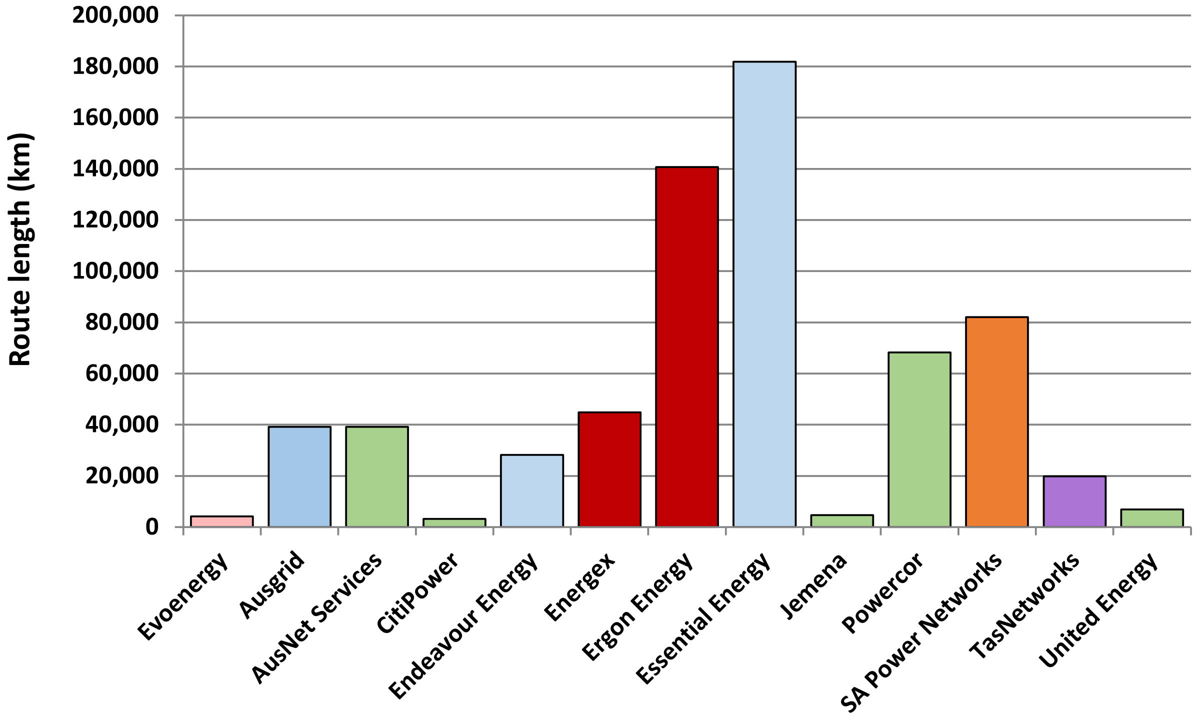
Figure B.2 Five-year average circuit line length by DNSP (2016–20)



Source: Economic Benchmarking RIN.

For PPI metrics, we use route (rather than circuit) length to calculate customer density because it is a measure of a DNSP's physical network footprint (because it does not count multiple circuits on the same route). Figure B.3 demonstrates that, for all DNSPs, route length on average over the period 2016-20 is shorter than circuit length but there is little-to-no change in DNSP rankings. The only difference is with Ausgrid having a smaller circuit length than AusNet but a marginally larger route line length than AusNet on average over the past five years.

Figure B.3 Five-year average route line length by DNSP (2016–20)



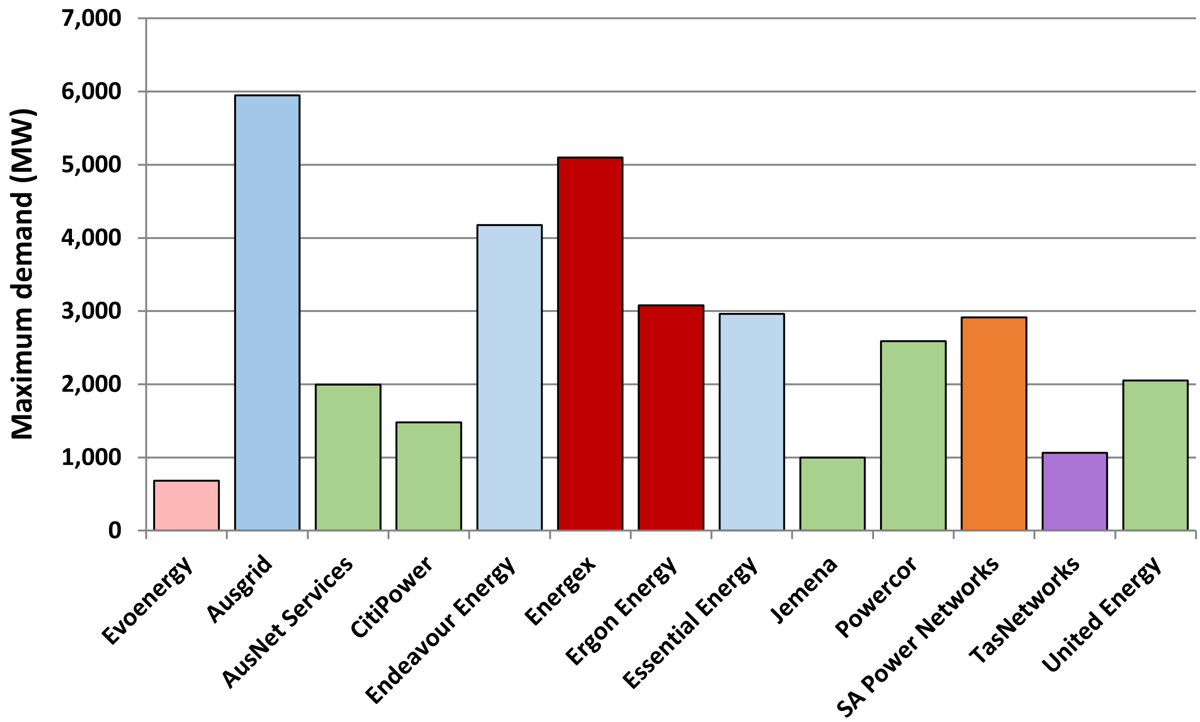
Source: Economic Benchmarking RIN.

Maximum demand

DNSPs are required to meet and manage the demand of their customers. This means that they must build and operate their networks with sufficient capacity to meet the expected peak demand for electricity. Maximum demand is a measure of the overall peak in demand experienced by the network. The maximum demand measure we use is non-coincident summated raw system annual maximum demand, at the transmission connection point, measured in megawatts (MW).

Figure B.4 shows each DNSP's maximum demand, on average, over the five years from 2016 to 2020.

Figure B.4 Five-year average maximum demand by DNSP (2016–20)

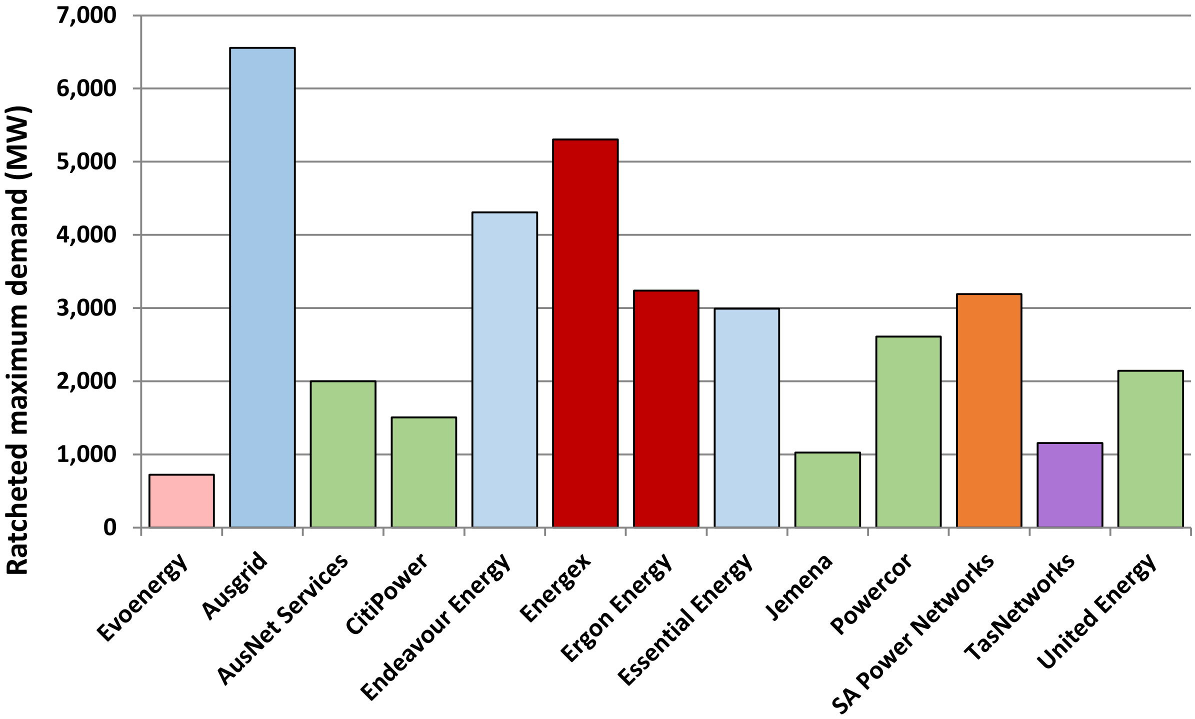


Source: Economic Benchmarking RIN.

The economic benchmarking techniques use 'ratcheted' maximum demand as an output rather than observed maximum demand. RMD is the highest value of peak demand observed in the time period up to the year in question for each DNSP. It thus recognises capacity that has actually been used to satisfy demand and gives the DNSP credit for this capacity in subsequent years, even though annual peak demand may be lower in subsequent years.

Figure B.5 shows each DNSP's ratcheted maximum demand, on average, over the five years from 2016 to 2020.

Figure B.5 Five-year average ratcheted maximum demand by DNSP (2016–20)



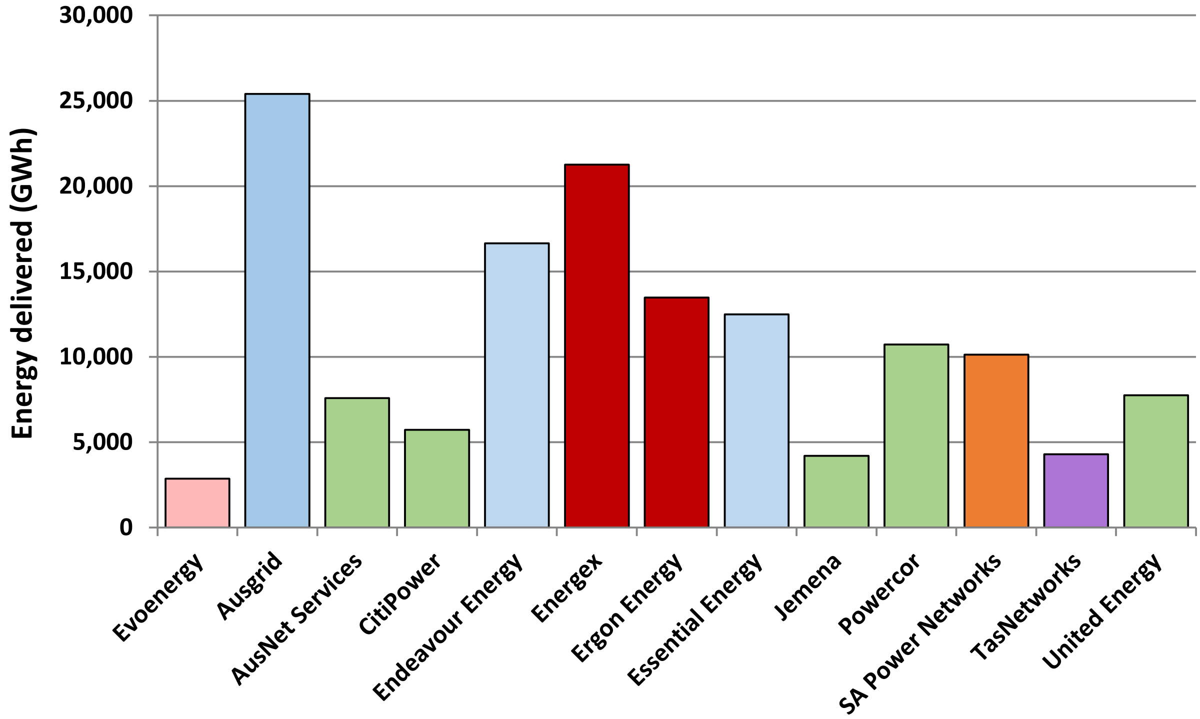
Source: Economic Benchmarking RIN.

Energy delivered

Energy delivered is a measure of the amount of electricity that DNSPs deliver to their customers. While energy throughput is not considered a major driver of costs (distribution networks are typically engineered to manage maximum demand rather than throughput) energy throughput reflects a service provided directly to customers and is a key part of what they pay for in their bills. Energy delivered is measured in Gigawatt hours (GWh).

Figure B.6 shows each DNSP's energy delivered, on average, over the five years from 2016 to 2020.

Figure B.6 Five-year average energy delivered by DNSP (2016–20)

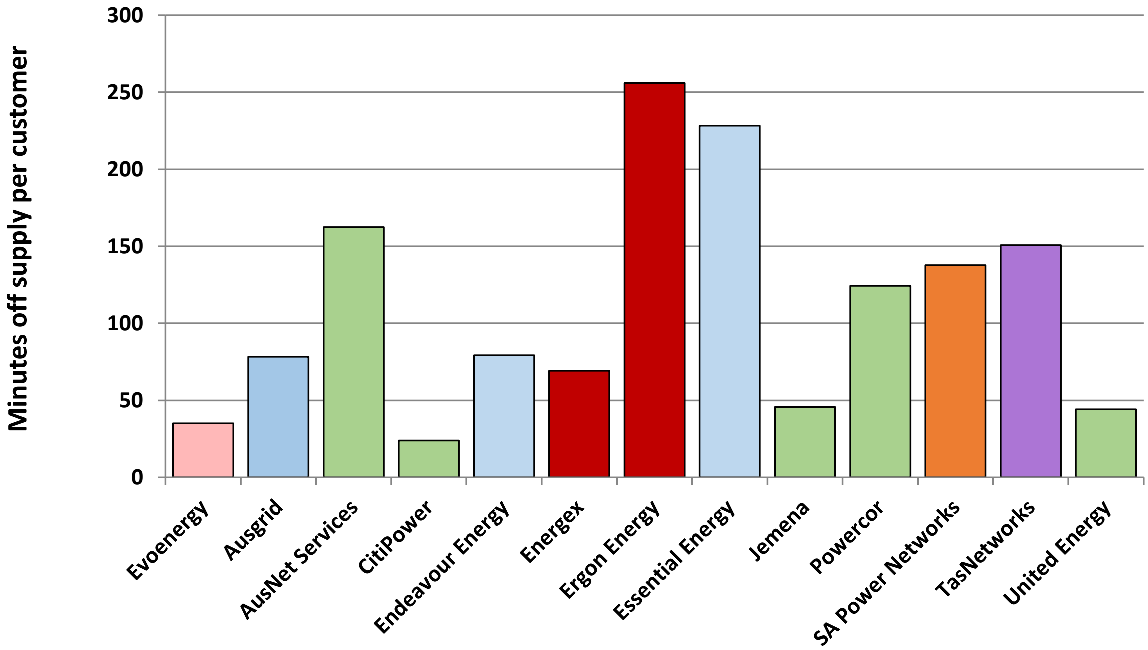


Source: Economic Benchmarking RIN.

Reliability

Another dimension of the outputs of DNSPs is the reliability of their electricity supply. This is commonly measured as the average number of minutes off-supply per customer (per annum) or the average number of interruptions per customer. Figure B.7 presents for each DNSP the average annual number of minutes off-supply per customer over the 2016-20 period, excluding the effects of major events, planned outages and transmission outages.

Figure B.7 Average annual minutes off supply per customer (2016–2020)

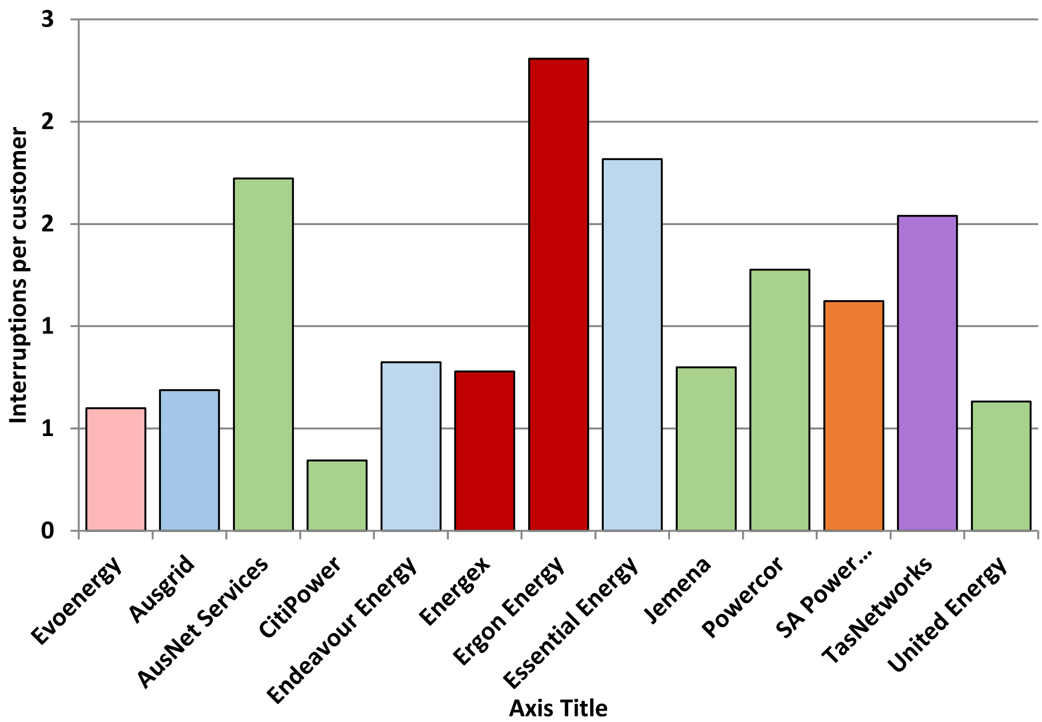


Source: Economic Benchmarking RIN.

Figure B.8 presents the average annual number of interruptions to supply per customer, excluding the effects of major events, planned outages and transmission outages. There are other measurements of reliability but the frequency and duration of interruptions to supply per customer are the Institute of Electrical and Electronics Engineers (IEEE) standard measures for DNSPs.

For productivity measurement purposes we use the number of customer minutes off-supply aggregated across all customers as the reliability output.

Figure B.8 Average annual number of interruptions per customer (2016–2020)



Source: Economic Benchmarking RIN.

Inputs

The inputs used in this report are capital (assets) and opex. DNSPs use a mix of assets and opex to deliver services. Electricity assets can provide useful service over several decades. However, benchmarking studies typically focus on a shorter period of time.

For our MTFP and TFP analyses we use physical measures of capital inputs. Using physical values for capital inputs has the advantage of best reflecting the physical depreciation profile of DNSP assets. Our MTFP and TFP analyses use five physical measures of capital inputs: the capacity of transformers, overhead lines of 33kV and above, overhead lines below 33kV, underground cables of 33kV and above, and underground cables below 33kV. The MTFP and TFP analyses also use constant dollar opex as an input. The November 2014 Economic Insights report referred to in Appendix A provides further detail on the capital inputs for MTFP and TFP.

For the purpose of PPI analysis we use the real value of the regulatory asset base as the proxy for assets as the starting point in deriving the real cost of using those assets. To be consistent with Economic Insights' MTFP and TFP analyses, and in response to a submission by Ausgrid,[105] we have adjusted the PPI analysis to remove assets associated with the first-stage of the two-step transformation at the zone substation level for those DNSPs with more complex system structures. This allows better like-with-like comparisons to be made across DNSPs.

Asset cost is the sum of annual depreciation and return on investment and is referred to as the annual user cost of capital.[106] This measure has the advantage of reflecting the total cost of assets for which customers are billed on an annual basis, using the average return on capital over the period. This accounts for variations in the return on capital across DNSPs and over time.

Table B.2 presents measures of the cost of network inputs relevant to opex and assets for all DNSPs. We have presented the average annual network costs over five years in this table to moderate the effect of any one-off fluctuations in cost.

Table B.2 Average annual input costs for 2016–20 ($m, 2020)

	Opex	Annual user cost of capital
Evoenergy (EVO)	52.5	103.0
Ausgrid (AGD)	509.9	1,094.9
AusNet (AND)	219.4	348.9
CitiPower (CIT)	55.6	158.0
Endeavour Energy (END)	273.5	425.7
Energex (ENX)	365.8	645.7

[105] Ausgrid, *Submission on the DNSP annual benchmarking report 2016*, 14 October 2016, p. 3.

[106] *To calculate the annual user cost of assets relevant to PPIs, MTFP, TFP, Capital MPFP and Capital PFP, where possible we have applied annual weighted average cost of capital values calculated in accordance with the AER's approach to setting rate of return in the most recent determination.* As noted earlier, we have updated the calculation of the annual user cost of capital to reflect the AER's Rate of Return Instrument 2018 for regulatory year 2020. In previous years the annual user cost of capital calculations broadly reflected the 2013 rate of return guideline. See: https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/rate-of-return-instrument-2018/final-decision.

	Opex	Annual user cost of capital
Ergon Energy (ERG)	382.4	655.0
Essential Energy (ESS)	370.9	612.2
Jemena (JEN)	83.6	123.4
Powercor (PCR)	184.7	305.9
SA Power Networks (SAP)	252.6	432.7
TasNetworks (TND)	85.9	154.3
United Energy (UED)	127.3	225.3

Source: Economic Benchmarking RIN; AER analysis.