Annual Benchmarking Report

Electricity distribution network service providers

November 2023

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 environmental policies).

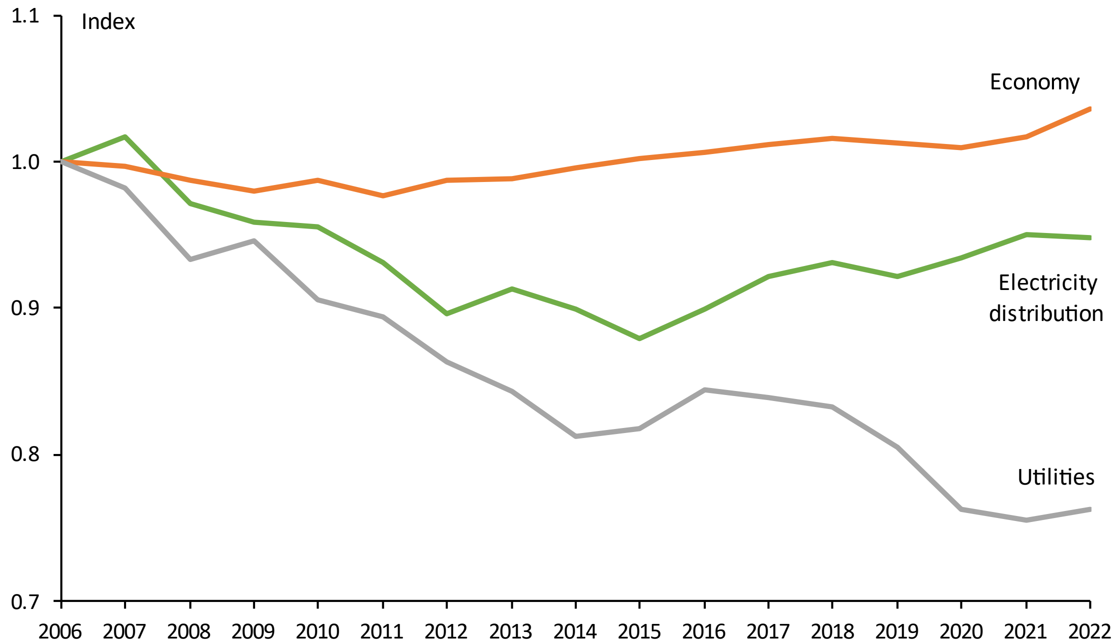
We use economic benchmarking to measure how productively efficient these networks are at delivering electricity distribution services over time and compared with their peers. Where distribution networks become more efficient, customers should benefit through downward pressure on network charges and customer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

In preparing this benchmarking report, we have taken into account stakeholder views received through our consultation process.

Distribution network industry productivity decreased slightly in 2022, against a trend of increasing productivity since 2015

Electricity distribution productivity, as measured by time series multilateral total factor productivity (TFP) analysis decreased by 0.2% over 2022 (see Figure 1). This decrease contrasts with the upward trend since 2015, which was only once interrupted by a 1.1% decline in 2019. The slight decrease in distribution network productivity in 2022 is primarily due to decreases in reliability due to storm events for all but one DNSP. This followed an improvement in reliability across most DNSPs in 2021, the most significant driver of higher productivity for that year. This year’s productivity decrease sits against a backdrop of increased productivity in the broader utilities sector (electricity, gas, water and waste services) (0.9%) and the Australian market economy (1.9%) over the same period.

Figure 1 Electricity distribution, utility sector, and economy productivity, 2006–2022



Source: Quantonomics; AER analysis.

Changes in DNSP productivity over 2022

Five of the 13 DNSPs improved their relative productivity as measured by panel multilateral total factor productivity (MTFP) comparative analysis over 2022.

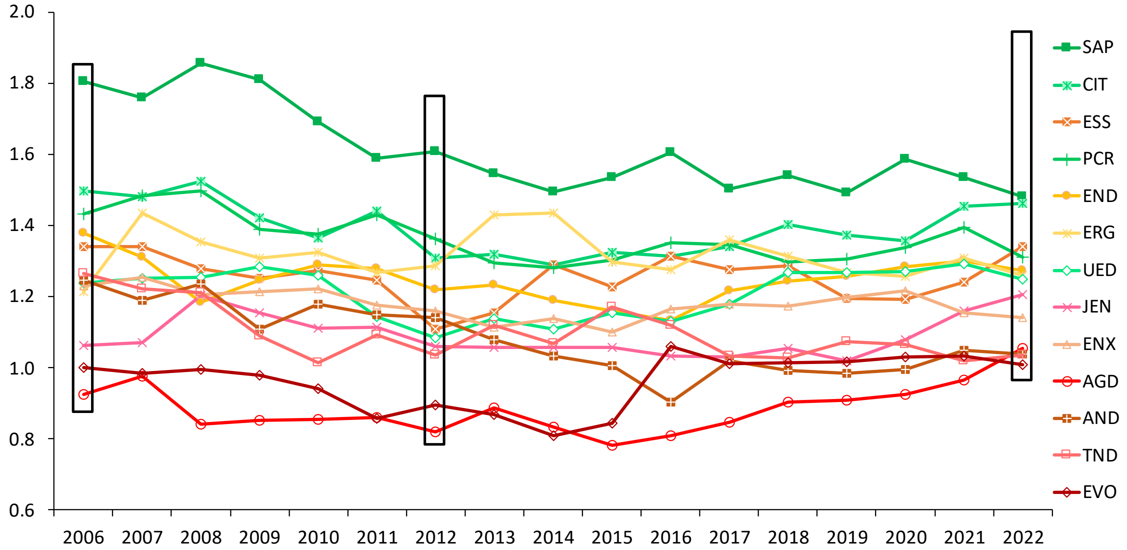
Ausgrid and Essential Energy increased their productivity the most over 2022, by 8.9% and 7.6% respectively. Jemena increased its productivity by 4.0% while TasNetworks and CitiPower had somewhat smaller productivity increases of 1.6% and 0.4% respectively. Improved operating expenditure (opex) multilateral partial factor productivity (PFP), reflecting lower opex, was the primary driver of Ausgrid, Essential Energy and Jemena's increased productivity.

Over the same period, eight DNSPs became less productive. Powercor had the largest decrease in productivity of 6.2%. Ergon Energy, SA Power Networks and United Energy all had reductions in productivity between 3% and 4%. Evoenergy and Endeavour Energy saw productivity declines between 2% and 2.5%, while Energex and AusNet Services had small productivity decreases of 1.3% and 1.0% respectively. Decreased reliability was generally the main source of the lower productivity across these DNSPs.

Figure 2 compares the levels of productivity between DNSPs and over time. It highlights the variability in productivity observed for individual DNSPs from year-to-year and emphasises the importance of considering the changes in productivity observed in 2022 in the context of longer-term trends.

MTFP accounts for some material differences in the environments in which DNSPs operate. We consider the four outputs measured in the MTFP benchmarking are material drivers of opex and capital inputs and allow for the differences in customer, energy and demand density across DNSPs. That said, not all material operating environment differences are incorporated, and this is important to note when considering the relative efficiency and rankings between DNSPs. Beyond the above factors some DNSPs may operate in more or less favourable operating environments than their peers, and thus may appear more or less efficient than they otherwise would.

Figure 2 Electricity distribution MTFP indexes by DNSP, 2006–2022



Source: Quantonomics, 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 the panel MTFP. This can be seen from the three equal-sized, black-bordered columns placed in 2006, 2012 and 2022 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, noting Evoenergy's slight decline since 2016.
- 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, Jemena, Endeavour Energy and Essential Energy, again reflecting improved opex efficiency.
- Further, while Powercor, SA Power Networks and CitiPower have consistently been the most productive DNSPs in the NEM, they have experienced a gradual overall decline in productivity for most of the period since 2006. The productivity of SA Power Networks is now much closer to the DNSPs that are middle-ranked. Their declines in MTFP are primarily due to higher opex, including as a result of new regulatory obligations among other factors. However, since 2014 there has

been a general 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. In this year's report, we present productivity results based on the approaches used in previous benchmarking reports. We also present the MTFP, multilateral partial factor productivity (MPFP) and econometric opex cost function results based on our preferred approach to addressing differences in capitalisation between DNSPs, as reflected in our final guidance note on this issue released in May 2023. The MTFP and MPFP models have been updated using a preliminary, fit for purpose, method for data adjustment that we will consult further on for future reports. The key messages outlined above in relation to the MTFP results, and observations around DNSPs' performance, broadly hold for these updated results.

We have made minor updates and adjustments to our benchmarking data along with the addition of new data for 2022. This year, we have also undertaken work to identify and adjust our benchmarking data for inconsistent accounting treatment of software-as-a-service (SaaS) implementation costs and lease costs across DNSPs.

We are currently undertaking development work relating to:

- Monitoring the availability of export services data with a view to commencing a further a review by 2027 in relation to what, if any, changes should be made to the benchmarking models to ensure productivity is appropriately measured.
- Addressing the impact of capitalisation differences between DNSPs.

We are also proposing to undertake future development work prioritising issues relating to:

- Independently reviewing the non-reliability output weights used in the Productivity Index Number (PIN) benchmarking method. To commence in 2023-24.
- Further investigating and improving where possible, the reliability performance of the Translog econometric opex cost function models, including in relation to satisfying the key monotonicity property that an increase in output can only be achieved with an increase in inputs, holding other things constant. This will occur over 2024 for the 2024 Annual Benchmarking Report.
- Reviewing the appropriateness of the current benchmarking comparison point. This was highlighted as part of our recent review of incentive schemes for regulated networks and in the final guidance note in relation to addressing capitalisation differences in benchmarking (where our initial modelling showed relative efficiency scores for DNSPs increased). This is likely to commence from 2025-26.

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 tenth benchmarking report for DNSPs. This report is informed by expert advice provided by Quantonomics.[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 using input to produce 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 2022, compared to 2021, and trends in productivity over the full period of our benchmarking analysis (2006–2022) as well as shorter time periods.[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

1 NER, cll 6.27(a) and 6.27(c).

2 The supplementary Quantonomics 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, we refer to *regulatory years.* For non-Victorian DNSPs, this is financial years (for example, 2022 refers to the 2021–22 financial year). For Victorian DNSPs, this is calendar years up to and including 2020, and financial years from 2021 (for example, 2020 refers to the 2020 calendar year, but 2021 refers to the 2020–21 financial year).

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.

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 comparison of productivity levels and trends over time and between networks. We use these PIN techniques for our:
  - Time-series multilateral total factor productivity (TFP) and capital and operating expenditure (opex) multilateral partial factor productivity analysis (PFP). TFP and capital and opex PFP results are used in this report to measure and compare changes in the productivity level of a single entity over time (i.e. whether productivity of the transmission industry as a whole or an individual TNSP has increased or decreased over time).
  - Panel data multilateral total factor productivity (MTFP) and capital and opex multilateral partial factor productivity analysis (MPFP). MTFP and capital and opex MPFP results are used in this report to measure and compare changes in 'relative productivity' over time (i.e. whether a given TNSP has a higher or lower productivity level relative to other TNSPs at a point in time and over time).
- **Econometric operating expenditure (opex) cost function models**. These estimate opex (as the input) as a function of outputs and some other operating environment factors (OEFs) to measure opex efficiency.
- **Partial performance indicators (PPIs)**. These simple ratio methods relate one input to one output. We use PPIs to examine relative performance across DNSPs.

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 across DNSPs and changes over time. These include considering those material OEFs that may not have been accounted for in the benchmarking modelling (see Section 7).

The time-series and panel data-based PIN techniques we use in this report to measure the productivity performance of DNSPs in the NEM both rely on multilateral productivity indexes. 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. Opex or capital 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 and consider the results from the different benchmarking techniques collectively in order to 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 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, 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 econometric opex cost function models are central in this assessment (as presented in Section 5). Importantly, this needs to include consideration and quantification of material OEFs that are not directly incorporated into these models (as presented in Section 7). Reflecting our collective use of the benchmarking techniques, we use the other approaches to qualitatively cross-check and confirm the results from the econometric opex cost function models.

What is multilateral total factor productivity?

TFP 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 a given level of outputs using less inputs, this reflects an increase in its productivity. MTFP and MPFP analysis 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. Energy throughput is a measure of the amount of electricity that DNSPs deliver to their customers (about 9% weight).
- Reliability (Customer 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 customer 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, which are used by Quantonomics in producing this year's results. We also discuss the outputs and inputs used further in Appendix B.

In order to assist with the ability to understand these inputs and outputs, as well as how they are used in the benchmarking analysis, we have provided some further detail in relation to these variables.

In terms of the inputs being used in the benchmarking analysis:

- The opex input reflects the costs associated with the labour, materials and services that are purchased and consumed in a given year. These costs are deflated by a price index of these inputs to establish a quantity measure of opex.
- The capital inputs, such as transformers and overhead lines and underground cables, measure the physical quantity of the assets (e.g. capacity*kilometres of overhead lines or capacity of transformers). This is used as a proxy for annual capital service flow as we assume relatively constant flow of services over the life of an asset, and thus that the annual flow is proportionate to capital stock.

At the start of the benchmarking program there was general agreement that outputs should be included on a functional rather than billed basis. This reflected that under the building block model approach to regulation there is not typically a direct link between the revenue requirement and how a DNSP structures its prices.[5] It was also noted that the outputs included should reflect services provided directly to customers, rather than activities undertaken by the DNSP which do not directly affect what the customer receives. In terms of the outputs being used in the benchmarking analysis and the services provided:

- Customer numbers provides a measure of the services and benefits ultimately provided to end users of the distribution networks regardless of how much they consume. It is an indicator of network complexity and connectivity.
- Circuit length reflects the geographic distribution of customers that DNSPs need to construct networks to connect in order to deliver energy. In combination with customer numbers, these variables will reflect the impact of different levels of end user density within an area on distribution costs.
- Ratcheted maximum demand reflects the (non-coincident) maximum demand from customers on the distribution network. The highest system peak demand observed in the period (up to the year in question) is used to give credit for the provision of capacity to meet higher maximum demand in the earlier years.

5 The AER generally sets the revenue requirement and then separately prices are set in order to recover this revenue requirement.

- Energy throughput reflects the energy delivered to customers.
- Reliability (Customer Minutes Off-Supply) reflects the extent to which networks are able to maintain a continuous supply of electricity.

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 Quantonomics and the benchmarking data and results files.

1.1 Updates in this benchmarking report

In this report we largely use the same benchmarking methodology as set out in previous reports. This includes the change introduced in the 2022 report to reflect that from the 2021 regulatory year the Victorian DNSPs submit for our use data on a financial year rather than a calendar year basis.

A key change in this year's report is that we present the MTFP, MPFP and econometric opex cost function results using our preferred method to address differences in capitalisation between DNSPs. We set out our preferred approach in our final guidance note released in May 2023.[6] This involves using DNSPs' opex under their 2022 Cost Allocation Methods (CAM) and including 100% of corporate overheads as opex for benchmarking purposes. The results implementing this approach are presented in Section 4 for the MTFP and MPFP modelling and in Section 5 for the econometric opex cost functions. This is a change from our previous approach of using opex under 2014 CAMs and only including those corporate overheads which are expensed. Given this is the first year we have implemented our preferred approach, for comparison we also present the MTFP, MPFP (Section 4) and the econometric opex cost function results (Section 5) using the previous approach. The TFP results for the distribution industry (Section 3) have not been impacted in this year's report.

We have implemented our preferred approach to adjusting for capitalisation differences to our MTFP and MPFP models using a preliminary, fit for purpose, method. This was in response to stakeholder submissions to Quantonomics' preliminary results for 2023 which did not make this change. The preliminary approach adjusts the annual user cost of capital (AUC) by removing capitalised corporate overheads from capital expenditure (capex). We will consult further on this approach for future reports to determine whether it needs to be refined or can be retained.

In relation to benchmarking data, for this report we have adjusted some of the historical

6 AER, *How the AER will assess the impact of capitalisation differences on our benchmarking, Final Guidance Note*, May 2023.

data we use after considering potential inconsistencies in how lease and Software as a Service (SaaS) implementation costs are reported by DNSPs. Accounting standard AASB16, which became effective for periods beginning on or after 1 January 2019, states that leases are to be considered as capex.[7] Guidance from the International Financial Reporting Standards (IFRS) noted in April 2021 that SaaS configuration costs are considered as opex under some circumstances.[8]

We have come to understand, after consultation with DNSPs, that adoption of new accounting standards is often delayed for the purpose of regulatory reporting (which we rely on as the source of our benchmarking data). These delays maintain consistency over each DNSP's regulatory control period, and the adoption will be assessed as part of their subsequent revenue determinations. Due to the staggered starting dates of regulatory control periods for DNSPs in the NEM, the adoption of the accounting standards discussed above has not been uniform.

Our benchmarking relies on the assumption that benchmarking data is reported consistently across DNSPs in accordance with instructions provided with our Regulatory Information Notice (RIN) templates. For this reason, our position on leases and SaaS implementation costs is that they should be considered under the legacy standard for the purpose of benchmarking. This is until a future date at which most or all DNSPs have transitioned onto the current reporting standards and an approach to recasting the historical cost to be on a consistent basis has been determined.

Our review found that there has been some inconsistency in terms of the reporting of leases and SaaS implementation costs between DNSPs. The majority of DNSPs reported both lease and SaaS implementation costs under the legacy standards (leases as opex and SaaS implementation as capex) in 2021–22, the final year of data included in this benchmarking report. However, Jemena, AusNet Services and Essential Energy confirmed they reported either leases and / or SaaS implementation costs under the new standards in part of the period up to and including 2021–22. As noted below, this has generally been to reflect the treatment of these costs in their most recent revenue determinations.

In this regard, through consultation with these DNSPs:

- Jemena provided adjusted 2021–22 data which reports SaaS implementation costs under the legacy standard (as capex rather than opex).
- AusNet Services provided adjustments to its 2019, 2020, 2020–21 and 2021–22[9]

7 Australian Accounting Standards Board, *Leases (AASB 16)*, February 2016.

8 IFRS, *Configuration Costs in a Cloud Computing Arrangement – IAS 38*, April 2021.

9 As outlined above, Victorian DNSPs moved from calendar year reporting to financial year reporting in 2021, coinciding with the commencement of their current regulatory control periods.

data. In order to align with the legacy accounting treatments, these adjustments reported lease costs as opex rather than on a capitalised basis over the entire period of interest. AusNet Services also reported SaaS implementation costs as capex rather than opex in 2021–22 as part of its adjustments. These adjustments resulted in increases to AusNet Services' opex in 2019, 2020 and 2020–21. In 2021–22, the opposing direction of adjustments to lease and SaaS implementation costs, and the greater magnitude of SaaS implementation costs relative to leases, meant that opex was adjusted downward while the regulatory asset base (RAB) was adjusted upward.

- Essential Energy was the first DNSP to adopt the new accounting standard for leases and reported lease costs as capex (instead of opex as the other NSW DNSPs do) since the commencement of its 2019–24 regulatory control period. This was in line with instructions specified in its regulatory determination for this period.[10] Essential Energy has committed to providing us adjusted opex and RAB figures in preparation for the 2024 Annual Benchmarking Report due to the number of years affected and the complexity of required adjustments. As a result, Essential Energy's opex is currently slightly understated relative to all other DNSPs in the period 2019–2022.

We will continue to monitor the basis upon which lease and SaaS implementation costs are reported by DNSPs, while consulting with individual DNSPs in circumstances where we require adjusted data to maintain cross-DNSP consistency.

This report also includes a number of other 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 benchmarking dataset published on our website.[11]

We have also developed a *customer friendly* benchmarking overview that is available on the AER's website to assist stakeholders to better understand the economic benchmarking, how it is used and the results.[12] We have done this and published it alongside this year's report.

1.2 Benchmarking development program

We seek to progressively review and incrementally refine elements of the

10 AER, *Essential Energy 2019-24 Draft decision, Attachment 5, Capital expenditure,* November 2018, pp. 61–62.

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

12 Powerlink, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity transmission network service providers – Consultation stage 1,* 25 July 2023.

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. We consider our benchmarking development program, and the work we progress, taking into account a variety of factors as set out in Section 8.

This year we progressed two significant development issues. Firstly, our consideration of the impact of export services on benchmarking and our measurement of productivity. Through a public review we considered if changes to the productivity benchmarking were needed, and if so, how our benchmarking techniques could be updated to better account for export services. We published a final report in March 2023. This concluded that given the current lack of high-quality export services data, a full review should be undertaken by 2027, or earlier if better export services data becomes available.[13] In the interim, we stated we will monitor export service impacts and consult on, and collect, data that will be useful to inform the future review.

Secondly, we have completed our review of how we will assess the impact of capitalisation differences on the benchmarking results. As noted above, we published a final guidance note on this issue in May 2023. This noted our view on the materiality of capitalisation differences on benchmarking results, our preferred approach to addressing the issue and matters related to implementing our preferred approach.[14] We have implemented this approach in this report by presenting the MTFP, MPFP (Section 4) and econometric opex cost function (Section 5) results, both in terms of our previous approach and those derived using our preferred approach to addressing differences in capitalisation between DNSPs. We will continue to work through issues related to incorporation of the preferred approach in future annual benchmarking reports, including the preliminary, fit for purpose, method to adjust the AUC data used for the MTFP and MPFP results.

We have also continued to examine possible options for improving the performance of the Translog econometric opex cost function models. Quantonomics has undertaken some additional work to consider possible options for improving the performance of these models and we intend to engage with interested stakeholders to consider these, and any other, options. We discuss this issue and our approach to working with stakeholders as a part of preparing the 2024 Annual Benchmarking Report in Section 8.2.2.

A further important piece of development work is an independent review of the non-reliability output weights. This follows the changes we made in the 2020 Annual Benchmarking Report for distribution to the non-reliability output weights used in the

13 AER, *Incentivising and measuring export service performance – Final report*, March 2023

14 AER, *How the AER will assess the impact of capitalisation differences on our benchmarking, Final Guidance Note*, May 2023.

PIN benchmarking to correct an error identified in how these had been calculated in previous years' reports. We scoped this review and included these details in our 2021 Annual Benchmarking report. It remains an important development priority and we aim for the review to commence in 2023–24.

Beyond this, in following years we will prioritise examining the choice of the benchmarking comparison point used to examine the efficiency score results from the econometric opex cost function models in the context of revenue determinations. These are specifically used when assessing the efficiency of a DNSP's base year opex. This is likely to occur after the conclusion of the next 'round' of revenue determinations, i.e. from 2025–26 after the Victorian DNSP resets.

We will also make other incremental improvements as our resourcing permits, including as part of the preparation of the annual benchmarking reports and as specifically raised in revenue determinations. This includes incrementally improving our approach to OEFs and other issues as they arise, such as the impact on benchmarking of the newly added National Energy Objective around emissions reduction. In terms of this new objective, this will likely include examining if / how emissions reductions are / should be captured in our benchmarking models.

1.3 Consultation and how we have responded

In developing this report, we have undertaken consultation with external stakeholders in two stages, consistent with the approach we adopted in previous years. Firstly, this involved consultation in relation to the preliminary benchmarking results and report prepared by our consultant, Quantonomics. Secondly, there was further consultation in relation to a draft of this year's annual benchmarking report. We sought submissions from DNSPs and other stakeholders, including customer representative groups.

The main issues raised and our response to each are discussed below.

Updates suggested to the 2023 Annual Benchmarking Reports

Several DNSPs suggested updating our MTFP and MPFP models, not just the econometric opex cost function models, to implement our preferred approach to addressing differences in capitalisation between DNSPs. They considered this was important given the use of these models to validate the results of the econometric opex cost function models.[15] Some DNSPs also included suggested methods to update these models.

In response to these suggestions, we have included MTFP and MPFP results in this report which implement our preferred approach for addressing capitalisation differences. This uses what we consider is a preliminary, fit for purpose, method as outlined in Section 4 and described in detail in Quantonomics' report (Appendix A5).[16] This method is not dissimilar to that AusNet Services outlined when suggesting the update, and following its review considers is appropriate for this year's report.[17] Ausgrid also supported the approach used, noting it is simple but transparent and fit for purpose.[18] TasNetworks also agreed the approach is sufficient for this year.[19] SA Power Networks considered the updated MTFP and MPFP scores as consistent with its expectations and supported their inclusion in this year's benchmarking report.[20]

We note these views, along with the feedback AusNet Services and TasNetworks provided supporting further engagement to refine the approach. Ausgrid also provided specific suggestions around how it considered the approach could be refined. Given this, and that the timeframes for the review of these results and the changes was relatively short, we will consult further on this approach for future reports to determine whether it should be refined or retained.

We also received feedback that it was appropriate to update the MTFP and MPFP models to incorporate revised output weights given the time that has passed since the

[15] AusNet Services, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023; Energex and Ergon Energy, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023; Ausgrid, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023; Evoenergy, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023.

[16] Quantonomics, *Economic Benchmarking Results for the Australian Energy Regulator's 2023 DNSP Annual Benchmarking Report*, November 2023, pp. 151–152.

[17] AusNet Services, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 26 October 2023.

[18] Ausgrid, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 27 October 2023.

[19] TasNetworks, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 20 October 2023.

[20] SA Power Networks, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 6 November 2023.

last update, as well as recent revisions to the historical benchmarking data.[21] Some DNSPs also called on these output weights to be updated on an annual basis, consistent with the econometric opex cost function models.

Our benchmarking development program (see Section 8) highlights our plan to commence an independent review of output weights that we aim to commence in 2023–24. In light of this upcoming review, as well as our preference to update the output weights periodically (roughly every 5 years), we do not intend to update the output weights prior to this independent review.

Some DNSPs also suggested providing greater clarity on adjustments made to lease and SaaS implementation costs in the benchmarking data this year.[22] We have included a summary of adjustments made to lease and SaaS implementation costs in Section 1.1 of this report.

Econometric opex cost function development issues

We also received submissions from stakeholders relating to issues with our econometric opex cost function models and associated development work, some of which touched on recurring themes raised in previous submissions.

Several submissions noted that monotonicity violations in the Translog models are worsening and called for prioritisation of development work in relation to this issue. In addition, they stated that the results of the Translog models should either be used with

21 Energex and Ergon Energy, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023; Energex and Ergon Energy, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 27 October 2023; Ausgrid, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023; Ausgrid, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 20 October 2023; Evoenergy, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023.

22 Jemena, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023.

great caution or not used at all unless this issue is resolved.[23] Further, some DNSPs suggested that monotonicity violations could be addressed by incorporating into the Translog models different time trends between jurisdictions to allow for diverging efficiency changes.[24]

We note the continued presence of monotonicity violations in our econometric cost function modelling. With the input of Quantonomics we are considering options to address this outcome and we intend to engage with interested stakeholders to consider these, and any other, option, as set out in Section 8.2.2. While this development work is ongoing, we consider our current definition of monotonicity violations, and our current approach to how these are addressed, is appropriate and exercises the required caution. In this regard, we do not use the Translog model efficiency score results for a DNSP in determining its average efficiency score when there are excessive monotonicity violations for a majority of observations for the DNSP, or for the majority of Australian DNSPs.

Ausgrid and Evoenergy also raised that results from the Stochastic Frontier Analysis (SFA) Translog model for the short period do not appear to be estimated correctly and are not a maximum.[25] According to Ausgrid, and its consultant, when estimated correctly, the model provides implausible efficiency scores.[26] Ausgrid also noted that its

23 AusNet Services, *Submission to Quantonomics memorandum,* 9 February 2023; Ausgrid, *Submission to Quantonomics memorandum*, 10 February 2023; Ausgrid, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023; Evoenergy, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023; Jemena, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023; Energex and Ergon Energy, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023; Ausgrid, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 20 October 2023.

24 Ausgrid, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023; Ausgrid, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 20 October 2023; Evoenergy, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023.

25 Ausgrid, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023; Ausgrid, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 20 October 2023; Evoenergy, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023.

26 Ausgrid, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity*

efficiency scores from the SFA Translog models seem implausible compared to the results from the other three econometric models.[27]

We sought supporting analysis from Ausgrid and Evoenergy and have worked with Quantonomics to examine the concerns raised around the validity of our SFA Translog results. Quantonomics disagrees with the conclusion that the results are not a maximum, particularly as this conclusion relies on results from a model that did not converge.[28]

Evoenergy also considered the Cobb-Douglas models are mis-specified and that it is hard to find a statistical justification for including the Cobb-Douglas model results.[29] We consider the use of average efficiency scores of more than one benchmarking model can help to ensure that efficiency assessment is not too dependent on one model specification, given they have different strengths and weaknesses and potential specification errors. In that regard, there are several criteria that can be used when evaluating models and which demonstrate their strength and weaknesses. For example, joint significance, goodness-of-fit and the meaningful economic interpretation of parameters. Considering these collectively, we do not consider the Translog model is unambiguously better than the Cobb-Douglas model.

Several DNSPs also requested that a program of work should be developed to address the issues identified with the econometric opex cost function models.[30] We agree with this suggestion, and as noted above, with input from Quantonomics, are considering options to address these issues. We are intending to engage with stakeholders as a part of preparing the 2024 Annual Benchmarking Report to consider these and any

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distribution network service providers – Consultation stage 1, 4 September 2023; Ausgrid, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 20 October 2023.

27 Ausgrid, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023.

28 Quantonomics, *Opex Cost Function-Options to Address Performance Issues with Translog models*, October 2023, p. 39.

29 Evoenergy; *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023.

30 Energex and Ergon Energy, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023; Energex and Ergon Energy, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 27 October 2023; Evoenergy, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023.

other options as set out in Section 8.2.2.

Other development issues

Ausgrid and Energy Queensland considered that the development work around the benchmarking comparison point used to examine the efficiency score results from the econometric opex cost function models should only occur once the issues and development work related to these models had been completed.[31] They considered that until this work has been finalised it was more appropriate to continue to use a conservative benchmarking comparison point to provide a margin for general limitations and uncertainties. In contrast, the Energy Users Association of Australia considered that this review should not wait until 2026 and should be undertaken sooner given recent productivity improvements.[32] As outlined above, and in section 8, at this stage, on balance, we are likely to undertake this review after the conclusion of the next 'round' of revenue determinations, i.e. from 2025–26 after the Victorian DNSP resets.

AusNet Services reiterated its position that GSLs should not be included in benchmarking and considered this could be addressed relatively quickly and easily rather than being deferred.[33] As noted in our 2022 Annual Benchmarking Report, we will investigate this as part of our future development work.

AusNet Services also requested consideration of a range of OEFs, raised in consultation with the AER, that it believes are either not accounted for or inadequately accounted for in benchmarking.[34] A separate point in AusNet Services' submission also sought clarification on whether more up-to-date data is required for the taxes and levies OEF. As noted in Section 7, we consider the current data fit for purpose as we have applied this approach consistently for all the Victorian DNSPs.

Ausgrid and Essential Energy also supported an overall / holistic review of OEFs,

31 Ausgrid, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 20 October 2023; Energex and Ergon Energy, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 27 October 2023.

32 Energy Users Association of Australia, *Email to the AER – Draft AER 2023 Annual Benchmarking Report for – Electricity distribution network service providers – Consultation stage 2*, 21 November 2023.

33 AusNet Services, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023; AusNet Services, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 19 October 2023.

34 AusNet Services, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023; AusNet Services, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 19 October 2023.

including refinement of the associated methodology and data, rather than these issues being addressed on a reset specific basis.[35] As noted in Section 1.2, we are prioritising other development issues ahead of refining and adding to our existing OEFs. We will consider the issues raised by these DNSPs as our resourcing permits, including as part of the preparation of revenue determinations.

Essential Energy and Energy Queensland considered that specific timeframes should be detailed around development work to enable stakeholders to better plan and resource this work and ensure issues seen to be priorities are addressed in a timely way.[36] Energy Queensland also considered issues should be prioritised which have a more direct bearing on revenue determinations and that these should be addressed through stand-alone processes. As outlined in Section 1.2, and set out in Section 8, we have set out the development work we will prioritise over the next few years and indicative timing.

Data updates

We also received submissions from Energy Queensland[37] and SA Power Networks[38] identifying potential errors in the benchmarking data. Energy Queensland's submission noted discrepancies in Energex's opex series used for benchmarking under the preferred approach to addressing differences in capitalisation between DNSPs. Energy Queensland noted discrepancies in Energex's opex from 2006–2008 and 2021–2022. SA Power Networks also noted inconsistencies between its 2022 RIN submission and the benchmarking data used to develop the results for the 2023 Annual Benchmarking Report. This concerned the capacity of its overhead 33kV and underground 7.6kV lines. We have confirmed the discrepancies raised by Energy Queensland and SA Power Networks as errors in the AER's benchmarking data.

Our analysis suggests that both errors identified have immaterial impacts on the benchmarking results. The discrepancies identified by Energy Queensland account for between 0.02% and 0.17% of Energex's total opex used in our capitalisation adjusted econometric opex cost function modelling in the affected years. The impact of this error

[35] Ausgrid, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 20 October 2023; Essential Energy, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 19 October 2023.

[36] Essential Energy, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 19 October 2023; Energex and Ergon Energy, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 27 October 2023.

[37] Energex and Ergon Energy, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023.

[38] SA Power Networks, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 7 September 2023.

is immaterial. The inconsistencies raised by SA Power Networks increase its 2021 and 2022 MTFP and Capital MPFP index scores by 0.001. There is no effect on SA Power Networks' rankings or growth rates presented in this report. The effects on other DNSPs' MTFP and MPFP results are even smaller in magnitude. Due to the immaterial nature of these errors, we did not update the data used to generate the results presented in this report. However, we will make these corrections as part of next year's 2024 Annual Benchmarking Report data preparation.

Consolidation of Appendix B: Benchmarking models and data

As a possible way to streamline the benchmarking reports, we also consulted stakeholders on whether Appendix B, which provides an overview of the economic benchmarking techniques and data we use, could be removed from these reports. We suggested options for consolidating some of the information in the appendix into the main body of the report or referencing where it could be found in other supporting documents we publish.

There was a limited and mixed response in submissions to the idea. TasNetworks Distribution did not support removing the appendix as it considered it provided useful context for readers and a concise summary of our benchmarking techniques. Of the transmission businesses, Powerlink supported removing the appendix while AusNet Transmission did not have any concerns with the idea. The Energy Users Association of Australia also supported retaining the appendix noting it is helpful to have all this information on the benchmarking techniques in one place. [39]

Given these responses, we have retained the appendix in this year's report. We will reconsider options for presenting a more concise overview of our benchmarking techniques and data, and consult more widely on a way forward, as part of next year's reports.

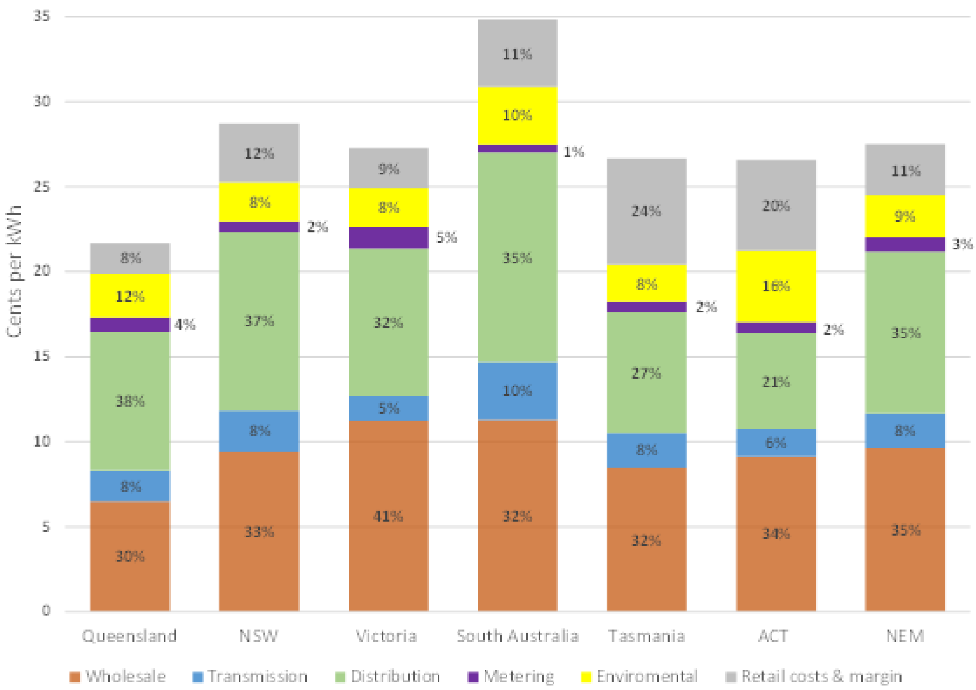
[39] TasNetworks, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 20 October 2023; Powerlink, *Email to AER – AER 2023 Annual Benchmarking Report for transmission - draft AER benchmarking report for consultation,* 18 October 2023; AusNet, *Email to AER – AER 2023 Annual Benchmarking Report for transmission - draft AER benchmarking report for consultation*, 9 October, 2023; Energy Users Association of Australia, *Email to the AER – AER 2023 Annual Benchmarking Report for transmission - draft AER benchmarking report for consultation*, 23 October, 2023.

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.[40] The remainder covers the costs of generating, transmitting and retailing electricity, as well as various regulatory programs related to environmental policies. Figure 3 provides an overview of the typical electricity retail bill.

Figure 3 Network costs as a proportion of retail electricity bills, 2021



Source: AEMC, *Residential Electricity Price Trends 2021,* Final Report, November 2021.

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

40 AEMC, *Residential electricity price trends 2021, Final Report*, November 2021. The AEMC noted it will publish its next Residential Electricity Price Trends report in late 2024. As this is not yet available, we have used its December 2021 report. See https://www.aemc.gov.au/news-centre/media-releases/update-residential-electricity-prices-report.

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 requires at the start of each five-year regulatory period. The AER determines network revenues through a 'propose-respond' framework.[41] 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 capex and opex, and to publish the benchmarking results in this annual benchmarking report.[42] The AEMC added 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.[43]

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

41 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. For more details, see: https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/expenditure-forecast-assessment-guideline-2013.

42 NER, cll. 6.27(a), 6.5.6(e)(4) and 6.5.7(e)(4).

43 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.

expenditure reviews.[44]

We use the economic benchmarking techniques described in Section 1 in a variety of holistic and targeted ways when assessing and amending network revenue proposals. The TFP and MTFP techniques are primarily used to measure total input efficiency. The econometric opex cost function results are used to test opex efficiency of DNSPs, supported and calibrated by the opex MPFP technique. The capital PFP and MPFP results also provide information on the efficiency of capital inputs. The PPIs provide supplementary information on how efficiently a network may be using particularly inputs. Taken together, these benchmarking techniques give us an additional source of information on the efficiency of historical network opex and capital inputs and the appropriateness of basing forecasts on them.

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 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.

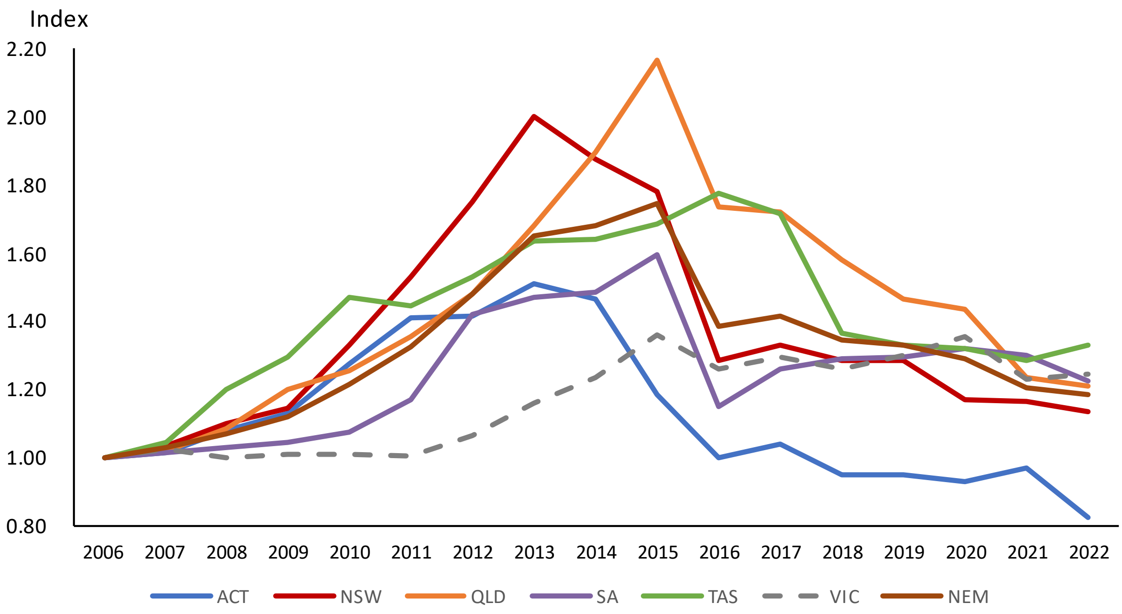
Since 2014, the AER has used benchmarking in various ways to inform our assessments of network expenditure proposals. Our economic benchmarking analysis has been one contributor to the reductions in network costs and revenues for DNSPs and minimising retail prices, and retail price increases, faced by 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 from 2007 to 2013, which contributed to

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

the large increases in retail electricity prices.[45] 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, 2006–2022



Source: Economic Benchmarking Regulatory Information Notices (RIN); AER analysis.

45 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 TFP analysis, decreased by 0.2% in 2022. The only significant factor driving lower productivity was a decrease in reliability (contributing -2.1 percentage points to the productivity decline). All other outputs, as well as some inputs, contributed to increasing TFP, particularly the opex input which contributed 1.0 percentage points to productivity growth.
- This year's decrease in TFP follows an increase in 2021 (+1.8%) and marks the first decrease in TFP since 2019. TFP for the distribution industry has generally followed an upward trend since 2015.
- Distribution industry TFP decreased in 2022, whereas there were productivity improvements in the utilities sector (0.9%) more broadly and the overall Australian market economy (1.9%).
- Distribution industry TFP has decreased slightly over the period 2006–2022 (-0.3% per annum)[46], with the long-term decline in capital partial factor productivity (-0.9% per annum) driving this result.

This section presents TFP results at the electricity distribution industry level over the 2006–2022 period and specifically for the regulatory year 2022. As set out in Section 1, TFP results are used in this report to measure and compare changes in productivity of a single entity (e.g. the distribution industry or a DNSP) over time. We also set out below the input and output drivers, and their contribution to the industry-wide productivity change in 2022. The variability in productivity from year-to-year can be seen in the results below and emphasises the importance of considering the changes in productivity in 2022 in the context of longer-term trends.

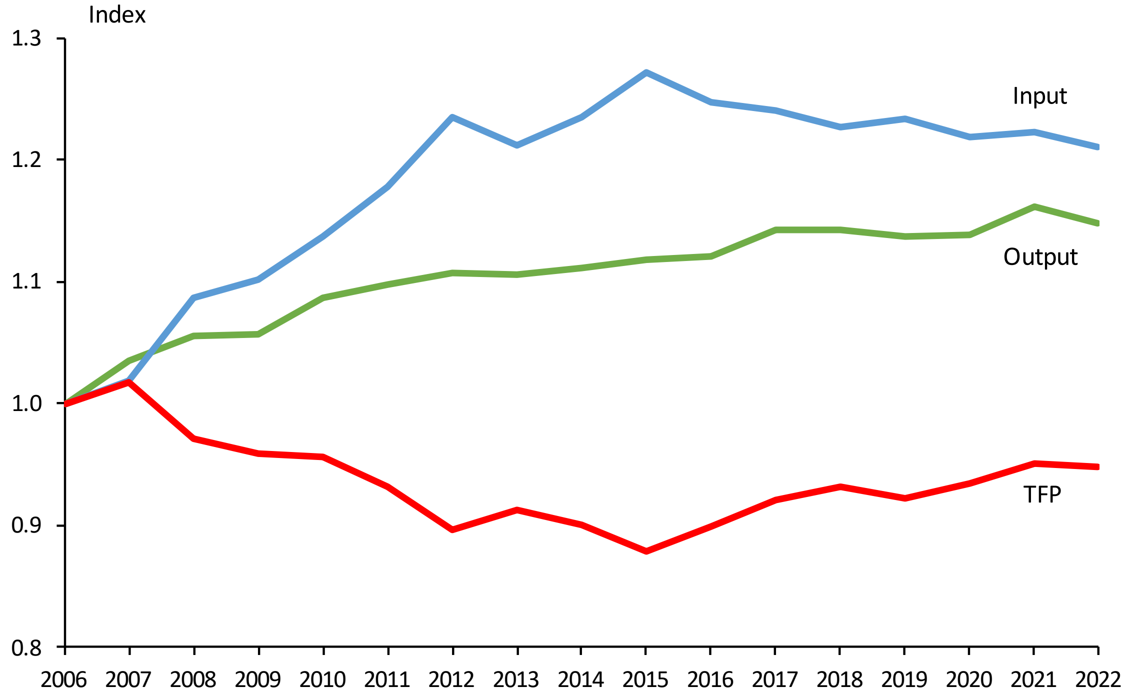
Industry-wide productivity decreased by 0.2% in 2022. The result was largely driven by a decrease in reliability (contributing -2.1 percentage points to TFP decline). Opex reductions were the main positive contributor to TFP over the year (contributing 1.0 percentage point to TFP growth). Some other inputs and outputs also contributed positively, albeit with lower magnitude. Collectively the non-reliability outputs and the capital inputs contributed 0.9 percentage points to TFP growth. While reliability can

[46] We note that percentage changes in this report are calculated as logarithm differences, accounting for compounding over multi-year periods.

fluctuate from year to year, as shown in Figure 5, the TFP decrease in 2022 follows two consecutive years of TFP increases (1.8% in 2021 and 1.3% in 2020). Despite the slight reduction in TFP in 2022, we still observe a generally upward trend in distribution industry productivity since 2015.

Figure 5 also shows that over the 2006–2022 period, TFP for the electricity distribution industry declined, by 0.3% per year on average. Over this 17-year period, input use grew faster (1.2% per year on average) than outputs (0.9% per year on average).

Figure 5 Industry-level distribution input, output and TFP indices, 2006–2022

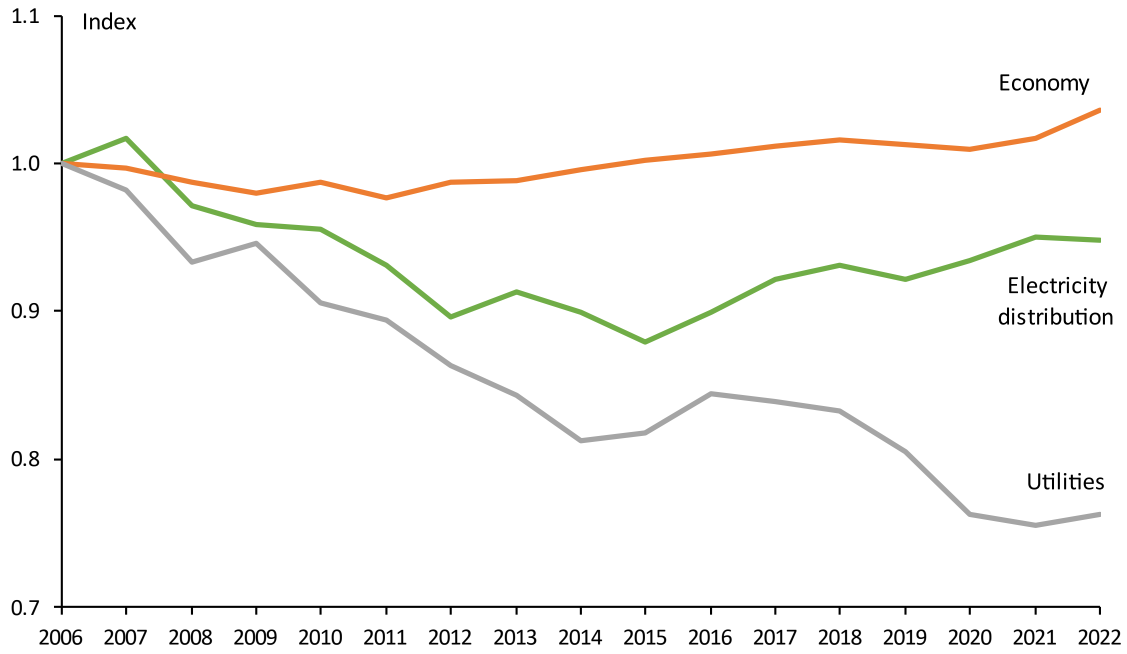


Source: Quantonomics

Figure 6 compares the time series multilateral TFP of the electricity distribution industry over time relative to productivity estimates of the overall Australian economy and utilities sector.[47] Distribution industry productivity decreased in 2022, while there were improvements in the utilities sector (0.9%) as well as the Australian market economy (1.9%). Growth in electricity distribution productivity has been higher on average than that of both the Australian economy and the utilities sector since 2015.

47 Electricity, gas, water and waste services (EGWWS).

Figure 6 Electricity distribution, utility sector, and economy productivity, 2006–2022



Source: Quantonomics; Australian Bureau of Statistics

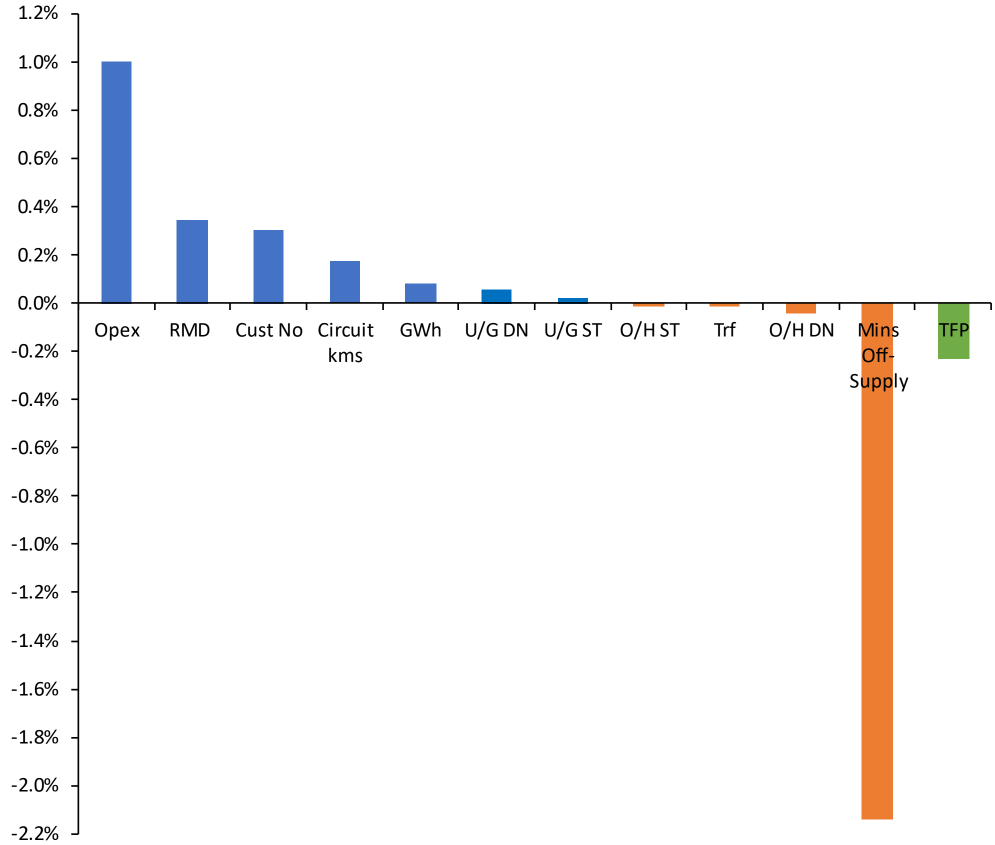
Note: The productivity of the Australian economy and the EGWWS industry is from the ABS indices within 5260.0.55.002 Estimates of Industry Multifactor Productivity, Australia, Table 1: Gross value added based multifactor productivity indexes (a). We have rebased the ABS indices to 1.0 in 2006.

Figure 7 helps us understand the drivers of change in electricity distribution industry productivity in 2022 by showing the contributions of each output and each input to the annual rate of change in TFP. Outputs consist of customer numbers, circuit length, ratcheted maximum demand, energy throughput and reliability (where customer minutes off-supply enters as a negative output). An increase in output increases 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 7Figure 7 shows that the decrease in electricity distribution productivity in 2022 was primarily driven by a reduction in reliability (contributing -2.1 percentage points to multilateral TFP growth). Opex had the largest positive impact on TFP, contributing 1.0 percentage point while ratcheted maximum demand, customer numbers and circuit length made smaller positive contributions at 0.3, 0.3 and 0.2 percentage points respectively. The remaining inputs and outputs had very little impact on TFP growth.

That said, we note that two underground inputs (for sub-transmission and distribution) made very small positive contributions to TFP change in 2022. These positive contributions are anomalies as these two inputs increased in 2022 (by 1.0 and 2.1 percentage points respectively) and therefore would have been expected to make negative contributions to TFP. As these contributions are counter-intuitive, we have investigated these anomalies, which is discussed further in Appendix C. This includes some anomalies for DNSPs, for example, in 2022 Evoenergy's underground distribution input makes a positive contribution to TFP despite this input increasing over this period.

Figure 7 Electricity distribution output and input percentage point contributions to annual TFP change, 2022



Source: Quantonomics

Note: The inputs and outputs in this chart are customer 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).

As with the 2022 results, where reliability was the primary driver of TFP change, reliability was the largest positive contributor to TFP growth in 2021. This can be attributed to volatility in reliability from year to year, due to its high weather dependency. In contrast, reliability has had a minor impact on TFP over the 2012–2022 period, contributing -0.2 percentage points per year on average to TFP change.[48] This illustrates that beyond variability from year-to-year it is important to consider changes in the context of longer-term trends. Conversely, opex reductions continue to play the largest role in driving improved electricity distribution productivity over the 2012–2022 period, contributing 1.0 percentage point on average annually to TFP.

Figure 8 displays the time series multilateral TFP, opex PFP and capital PFP in the electricity distribution industry from 2006 to 2022. Consistent with the above observations, since 2012, opex reductions have been the most significant contributor to TFP growth, with opex PFP increasing on average by 2.9% each year. This level of sustained growth in opex productivity since 2012 is higher than the productivity growth rate assumption for DNSPs of 0.5% per year, used in regulatory decisions. This is something that we may consider reviewing in future. Capital PFP has declined 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 the energy throughput, which slightly fell. The steadier nature of the trend in capital PFP might be expected given that the capital inputs used in the model are a stock measure and the largely sunk and long-lived nature of DNSP capital assets. We also note that the TFP outputs may not be fully capturing all of the outputs provided by DNSPs related to export services (see Section 8).

Figure 8 Electricity distribution, total, capital and opex productivity, 2006–2022

Source: Quantonomics; AER Analysis.

48 Quantonomics, *Economic Benchmarking Results for the Australian Energy Regulator's 2023 DNSP Annual Benchmarking Report*, November 2023, p. 23.

4 The relative productivity of distribution network service providers

Key points

Five DNSPs became more productive in 2022 as reflected by their MTFP results under the benchmarking approach used in previous reports:

- Ausgrid (8.9%) and Essential Energy (7.6%) increased their productivity the most.
- Jemena increased its productivity by 4.0%.
- TasNetworks and CitiPower had somewhat smaller productivity increases of 1.6% and 0.4% respectively.
- Increasing opex productivity, reflecting lower opex, was the primary driver of Ausgrid, Essential Energy and Jemena's increased productivity in 2022.

Eight DNSPs became less productive in 2022 as reflected by their MTFP results under the benchmarking approach used in previous reports:

- Powercor (-6.2%) had the largest decrease in productivity over the year.
- Ergon Energy, SA Power Networks and United Energy all had reductions in productivity between 3 and 4 percentage points.
- Evoenergy (-2.4%), Endeavour Energy (-2.1%), Energex (-1.3%) and AusNet Services (-1.0%) services all saw smaller decreases in their productivity.
- Reductions in reliability over 2022 were generally the main drivers of decreased productivity across DNSPs.

SA Power Networks, CitiPower and Powercor have consistently been amongst the most productive distributors in the NEM since 2006, although the productivity of each is lower in 2022 than in 2006. Essential Energy's large increase in productivity in 2022 saw it become the third highest ranked DNSP, ahead of Powercor. Endeavour Energy, Ergon Energy and United Energy have shown strong increases in productivity since 2016 and remain close to the most productive distributors in 2022.

On a State level, South Australia had the highest distribution ranking, as measured by MTFP, in 2022 and over the period 2006 to 2022. In 2022 NSW was ranked second, followed by Queensland, Victoria, and Tasmania. Distribution productivity in the ACT was the lowest ranked of the NEM states and territories in 2022.

We have updated these results to implement our preferred approach to address capitalisation differences between DNSPs. This uses what we consider is a preliminary, fit for purpose method to adjusting AUC to remove capitalised corporate overheads from capex. Using this approach:

- There are some minor MTFP ranking changes between DNSPs, with four DNSPs moving up or down by one place in 2022. The largest change was for United Energy with its 2022 MTFP ranking improving two places from 7th to 5th.
- There were larger changes to Opex MPFP results and associated rankings. Seven

DNSPs have seen changes in their Opex MPFP rankings with Jemena and CitiPower both dropping by 5 places and both Ausgrid and United Energy both improving by 4 places.

The results from the MTFP models include the impact of some OEFs, such as energy, demand and customer density, but not all material OEFs are captured in the results. This is important when considering the relative efficiency and rankings between DNSPs, as some DNSPs may have more or less favourable OEFs than their peers and may appear more or less efficient than they otherwise would. It is desirable to further account for OEFs not included in the benchmarking models. Our benchmarking report includes information about the most material OEFs driving apparent differences in 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 panel data MTFP comparative analysis, which relates total inputs to total outputs and provides a measure of overall network productivity relative to other networks. We provide our analysis at a state and DNSP level, including key observations on the reasons for changes in the relative productivity of each DNSP in the NEM. This is supported by the corresponding partial factor productivity measures of opex and capital inputs (opex MPFP and capital MPFP).

In response to DNSP submissions on Quantonomics' preliminary 2023 benchmarking results and report, we also present MTFP and MPFP results for DNSPs under our preferred approach to address capitalisation differences. Under this approach, we consider each DNSP's opex based on its 2022 CAM, with 100% of corporate overheads included as opex. We have also made adjustments to capital input weights by adjusting the AUC calculation (specifically the RAB and regulatory depreciation components of the AUC calculation). This is in order to prevent the double-counting of capitalised corporate overheads that are reclassified from capex to opex under the preferred approach. Further detail can be found in Appendix A5 of Quantonomics' report.[49] We intend to consult further with DNSPs in relation to this preliminary method, particularly in terms of the AUC adjustment. We consider it to be fit for purpose for this report but will consider whether it should be retained or refined for use in future Annual Benchmarking Reports.

Given this is the first year we have implemented our preferred approach, for comparison we also present the MTFP and MPFP results under our previous approach. This uses opex under the 2014 CAMs and only includes expensed corporate overheads.

49 Quantonomics, *Economic Benchmarking Results for the Australian Energy Regulator's 2023 DNSP Annual Benchmarking Report*, November 2023, pp. 151–152.

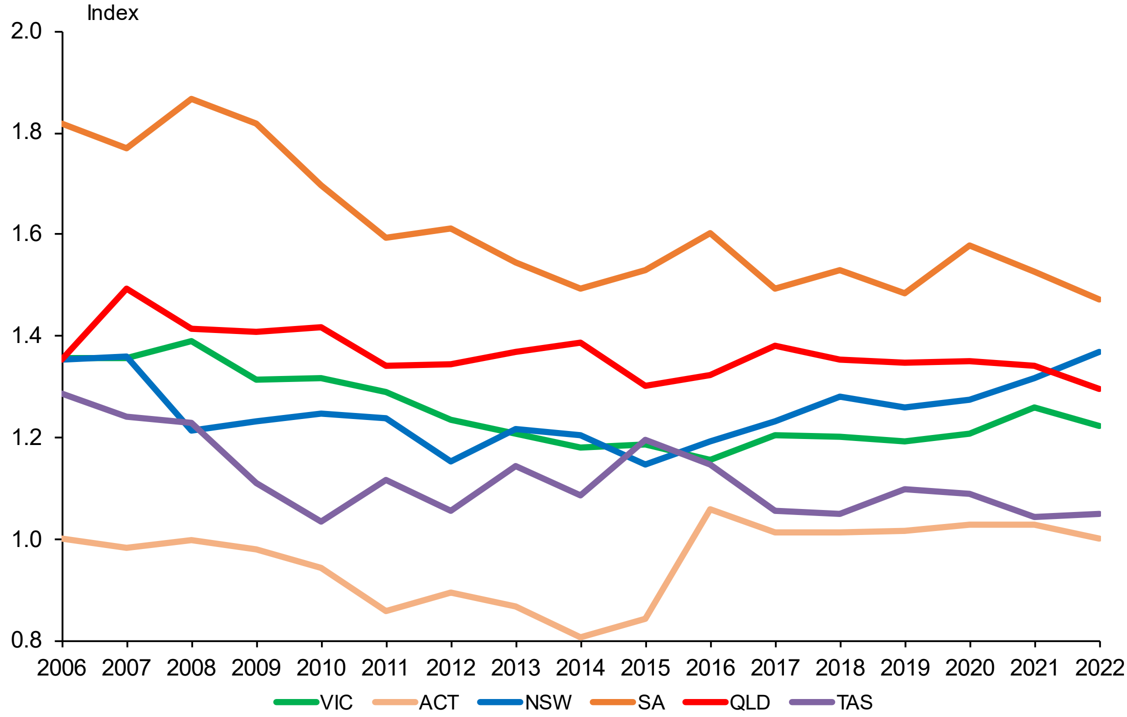
4.1 MTFP results for DNSPs

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 2022 under the approach used in previous reports. This shows that South Australia is the most productive state in the NEM in both 2022 and over the period 2006 to 2022, although its productivity has declined over this timeframe. In 2022, the next most productive state is NSW, followed by Queensland and Victoria. Tasmania is next, with the ACT's distribution total productivity level the lowest of the states in the NEM in 2022, which has generally been the case over the period 2006 to 2022.[50] NSW's productivity as measured by MTFP is slightly higher in 2022 as compared to 2006, while productivity in Queensland and the ACT in 2022 is roughly equal to their MTFP in 2006. Victoria, SA and Tasmania had lower productivity levels in 2022 than in 2006.

50 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 distribution lines. This disadvantages TasNetworks' MTFP ranking because low voltage assets generally receive the highest capital input weighting under our benchmarking models. Our previous consultant, Economic Insights, advised 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).

Figure 9 Electricity distribution MTFP levels by state, 2006–2022



Source: Quantonomics, 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 under the approach used in previous reports as well as our preferred approach to addressing capitalisation differences.

Table 1 presents the MTFP rankings for individual DNSPs in 2022 and 2021, the annual growth in productivity in 2022 (column four) and the average annual growth in the 2006–2022 and 2012–2022 periods (columns five and six) under the previous approach.

Table 1 Individual DNSP MTFP rankings and annual growth rates under the approach used in previous reports

DNSP	2022 Rank	2021 Rank	Change (2022)	Change (2006–2022)	Change (2012–2022)
SAP	1	1	-3.5%	-1.2%	-0.8%
CIT	2	2	0.4%	-0.2%	1.2%
ESS	3↑	7	7.6%	0.0%	1.9%
PCR	4↓	3	-6.2%	-0.6%	-0.4%
END	5	5	-2.1%	-0.5%	0.4%
ERG	6↓	4	-3.7%	0.2%	-0.2%
UED	7↓	6	-3.4%	0.1%	1.5%
JEN	8	8	4.0%	0.8%	1.3%
ENX	9	9	-1.3%	-0.5%	-0.2%
AGD	10↑	13	8.9%	0.8%	2.5%
AND	11↓	10	-1.0%	-1.2%	-1.0%
TND	12	12	1.6%	-1.2%	0.0%
EVO	13↓	11	-2.4%	0.1%	1.2%

Source: Quantonomics, 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 some moderate changes in the rankings in 2022: Essential Energy rose 4 places to 3rd while Ausgrid rose three places to 10th. Powercor, United Energy and AusNet Services each dropped by one place to 4th, 7th and 11th respectively while Ergon Energy and Evoenergy both dropped by two places to 6th and 13th respectively. We also note the significant improvements in relative productivity as measured by MTFP by Ausgrid, Essential Energy and Jemena in 2022. These improvements can be attributed primarily to increasing opex productivity reflecting lower opex.

Table 2 presents the same analysis as Table 1, however, under our preferred approach to addressing capitalisation differences. We observe 9 changes in rankings when comparing the MTFP results in 2022 against 2021 under our preferred approach, with the ranking changes being of a similar magnitude to those in Table 1. Essential Energy rose 4 places to 3rd, Ausgrid rose 3 places to 10th and CitiPower rose 1 place to 2nd. Powercor and Ergon Energy both dropped by two places to 4th and 7th respectively. United Energy, AusNet Services, TasNetworks and Evoenergy each dropped 1 place to 5th, 11th, 12th and 13th respectively. The changes in productivity as measured by MTFP analysis under our preferred approach to addressing capitalisation differences largely reflect those we see under our previous approach in each of the 2021–22, 2006–22 and 2012–22 periods.

Table 2 Individual DNSP MTFP rankings and annual growth rates under our preferred approach to addressing capitalisation differences

DNSP	2022 Rank	2021 Rank	Change (2022)	Change (2006–2022)	Change (2012–2022)
SAP	1	1	-3.0%	-1.2%	-0.7%
CIT	2↑	3	0.2%	-0.1%	1.0%
ESS	3↑	7	7.0%	0.4%	2.6%
PCR	4↓	2	-5.9%	-0.5%	-0.3%
UED	5↓	4	-3.6%	0.1%	1.5%
END	6	6	-2.3%	-0.5%	0.7%
ERG	7↓	5	-3.3%	0.7%	0.7%
ENX	8	8	-0.2%	-0.2%	0.2%
JEN	9	9	2.0%	0.2%	1.3%
AGD	10↑	13	9.8%	0.9%	2.7%
AND	11↓	10	-1.1%	-1.0%	-0.7%
TND	12↓	11	1.7%	-1.3%	0.0%
EVO	13↓	12	-2.5%	0.0%	1.4%

Source: Quantonomics, 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).

Figure 10 presents MTFP results for each DNSP from 2006 to 2022 under our previous benchmarking approach while Figure 11 presents the results under our preferred approach to addressing capitalisation differences. In addition to MTFP, we also present the results of two MPFP measures under the previous and preferred approaches:

- Opex MPFP under the previous approach is shown in Figure 12 and under the preferred approach to addressing capitalisation differences is shown in Figure 13. This considers the relative productivity of the DNSPs in terms of opex use.
- Capital MPFP under the previous approach is shown in Figure 14 and under the preferred approach is shown in Figure 15. This considers the relative productivity of the DNSPs' use of capital inputs, namely overhead lines and underground cables (each split into distribution and sub-transmission components) and transformers.

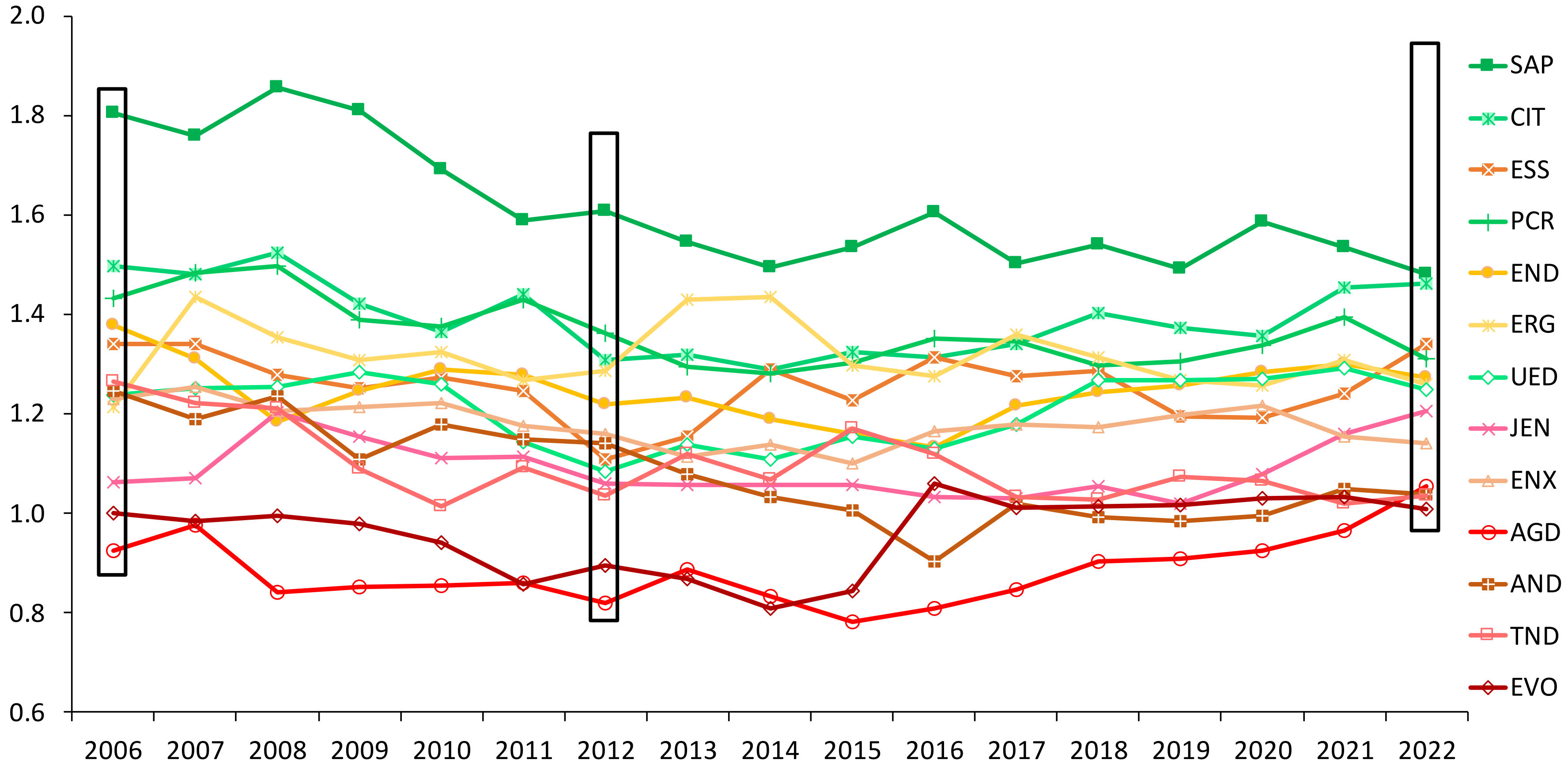
These partial approaches assist in interpreting the MTFP results by examining the contribution of capital inputs and opex to overall productivity. They use the same output specification as MTFP but relate the aggregated output to the individual components of capital and opex separately to measure partial factor 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 results across DNSPs, or over time, may reflect changes in the OEFs not accounted for in the modelling, noting that it is not feasible to account for all material OEFs. Section 7 provides more information about some of these additional factors.

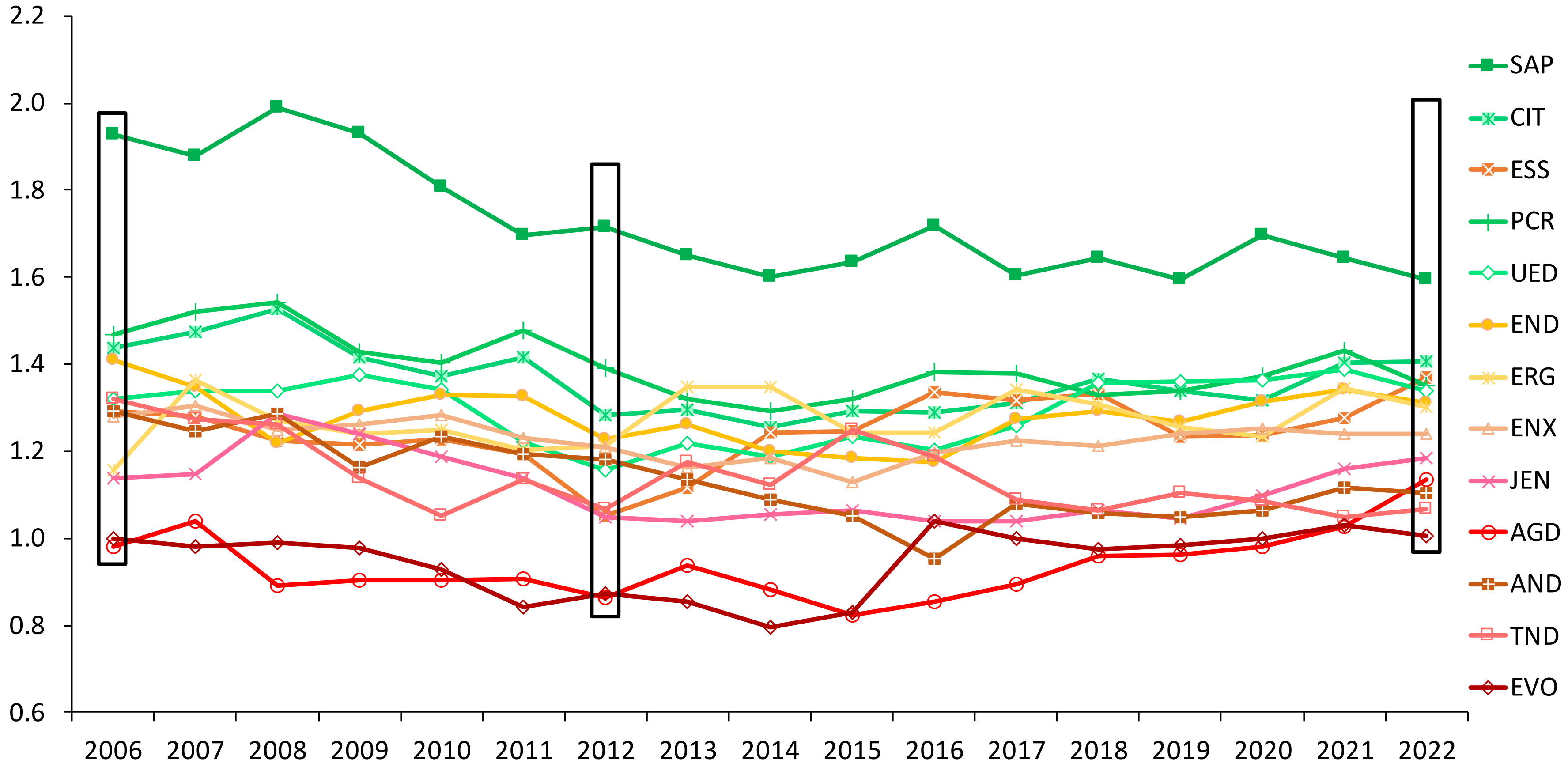
Our observations about these MTFP and MPFP results are discussed in Section 4.2.

Figure 10 MTFP indexes by individual DNSP under the approach used in previous reports, 2006–2022



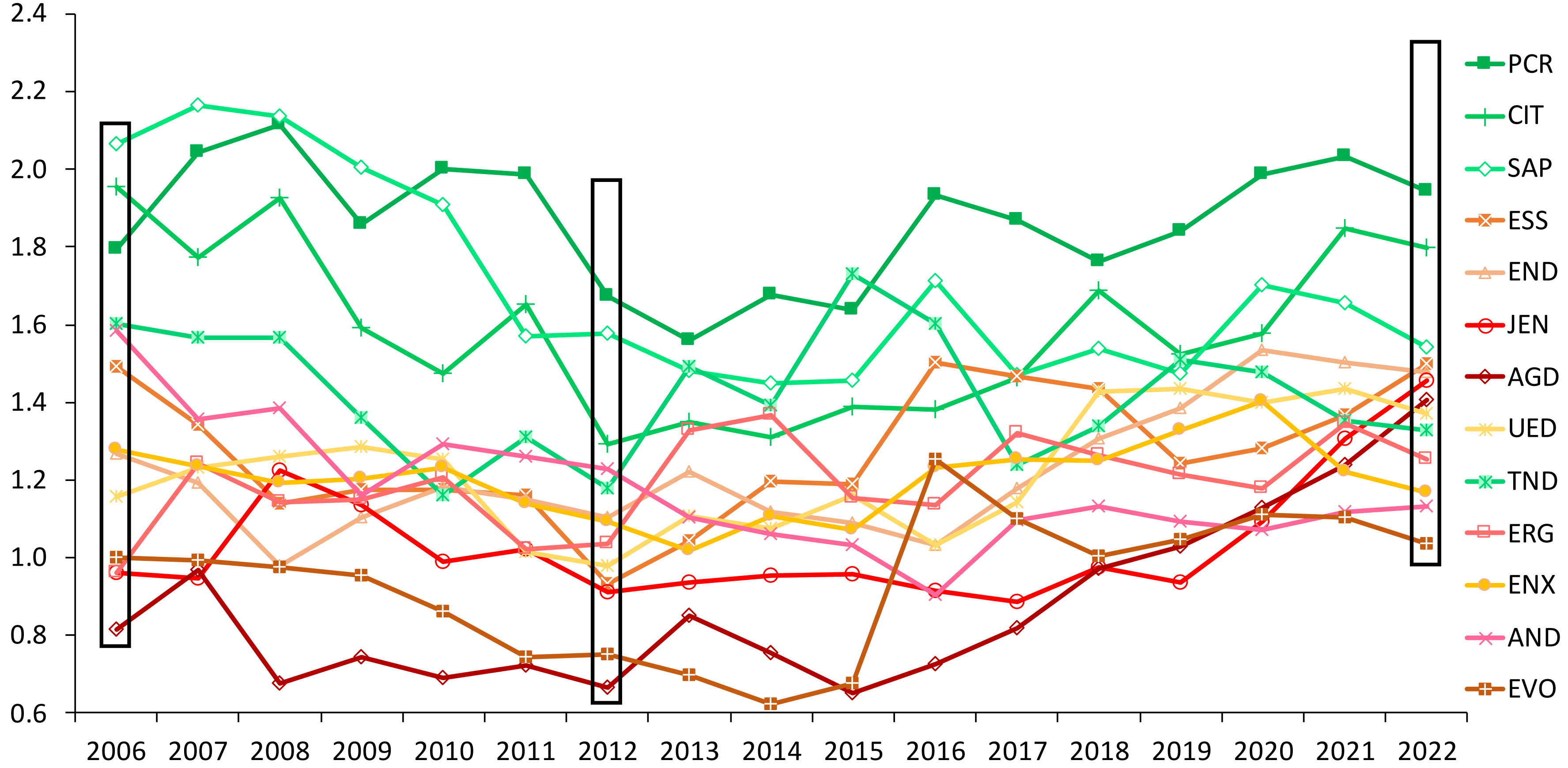
Source: Quantonomics; AER analysis. Note: These results do not reflect the impact of a range of material OEFs (see Section 7).

Figure 11 MTFP indexes by individual DNSP under the preferred approach to addressing capitalisation differences, 2006–2022



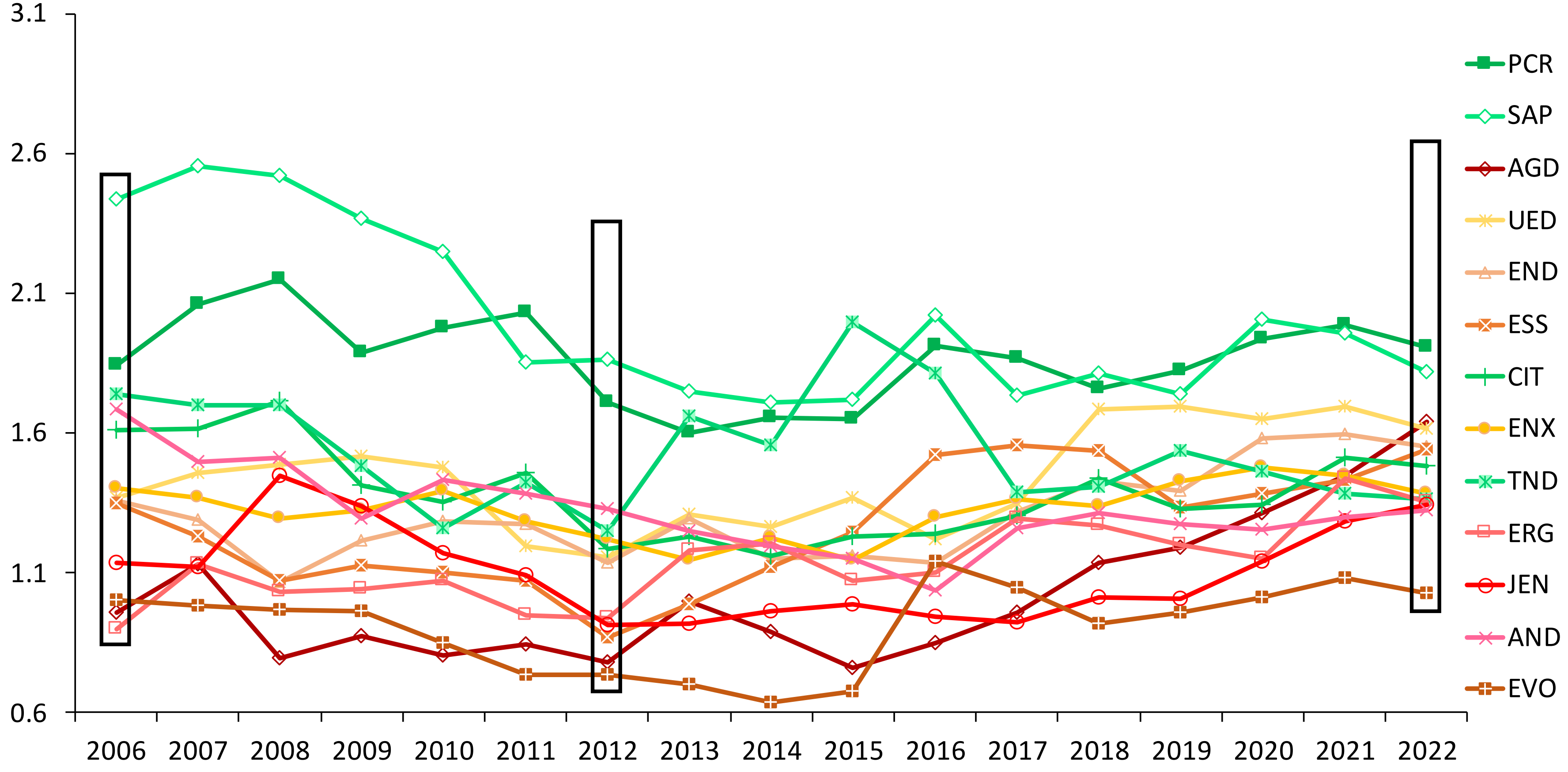
Source: Quantonomics; AER analysis. Note: These results do not reflect the impact of a range of material OEFs (see Section 7).

Figure 12 DNSP opex MPFP indexes under the approach used in previous reports, 2006–2022



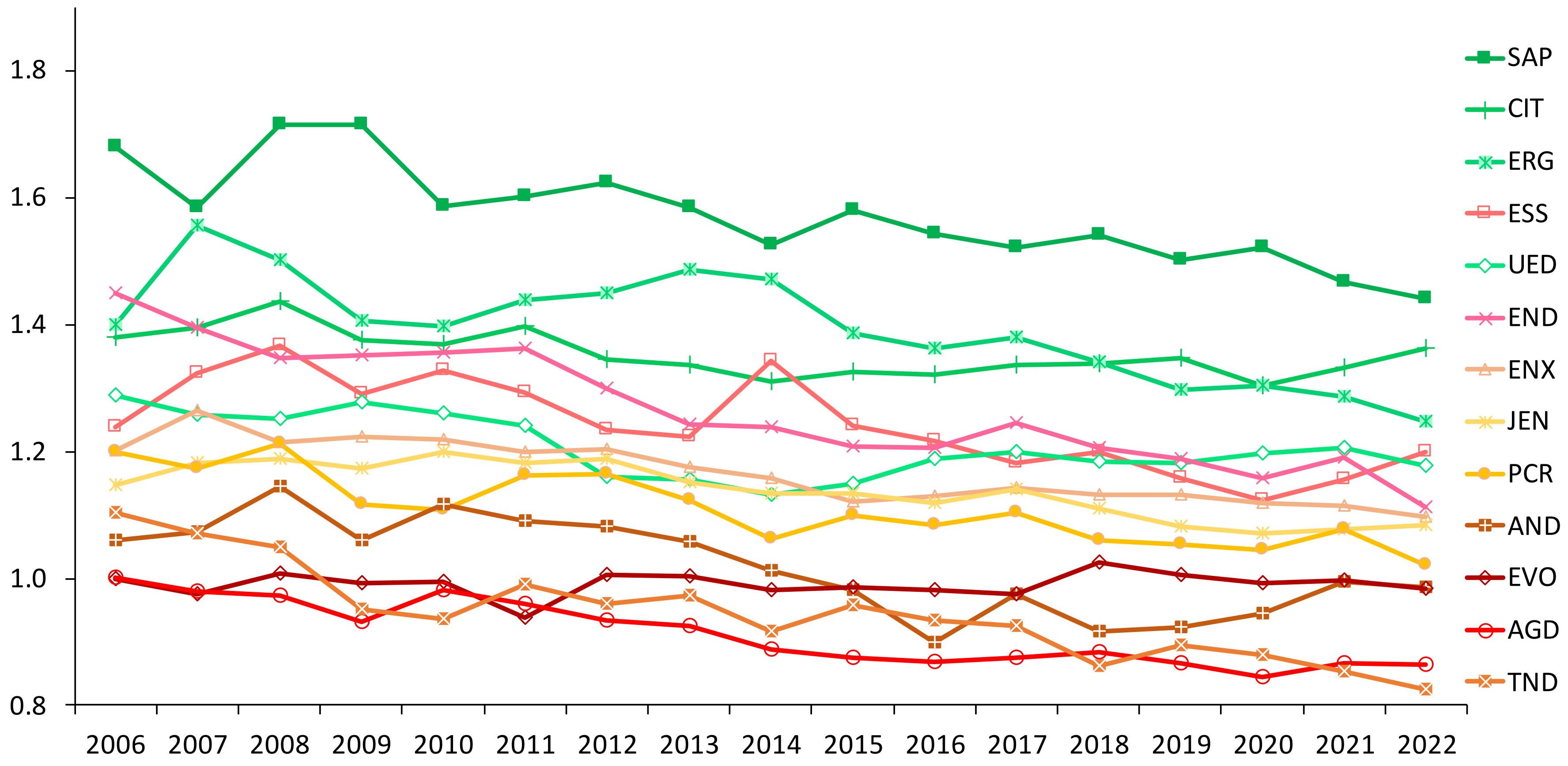
Source: Quantonomics; AER analysis. Note: These results do not reflect the impact of a range of material OEFs (see Section 7).

Figure 13 DNSP opex MPFP indexes under the preferred approach to addressing capitalisation differences, 2006–2022



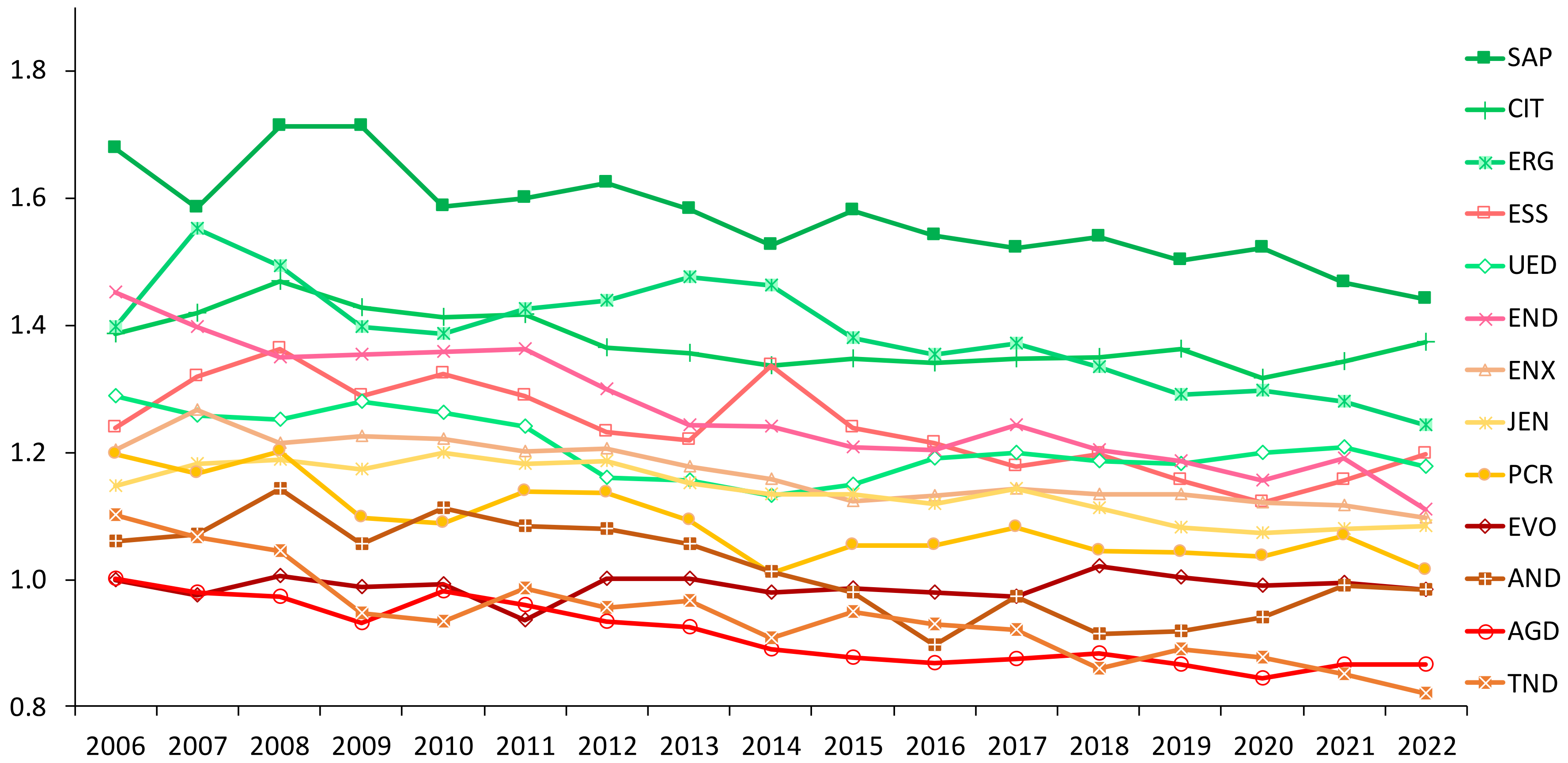
Source: Quantonomics; AER analysis. Note: These results do not reflect the impact of a range of material OEFs (see Section 7).

Figure 14 DNSP capital MPFP indexes under the approach used in previous benchmarking reports, 2006–2022



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

Figure 15 DNSP capital MPFP indexes under the preferred approach to addressing capitalisation differences, 2006–2022



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

4.2 Key observations about changes in productivity

This section describes some of our key observations about changes in the relative productivity of DNSPs for both 2022 and recent years, based on the panel MTFP and MPFP results presented above.

4.2.1 Significant changes in productivity in 2022

Five DNSPs became more productive in 2022

As can be seen in Figure 10 and Table 1, five of the 13 DNSPs became more productive in 2022 as reflected by their MTFP results under the approach used in previous benchmarking reports. Ausgrid and Essential Energy increased their productivity by 8.9% and 7.6% respectively in 2022, which were the largest increases among the DNSPs in the NEM. Jemena increased its productivity by 4.0% in 2022. TasNetworks and CitiPower had smaller increases in productivity of 1.6% and 0.4% respectively in 2022. Increased opex productivity, reflecting lower opex, was generally the main driver of the results for these distributors.[51]

Under our preferred approach to addressing capitalisation differences, we observe similar changes to productivity as measured by MTFP in 2022. Under this approach, the same 5 DNSPs became more productive in 2022 with Ausgrid and Essential Energy increasing their productivity by 9.8% and 7.0% respectively in 2022. These were the largest increases among the DNSPs in the NEM. Jemena, TasNetworks and CitiPower saw smaller increases in productivity of 2.0%, 1.7% and 0.2% respectively, similar to those observed under the previous approach.

Of the DNSPs which had increases in MTFP in 2022, Ausgrid, Jemena and Essential Energy's opex productivity measured in terms of opex MPFP increased by 12.7%, 10.8% and 9.3% respectively in 2022 under the approach used in previous benchmarking reports. These were the largest increases in the NEM. Similarly, under the preferred approach to addressing capitalisation differences, Ausgrid, Essential Energy and Jemena saw their opex productivity as measured by opex MPFP increase by 12.5%, 7.4% and 4.4% respectively.

The improvement in Jemena's opex productivity in 2022 under the preferred approach to addressing capitalisation differences is significantly lower than that observed under the approach used in previous benchmarking reports, while Ausgrid and Essential Energy's increases are more comparable across the two approaches. Under the approach used in previous benchmarking reports, Ausgrid and Jemena's opex MPFP rankings rose by 3 places from 10th to 7th and 9th to 6th respectively. Essential Energy

[51] Quantonomics, *Economic Benchmarking Results for the Australian Energy Regulator's 2023 DNSP Annual Benchmarking Report*, November 2023, pp. 95, 120, 125.

rose by two places from 6th to 4th. Under the preferred approach to addressing capitalisation differences, Ausgrid's opex MPFP ranking rose by 4 places from 7th to 3rd in 2022, Essential Energy's opex MPFP ranking rose by 3 places from 9th to 6th and Jemena's ranking rose by 1 place from 11th to 10th.

Under the approach used in previous benchmarking reports, TasNetworks and CitiPower were the only DNSPs which had an increase in MTFP in 2022, but a decrease in opex productivity as measured by opex MPFP in 2022 (-1.9% and -2.9% respectively). An increase in opex was the main driver of CitiPower's reduction in opex MPFP. Under the preferred approach to addressing capitalisation differences, we similarly observe a decrease in TasNetworks' and CitiPower's opex MPFP (-1.6% and -2.0% respectively), despite these DNSPs increasing their MTFP.

Out of the five DNSPs which had increases in MTFP in 2022, Essential Energy had the largest increase in capital productivity as measured by capital MPFP under the approach used in previous benchmarking reports. Its increase of 3.5% was slightly larger than that of other DNSPs. CitiPower and Jemena also recorded smaller increases in capital MPFP of 2.2% and 0.5% respectively. The two remaining DNSPs had decreases in capital MPFP. Ausgrid's capital MPFP declined by a very minor 0.1 percentage points, while TasNetworks had a 3.5% decline in its capital productivity. Under our preferred approach to addressing capitalisation differences, we saw near-identical capital MPFP changes for Essential Energy (3.6%), CitiPower (2.1%), Jemena (0.5%), Ausgrid (-0.2%) and TasNetworks (-3.6%) as compared to the results observed under the previous approach.

SA Power Networks remains the most productive DNSP in terms of capital productivity in the NEM in 2022 under both the previous approach and preferred approach to addressing capitalisation differences. This is despite its decline in capital productivity as measured by capital MPFP of 1.8% in 2022 under both approaches. TasNetworks remains the lowest ranked DNSP in terms of capital MPFP in 2022 under both approaches. There were few significant changes in the capital productivity rankings in 2022, with the exception of Essential Energy, which moved from 6th to 4th under both approaches. United Energy and Endeavour Energy moved from 4th to 5th and 5th to 6th respectively under both approaches. AusNet Services moved from 11th to 10th and Evoenergy moved from 10th to 11th under the approach used in previous reports while their respective ranks did not change in 2022 under the preferred approach to addressing capitalisation differences.

Eight DNSPs became less productive in 2022

Eight DNSPs became less productive in 2022 as reflected by their MTFP results under the previous approach. Figure 10 shows that Powercor had the largest decrease in productivity of 6.2%, driven predominantly by a reduction in reliability and an increase in opex.[52] Ergon Energy (-3.7%), SA Power Networks (-3.5%) and United Energy (-3.4%) experienced moderate decreases in productivity. Evoenergy (-2.4%), Endeavour Energy (-2.1%), Energex (-1.3%) and AusNet Services (-1.0%) round off the remaining DNSPs which recorded smaller decreases in their productivity. Decreasing reliability was a common driver of decreasing productivity across these DNSPs.

Under the preferred approach to addressing capitalisation differences, the same eight DNSPs became less productive in 2022 as reflected by their MTFP results. Productivity decreases for Powercor (-5.9%), United Energy (-3.6%), Ergon Energy (-3.3%), SA Power Networks (-3.0%), Evoenergy (-2.5%), Endeavour Energy (-2.3%), AusNet Services (-1.1%) and Energex (-0.2%) were generally comparable to the productivity decreases observed under the approach used in previous benchmarking reports.

AusNet Services was the only DNSP which recorded a decrease in MTFP and an increase in opex MPFP in 2022 under both approaches. Its opex MPFP increased by 1.3% under the previous approach, and by 1.9% under the preferred approach to addressing capitalisation differences. This result was driven by a substantial reduction in opex in 2022, along with an offsetting reduction in reliability.

Under the previous approach, opex MPFP decreased across SA Power Networks (-7.3%), Ergon Energy (-7.0%), Evoenergy (-6.4%) Energex (-4.6%), United Energy (-4.6%), Powercor (-4.6%) and Endeavour Energy with a much smaller decrease of 1.6%. Increased opex and reduced reliability were generally the main drivers of these reductions in opex MPFP. Under the preferred approach to addressing capitalisation differences, opex MPFP decreased across SA Power Networks (-7.3%), Ergon Energy (-6.2%), Evoenergy (-5.2%) Energex (-4.6%), United Energy (-4.6%), Powercor (-4.2%) and Endeavour Energy (-2.8%), broadly similar to the opex MPFP decreases observed under the approach used in previous reports.

The most notable decreases in opex MPFP rankings in 2022 under the approach used in previous reports included United Energy's fall from 5th to 8th in 2022, and TasNetworks' and Ergon Energy's falls from 7th to 9th and 8th to 10th respectively. Significant decreases in opex MPFP rankings in 2022 under the preferred approach to addressing capitalisation differences included Ergon Energy's, Energex's and CitiPower's falls from 8th to 10th, 6th to 8th and 5th to 7th respectively.

All of the DNSPs with reduced MTFP in 2022 also had decreased capital productivity as measured by capital MPFP in 2022 under the approach used in previous benchmarking reports. Endeavour Energy, Powercor, TasNetworks and Ergon Energy had the largest decreases to capital MPFP of 6.8%, 5.5%, 3.5% and 3.0% respectively.

52 Quantonomics, *Economic Benchmarking Results for the Australian Energy Regulator's 2023 DNSP Annual Benchmarking Report*, November 2023, p. 130.

United Energy, SA Power Networks, Energex, Evoenergy and AusNet Services also had smaller decreases in their capital MPFP of 2.4%, 1.8%, 1.7%, 1.1% and 0.9% respectively. Reduced reliability was generally the main driver of these reductions in capital MPFP. Similarly, under our preferred approach to addressing capitalisation differences, all DNSPs with reduced MTFP in 2022 also had decreased capital MPFP results. The decreases to capital MPFP for Endeavour Energy (-6.9%), Powercor (-5.3%), TasNetworks (-3.6%), Ergon Energy (-3.0%), United Energy (-2.4%), SA Power Networks (-1.8%), Energex (-1.7%), Evoenergy (-1.1%) and AusNet Services (-0.7%) were nearly identical to the decreases in capital productivity observed under the approach used in previous reports.

Reliability decreased for all but one DNSP in 2022

Other than CitiPower, all DNSPs had lower reliability in 2022, reflecting an increase in customer minutes off-supply by 14.1% at the industry level. This decrease in reliability follows a 13.0% improvement in 2021, the largest increase in reliability since the beginning of our records in 2006. Endeavour Energy (-34.5%), Evoenergy (-26.6%), United Energy (-25.2%) and AusNet Services (-22.4%) had the largest falls in reliability in 2022. Energex (-19.5%), Ergon Energy (-18.2%), Powercor (-14.4%) and TasNetworks (-12.9%) also saw drops in reliability over 10%. SA Power Networks (-7.9%), Ausgrid (-6.4%), Essential Energy (-2.5%) and Jemena (-1.5%) had below average decreases in reliability.

The large fall in reliability across most DNSPs in 2022 was attributed to bad weather events, particularly storms. CitiPower was the only DNSP to record an improvement in reliability in 2022 (15.6%); this is particularly noteworthy given that CitiPower also managed to improve reliability by 46.8% in 2021. The large industry-wide reduction in reliability seen in 2022 is the primary driver of lower distribution industry productivity in 2022. In contrast, 2021 saw an increase in distribution industry productivity, largely as a result of improved reliability.

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 in terms of MTFP and opex MPFP. This is true under both the approach used in previous reports as well as under our preferred approach for addressing capitalisation differences. For both of these measures, the spread of productivity levels in 2022 is smaller than in 2012, which was also smaller than in 2006. This can be seen from the three equal-sized, black-bordered columns placed in 2006, 2012 and 2022 in Figure 10 and Figure 11, with a broadly similar pattern observed for opex MPFP under both approaches in Figure 12 and Figure 13. 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 within the middle-ranked group. Under the approach used in previous reports, since 2012, Ausgrid and Evoenergy have increased their overall productivity (MTFP) by 2.5% and 1.2% per annum respectively, compared with the industry average of 0.6% per annum. The growth in productivity of these DNSPs can be largely attributed to improvements in opex efficiency. Similarly, under the preferred approach to addressing capitalisation differences, since 2012, Ausgrid and Evoenergy have increased their MTFP by 2.7% and 1.4% per annum respectively, compared with the industry average of 0.8% per annum.

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 Essential Energy, Jemena and United Energy, 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 under both approaches.

Further, while under the approach used in previous reports Powercor, SA Power Networks and CitiPower have consistently been the most productive DNSPs in the NEM as measured by MTFP over the 2006 to 2022 period, they have experienced a gradual decline in productivity over this period. Although SA Power Networks' MTFP rise in 2020 increased its gap over the rest of the DNSPs, this has been reduced following its fall in MTFP in both 2021 and 2022. The productivity of SA Power Networks is now much closer to the middle ranked DNSPs than in 2006. Under our preferred approach to addressing capitalisation differences, the same MTFP observations are accurate, however SA Power Networks' relative performance is a clear standout compared to other DNSPs over the entire 2006–2022 period.

Changes in relative opex productivity as measured by opex MPFP are the main driver of productivity convergence in the electricity distribution industry. There has been an upward trend in opex MPFP since 2012 under the approach used in previous benchmarking reports as well as the preferred approach to addressing capitalisation differences. This can be seen in Figure 12 and Figure 13, with eleven out of the thirteen DNSPs (all bar AusNet Services and SA Power Networks) increasing their opex productivity. In contrast, relative 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 2022 as compared to 2006. This is only marginally different when comparing 2022 to 2012, as CitiPower and United Energy are the only DNSPs that have increased their relative capital productivity slightly over that time span. Specifically, by between 0.1% and 0.2% per annum in each case under the approach used in previous reports and under the preferred approach to addressing capitalisation differences.

4.2.3 Differences in results between the preferred approach to addressing capitalisation differences and the approach used in previous reports

The implementation of our preferred approach to addressing capitalisation differences has generally not resulted in substantial variation in either MTFP or opex or capital MPFP results for 2022 compared to the approach used in previous benchmarking reports. The primary difference between the two approaches, and the main driver of differences in results, is the inclusion of all corporate overheads as opex and the use of opex reported under each DNSP's 2022 CAM under the preferred approach. This is compared to the inclusion of only expensed corporate overheads and opex under each DNSP's 2014 CAM under the previous approach. This directly impacts the MTFP and opex MPFP results. This change in approach also requires adjustments to remove capitalised corporate overheads from the RAB and associated impacts on regulatory depreciation, which effects the AUCs that serve as the source of our capital input weights. This also impacts the MTFP and capital MPFP results.

Capitalised corporate overheads are generally more significant in magnitude compared to a DNSP's total opex. This means the inclusion of all corporate overheads as opex under the preferred approach has a more significant impact on opex for some DNSPs, particularly those which capitalise a greater share of their corporate overheads. For this reason, we see greater variation in opex MPFP results when implementing our preferred approach.

Under the preliminary method for AUC data adjustment, capitalised corporate overheads from 2006 to 2022 form a small proportion of the total RAB for DNSPs. As such, the removal of capitalised corporate overheads has a rather limited impact on the AUC. As capital inputs are measured by physical quantity, and the AUC only serves as the capital input weights, the AUC data updates have little impact on capital MPFP results. This is illustrated by the comparison between Figure 14 and Figure 15.

Opex relative to AUC affects the relative shares of opex and capital inputs, and thus the relative contributions of opex MPFP and capital MPFP to MTFP. In combination with greater variations in opex MPFP results, and little changes in capital MPFP results, the changes in MTFP results appear to be modest.

SA Power Networks, United Energy and Ausgrid see the largest increases in opex MPFP (which can be seen by comparing Figure 12 and Figure 13) under the preferred approach. This is as a result of these DNSPs expensing most of their corporate overheads under their 2014 CAMs, with United Energy expensing 100% of its corporate overheads in the period 2006–2022. When previously capitalised corporate overheads are added to all DNSP's total opex under the preferred approach, then the relative performance of these three DNSPs improves. Similarly, CitiPower sees the largest decrease in its opex MPFP under the preferred approach as the majority of its corporate overheads were capitalised under its 2014 CAM. This means its opex under our preferred approach, which now includes these overheads, is much higher. Under our preferred approach Jemena's opex MPFP ranking falls 5 places in 2022. This is driven by the fact that under its 2014 CAM it was capitalising a significant proportion of corporate overheads from 2011 onwards, which under our preferred approach are now all being recognised as opex.

These variations in opex MPFP, primarily driven by the inclusion of capitalised corporate overheads as opex, are the main driver of the more moderated differences in MTFP results between the two approaches.

4.2.4 Interpreting the results

As noted above, and explained further in Sections 7 and 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 do not reflect the impacts, both positive and negative, on measured relative productivity across DNSPs of a range of material OEFs. 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 electricity distribution industry are consistent with our general expectations.

As discussed in Section 8, improving our quantification of material OEFs remains an area of benchmarking development. We also note there that our MTFP model outputs may not be fully capturing all of the outputs provided by DNSPs related to export services, but that there is not sufficient evidence to conclude this is having a material impact on the benchmarking results. Further, we have begun monitoring the availability of export services data with a view to commencing a further review of this issue by 2027.

That said, we consider our MTFP model accounts for differences in DNSPs' outputs and as a result relevant density factors are accounted for in the output index. 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.

5 Opex econometric models

Key points

- Powercor, CitiPower, TasNetworks, SA Power Networks and United Energy remain the most efficient DNSPs in terms of opex efficiency scores, for both the 2006 to 2022 and 2012 to 2022 periods under the benchmarking approach used in previous reports.
- Implementing our preferred approach to address differences in capitalisation between DNSPs results in the addition of AusNet Services as one of the most efficient DNSPs in terms of opex efficiency scores over these two periods. There are also some changes to the rankings of the top 6 DNSPs implementing this approach to addressing capitalisation differences. This includes CitiPower's ranking moving from second to fifth and sixth in the 2006 to 2022 and 2012 to 2022 periods respectively.
- Opex efficiency scores from the econometric opex cost function models are broadly consistent with opex MPFP efficiency scores, including when updated for our preferred approach.
- The econometric opex cost function models take into account some OEFs e.g. relevant density factors, some service classification differences for opex and the extent of undergrounding, but do not include other OEFs. It is desirable to further consider OEFs 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 econometric opex cost function models are central in our assessment of the efficiency of opex revealed in the most recent years prior to a DNSP's revenue determination process.
- We continue to observe some issues with the reliability of the performance of the Translog models. This is an area for development that we discuss further in Section 8.

This section presents the results of four econometric opex cost function 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 2022 (long) period and the 2012 to 2022 (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.

In this year's report, we present results implementing our preferred approach to control for differences in capitalisation between DNSPs.[53] Under this approach, the same four econometric models are used with an opex series for the benchmarking period based on each DNSP's 2022 CAM and with 100% of corporate overheads included as opex. As noted in Section 1.1, given this is the first year we have implemented our preferred approach we also present the results using the previous approach. This uses opex under the 2014 CAMs and only includes expensed corporate overheads.

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:[54]

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

5.1 Monotonicity requirements

A key economic property required for these econometric opex models is monotonicity: that is, that an increase in output can only be achieved with an increase in inputs, holding other things constant.[55] 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 hold across all the data points in 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 benchmarking 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, 2021 and 2022 Annual Benchmarking Reports the number of instances where this property was not met

[53] Figures 18 and 19 for the long period and short period respectively.

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

[55] See Quantonomics, *Economic Benchmarking Results for the Australian Energy Regulator's 2021 DNSP Annual Benchmarking Report*, November 2022, pp. 33–34.

became somewhat more prevalent for the models over the short period.

For the current report, the number of instances where monotonicity does not hold in the Translog models is prevalent again and has increased since last year. This year, for the 2006 to 2022 period, we observe monotonicity violations in the Translog LSE model for three DNSPs and in the Translog SFA model for a separate group of three DNSPs. In the 2022 Annual Benchmarking Report, we observed no monotonicity violations for all of the Australian[56] DNSPs in both Translog models over the long period.

The poor monotonicity performance of the Translog models over the long period also extends to our preferred approach to control for differences in capitalisation between DNSPs. However, monotonicity violations are more concentrated in the Translog SFA model, which sees monotonicity violations for 5 DNSPs, while there is 1 DNSP that has monotonicity violations in the Translog LSE model.

For the shorter period from 2012 to 2022, the results are again slightly worse than last year. The Translog SFA model presents violations in a majority of observations for most of the Australian DNSPs:

- For the Translog SFA model there are ten DNSPs for whom a majority of their data points do not satisfy monotonicity: Evoenergy, Ausgrid, CitiPower, Endeavour Energy, Energex, Jemena, Powercor, SA Power Networks, AusNet Services and United Energy.
- For the Translog LSE model there are six DNSPs where monotonicity is not satisfied: Ausgrid, CitiPower, Energex, Jemena, AusNet Services and United Energy.

Under our preferred approach to control for differences in capitalisation between DNSPs, we see a slight increase in the total number of monotonicity violations over the 2012 to 2022 period relative to the approach used in previous reports:

- For the Translog SFA model there are monotonicity violations for the same ten DNSPs
- For the Translog LSE model there are monotonicity violations for the same six DNSPs plus Endeavour Energy.

Almost all of these cases where monotonicity is not satisfied relate specifically to the elasticity of opex with respect to the customer numbers output, i.e. there is a decrease (instead of an expected increase) in opex in response to an increase in customer numbers. Under our preferred approach to addressing capitalisation differences there

56 As discussed in Appendix B, we include both the NEM DNSPs and overseas DNSPs in the opex econometric models sample of DNSPs.

are also two instances where the elasticity of opex with respect to RMD is negative in the long period (2006–2022).

Where a majority of a DNSP's observations in a given model violate this property (indicated by a hatched pattern in Figures 16, 17, 18 and 19), 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). This is consistent with the approach used in previous reports. Further, if a model shows monotonicity violations for the majority of Australian DNSPs (seven DNSPs or more), then we exclude the model from calculating the model-average efficiency score for all Australian DNSPs, even though the property is satisfied for some DNSPs. Following this approach, the Translog SFA model for the short period (2012–2022) is excluded under the previous modelling approach (as shown in Figure 17). Both Translog models for the short period (2012–2022) are excluded under the preferred modelling approach to addressing capitalisation (as shown in Figure 19).

As discussed further in Section 8, we have undertaken some consideration of how we can improve the performance of these models in relation to monotonicity. We also set out in Section 8 our approach to further considering issues and engaging with stakeholders in relation to options for improving the performance of these models.

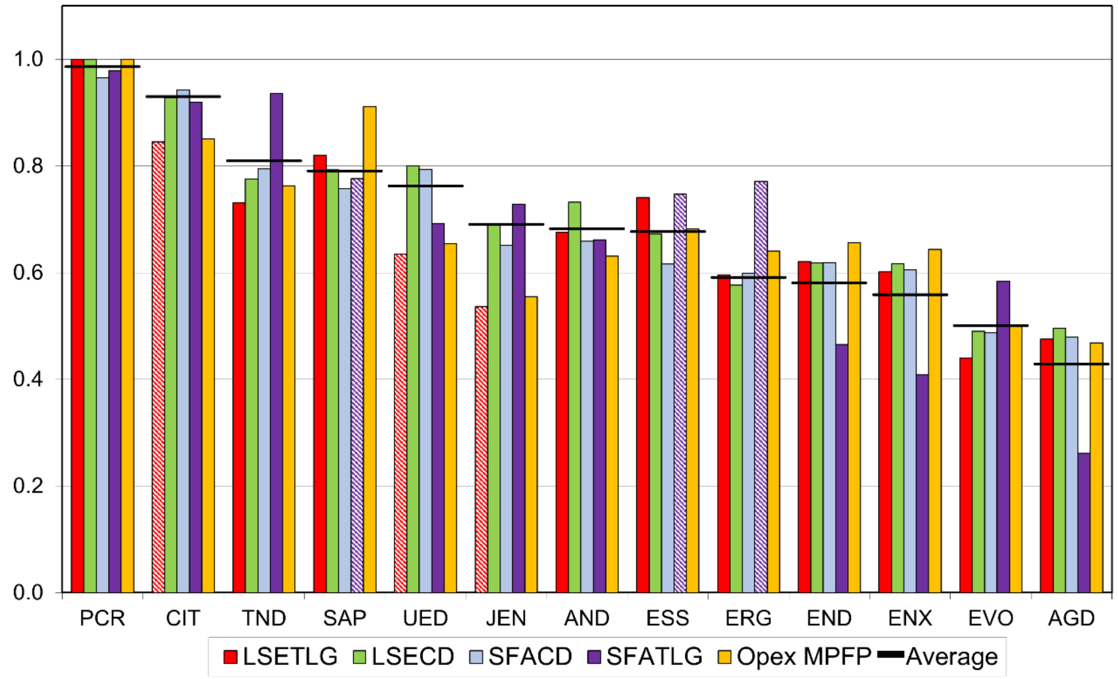
5.2 Opex efficiency scores

Figure 16 presents average efficiency scores for the above four models (plus opex MPFP) over the long period (2006–2022) under the approach used in previous reports. This is ranked from highest to lowest according to the model-average score including opex MPFP. Powercor and CitiPower have the highest average efficiency scores, followed by TasNetworks, SA Power Networks and United Energy. Evoenergy and Ausgrid have the lowest average opex efficiency scores over this period. The average opex efficiency scores represented by the black line for each DNSP do not include the opex MPFP results.

As can be seen in Figure 16 the opex MPFP results (in the orange columns) are broadly consistent with the results from these econometric opex cost function models.[57] The opex MPFP results are somewhat higher for SA Power Networks, Endeavour Energy, Energex and Ergon Energy and somewhat lower for CitiPower, United Energy, AusNet Services, and Jemena.

[57] The opex MPFP model has a slightly different combination of outputs than the econometric opex cost function models. See Appendix B and Quantonomics, *Economic Benchmarking Results for the Australian Energy Regulator's 2022 DNSP Annual Benchmarking Report*, November 2022, pp. 5–9.

Figure 16 Opex efficiency scores and opex MPFP under the approach used in previous reports (2006–2022)



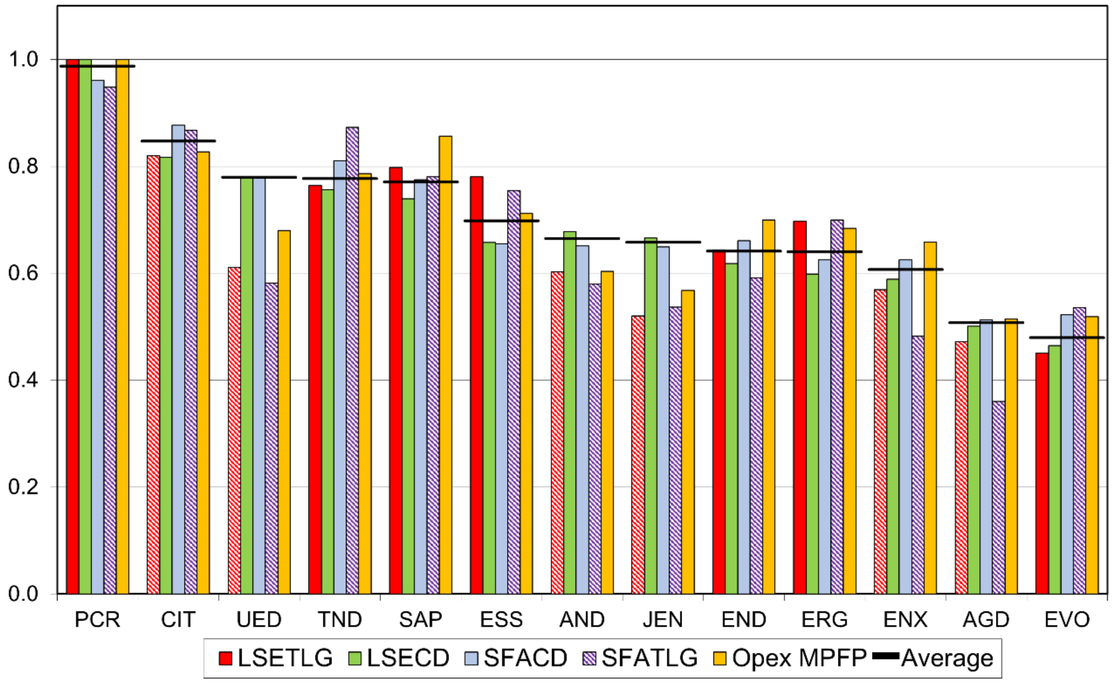
Source: Quantonomics; AER analysis.

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. These results do not reflect the impact of a range of material OEFs (see Section 7). Opex MPFP scores for each DNSP are displayed for comparison but are not included in the calculation of the average score which represents an average of the four econometric model scores, excluding any result where monotonicity violations are present.

Figure 17 presents the average opex efficiency of each DNSP for these four models (plus opex MPFP) over the short period (2012–2022), again under the approach used in previous reports. The model-average (including only those econometric opex cost function 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 short period, the Translog SFA model has been excluded for the purpose of calculating the model-average efficiency scores for all Australian DNSPs. Figure 17 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 have improved their opex efficiency performance over recent years. This has a more pronounced effect on their opex efficiency scores for the shorter rather than the longer period. Powercor, United Energy, Essential Energy, Ergon Energy, Endeavour Energy, Energex and Ausgrid improved their opex efficiency scores in the shorter period relative to the longer period. United Energy (5th to 3rd), Essential Energy (8th to 6th), Endeavour Energy (10th to 9th), and Ausgrid (13th to 12th) also have higher rankings in the shorter period than in the longer period.

Figure 17 Opex efficiency scores and opex MPFP under the approach used in previous reports (2012–2022)



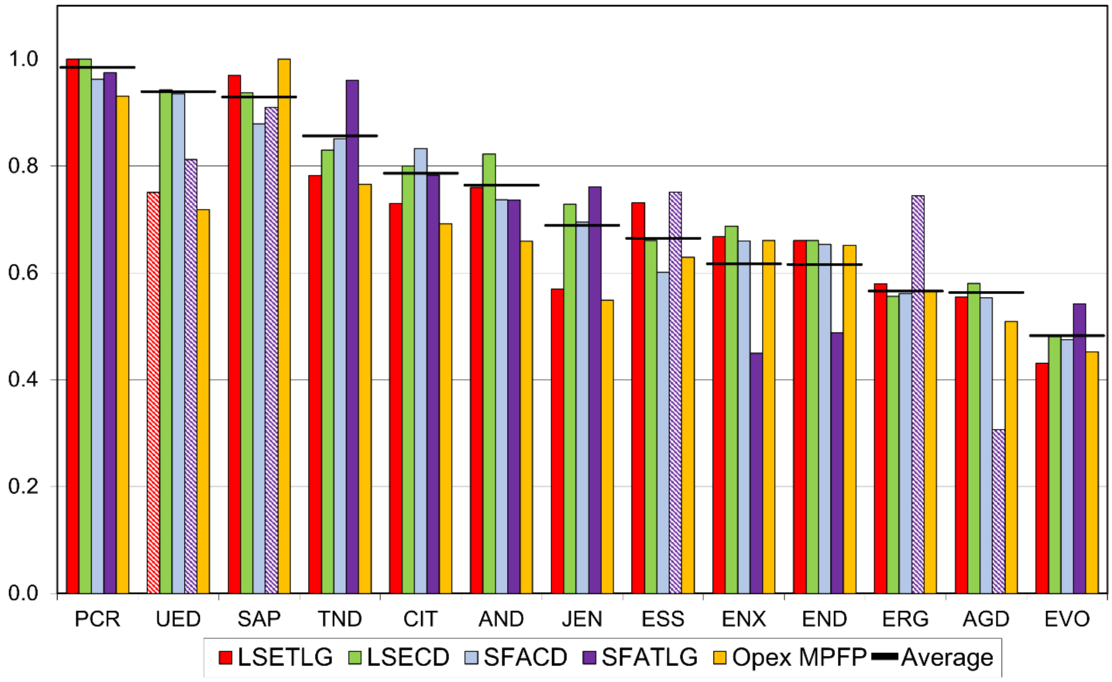
Source: Quantonomics; AER analysis.

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 the SFA Translog model, as the majority of DNSPs have violations of this property, and as the models estimate negative elasticities of opex with respect to customer numbers on average for Australian DNSPs, we have excluded the efficiency scores of the SFA Translog model 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). Opex MPFP scores for each DNSP are displayed for comparison but are not included in the calculation of the average score which represents an average of the four econometric model scores, excluding any result where monotonicity violations are present.

Figure 18 presents average efficiency scores for the above four models and opex MPFP based on our preferred approach to addressing capitalisation differences between DNSPs over the long period (2006–2022). This is ranked from highest to lowest according to the model-average score. Powercor remains the highest ranked DNSP under this approach, followed closely by United Energy and SA Power Networks. TasNetworks, CitiPower and AusNet Services form the remainder of the most efficient DNSPs, being those DNSPs with model-average efficiency scores above 0.75. A key change when implementing our approach to addressing capitalisation differences is that AusNet Services' efficiency score has improved and at 0.76 is just over the 0.75 benchmarking comparator score that we generally use to determine the most efficient DNSPs.

The average efficiency score for all models over the long period across all DNSPs rises from 0.69 under the approach used in previous benchmarking reports, to 0.73 when adopting the new approach.

Figure 18 Opex efficiency scores under the approach to address capitalisation differences between DNSPs (2006–2022)

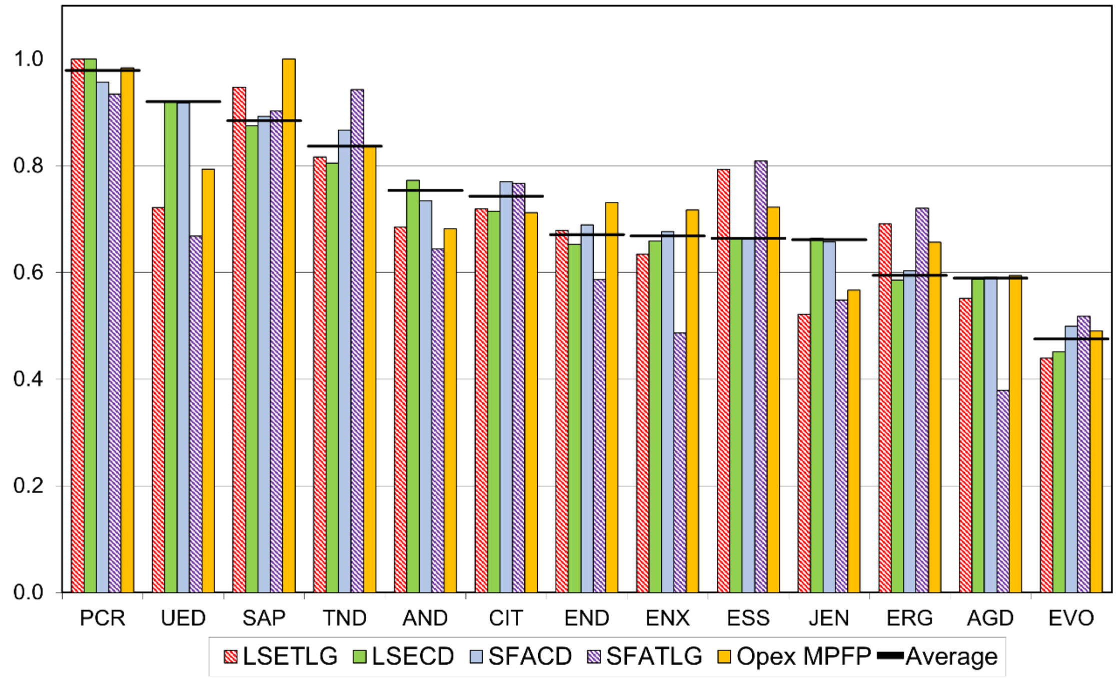


Source: Quantonomics; AER analysis.

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. These results do not reflect the impact of a range of material OEFs (see Section 7). Opex MPFP scores for each DNSP are displayed for comparison but are not included in the calculation of the average score which represents an average of the four econometric model scores, excluding any result where monotonicity violations are present.

Figure 19 presents average efficiency scores for the above four models and opex MPFP based again on implementing our preferred approach to addressing capitalisation differences, but over the short period (2012–2022). Again, this is ranked from highest to lowest according to the model-average score. As a result of monotonicity violations, the model-average scores are based on the two Cobb Douglas models (with results of the two Translog models shown in Figure 19 in a hatched pattern). The results resemble those seen in Figure 18, with the top four DNSPs ranked by model-average efficiency score being Powercor, United Energy, SA Power Networks and TasNetworks. In contrast to the long period results depicted in Figure 18, AusNet Services switches rankings with CitiPower to become the 5th highest ranked DNSP. CitiPower's model average efficiency score (0.74) in the short period is now slightly below the 0.75 benchmark comparator score that we generally use to determine the most efficient DNSPs.

Figure 19 Opex efficiency scores under the approach to address capitalisation differences between DNSPs (2012–2022)



Source: Quantonomics; 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 the SFA and LSE Translog models, as the majority of DNSPs have violations of this property, and as the models estimate negative elasticities of opex with respect to customer numbers on average for Australian DNSPs, we have excluded the efficiency scores of the SFA and LSE 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). Opex MPFP scores for each DNSP are displayed for comparison but are not included in the calculation of the average score which represents an average of the four econometric model scores, excluding any result where monotonicity violations are present.

An important limitation of these results is that, apart from relevant density factors, service classification differences for opex and extent of undergrounding, the econometric opex cost function 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 materially 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 generally 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.

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

The econometric opex cost function 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 2006–2022 period and the 2012–2022 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 period-average efficiency scores will not reflect a DNSP's relative efficiency in the most recent years.

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 circumstances of the DNSP in question. We do this by first averaging the DNSP's actual opex over the relevant benchmarking period (deflated by the opex price index) and calculating its average efficiency score from the models. We then compare the DNSP's opex efficiency score against a benchmark comparison point of 0.75[58] (the best possible efficiency score is 1.0), adjusted for the impact of material 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 down by the difference between the two efficiency scores. This results in an estimate of period-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 the impact of changes in outputs, share of undergrounding 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 draft decision for Evoenergy for the 2024–29 regulatory control period and the final decisions for Jemena and AusNet Services for the 2021–26 regulatory control period, including the application of material OEFs that we have been able to quantify.[59]

58 The benchmark comparators we generally use are those DNSPs that have an econometric model-average efficiency score above the 0.75 benchmark comparison score.

59 AER, *Draft Decision Evoenergy, Regulatory proposal 2024 to 2029, Attachment 6 Operating Expenditure*, September 2023; AER, *Final Decision*, *Jemena distribution determination 2021–26 - Attachment 6 - Operating Expenditure*, April 2021; AER, *Final Decision, AusNet Services distribution determination 2021–26 - Attachment 6 - Operating Expenditure*, April 2021.

During 2022 we undertook work to improve the benchmarking roll-forward models which implement the modelling described in the above box, particularly in terms of the transparency and usability of the models. This included the models calculating and comparing the opex efficiency scores as well as those which calculate the OEFs that are used to adjust the benchmarking comparison point.

Appendix B provides more information about our econometric models.

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 relatively 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 compares inputs to one output. This contrasts with the MTFP, MPFP and econometric opex cost function 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 predominantly 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, larger, more rural DNSPs will perform better because their costs are spread over a longer network. Where possible, we have plotted PPIs against customer density,[60] to enable readers to visualise and account for these effects when interpreting the results.

We have updated the PPIs in this report to include 2022 data and present them as an average for the five-year period 2018–2022.[61] The results are broadly consistent with

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

[61] The updated PPIs are in dollar values as at the end of June quarter 2022.

those presented in the 2022 Annual Benchmarking Report with no major changes.

6.1 Total cost PPIs

This section presents total cost PPIs averaged over the 2018–2022 period. These compare each DNSP's total costs (opex and asset cost) against a number of outputs in turn.[62] The asset cost is measured by the AUC which is made up of the return on capital (return on the DNSPs' regulatory asset base) together with the return of capital (annual regulatory depreciation on the DNSPs' regulatory asset base) plus the benchmark tax liability as calculated under the building block model approach.[63] 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.

We note that in 2022 there has been a significant reduction in AUC due to the reduction in the 'return of capital' which is a measure of straight-line depreciation adjusted for inflation. Historically the adjustment for 'inflation addition' has been small, resulting in a larger return of capital and AUC. The significant increase in inflation in 2022 has resulted in a larger inflation adjustment, smaller return of capital and therefore a smaller AUC. The impact of the significantly lower AUC in 2022 is somewhat mitigated by our use of a 5-year average for the PPIs presented in this section. The use of a 5-year average works to decrease volatility in both the output and input sides. Further, we rely on PPIs to compare relative performance between DNSPs over a selected 5-year period, rather than over time. This further lessens the impact of any volatility in AUC as all DNSPs will be affected similarly by an exogenous variable such as inflation.

Figure 20 shows each DNSP's total cost per customer. Customer numbers are one of

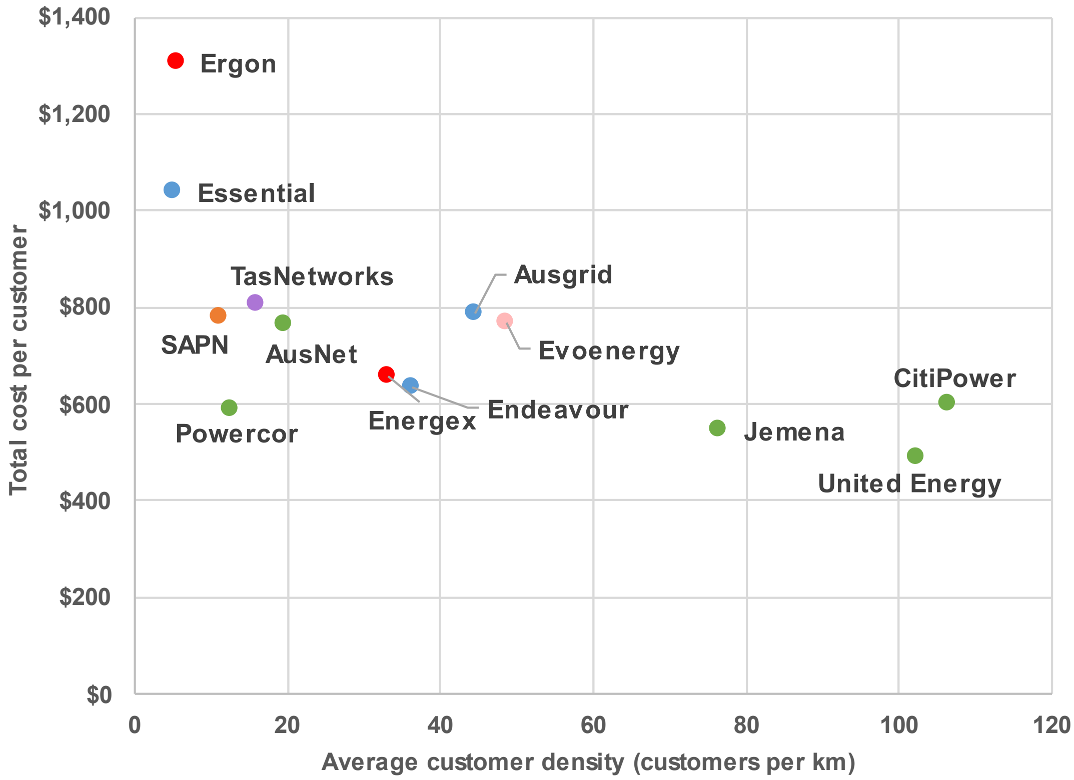
[62] Asset cost is the sum of annual depreciation and return on investment associated with the historical and current capex of a DNSP (as included in its regulatory asset base), using the annual weighted average cost of capital. In economic benchmarking studies, it is generally referred to as the AUC. We have applied to the PPI calculations the same AUC approach we applied to MTFP and MPFP analysis. We have updated the calculation of the AUC for the regulatory years 2020 and 2021 and 2022 to reflect the AER's Rate of Return Instrument 2018. In previous years the AUC calculations broadly reflected the 2013 rate of return guideline. For more details, see: https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/rate-of-return-instrument-2018/final-decision.

[63] We have applied to the PPI calculations the same AUC approach we applied to MTFP and MPFP analysis.

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 other largely rural DNSPs, including SA Power Networks, Powercor, AusNet Services and TasNetworks. Ausgrid and Evoenergy also have relatively higher costs per customer compared to other networks with similar customer densities and most networks with lower customer densities.

Figure 20 Total cost per customer ($2022) (average 2018–2022)

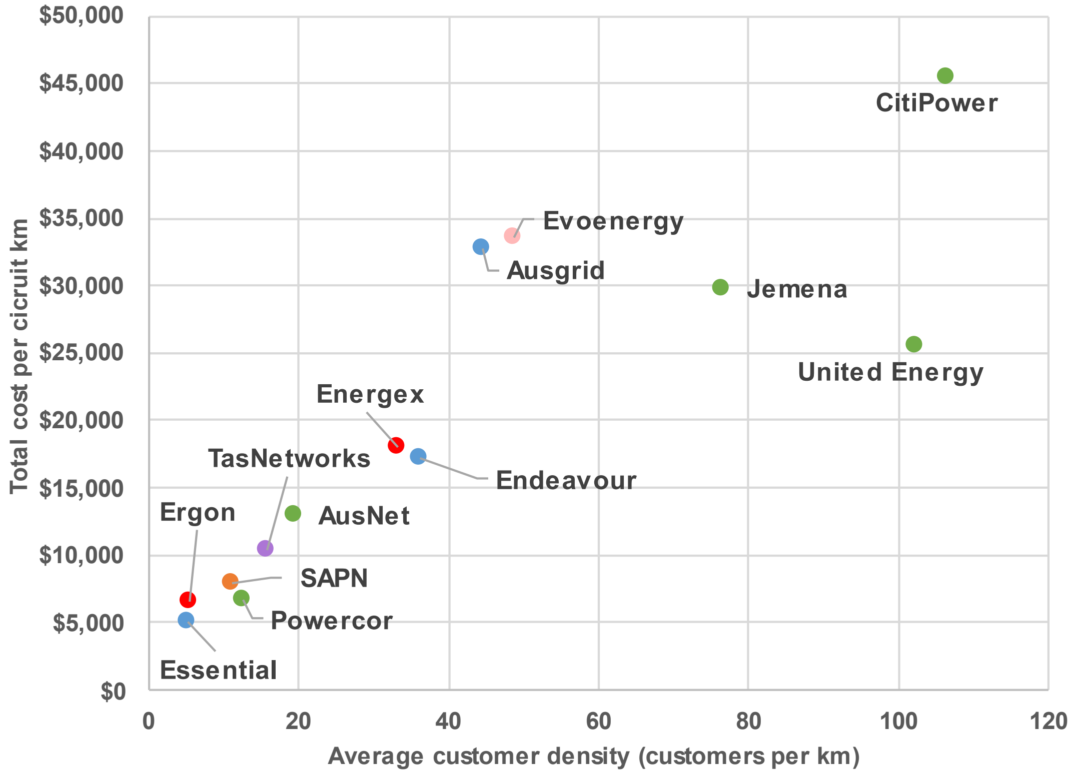


Source: AER analysis; Economic Benchmarking RINs.

6.1.1 Total cost per kilometre of circuit line

Figure 21 presents each DNSP's total cost per kilometre 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 kilometre' 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. Evoenergy and Ausgrid report the second and third-highest total cost per kilometre of circuit line length in the NEM, and perform worse than some networks with higher customer densities (Jemena and United Energy).

Figure 21 Total cost per kilometre of circuit line length ($2022) (average 2018–2022)

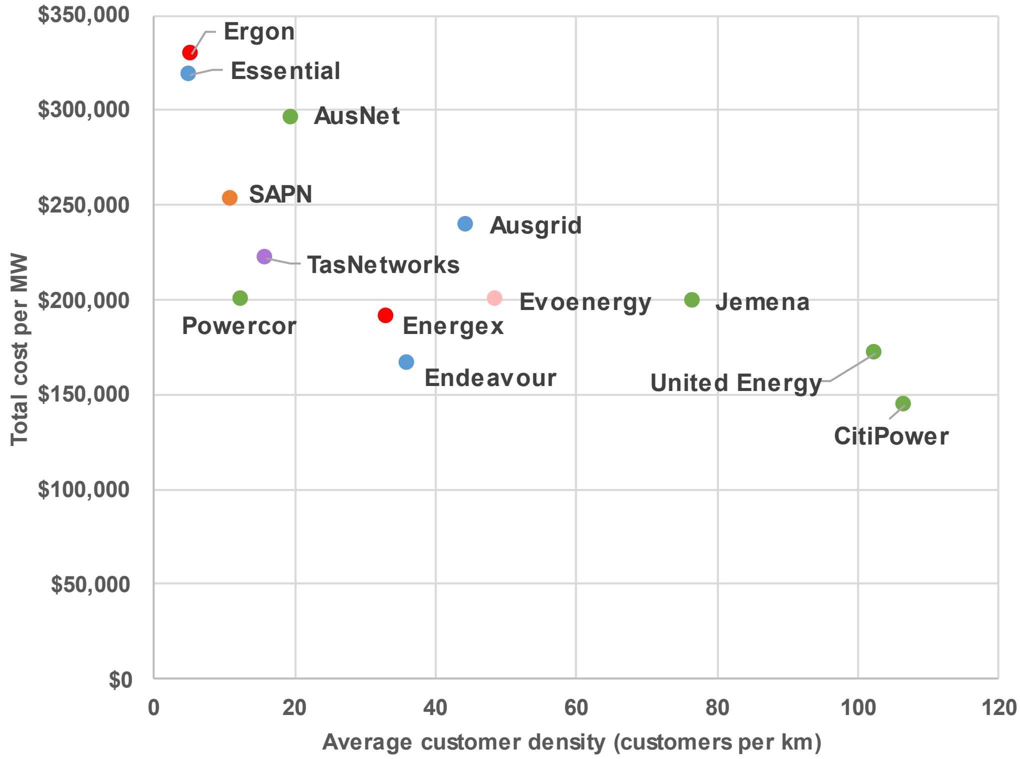


Source: AER analysis; Economic Benchmarking RINs.

6.1.2 Total cost per MW of maximum demand

Figure 22 shows each DNSP's total cost per MW of maximum demand. DNSPs install assets to meet maximum demand. Maximum demand also influences opex, as DNSPs need to operate and maintain assets installed to meet demand at peak time. 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 22 Total cost per MW of maximum demand ($2022) (average 2018–2022)



Source: AER analysis; Economic Benchmarking RINs.

6.2 Cost category PPIs

This section presents the opex category level cost PPIs averaged over the 2018–2022 period. These compare a DNSP's category level opex (vegetation management, maintenance, emergency response) and total overheads against a relevant output.[64] The data for these PPIs are from the category analysis RIN and economic benchmarking RIN reported to the AER.[65]

When used in isolation, these category level PPI results should be interpreted with

64 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.

65 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.

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 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

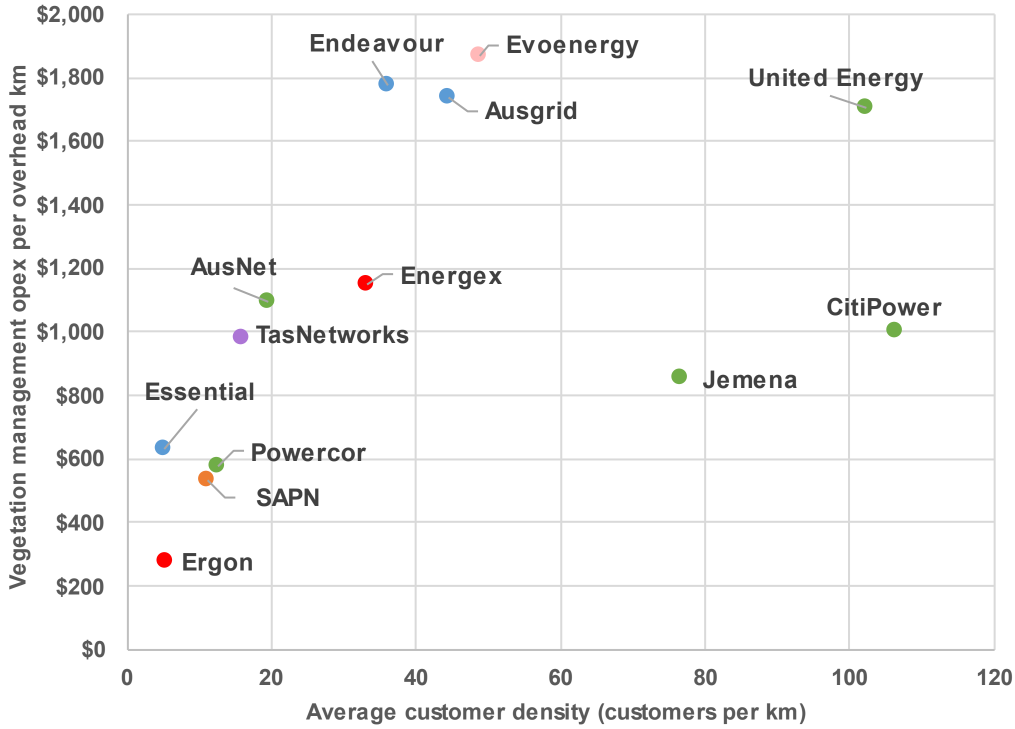
Vegetation management expenditure includes tree trimming, hazard tree clearance, ground clearance, vegetation corridor clearance, inspection, audit, vegetation contractor liaison, and tree replacement costs. We measure vegetation management per kilometre of overhead circuit line length because overhead line length is the most relevant proxy of vegetation management costs.[66]

Figure 23 shows that Evoenergy, 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, including DNSPs with similar customer densities.

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

[66] We note that circuit 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.

Figure 23 Vegetation management opex per km of overhead circuit length ($2022) (average 2018–2022)



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

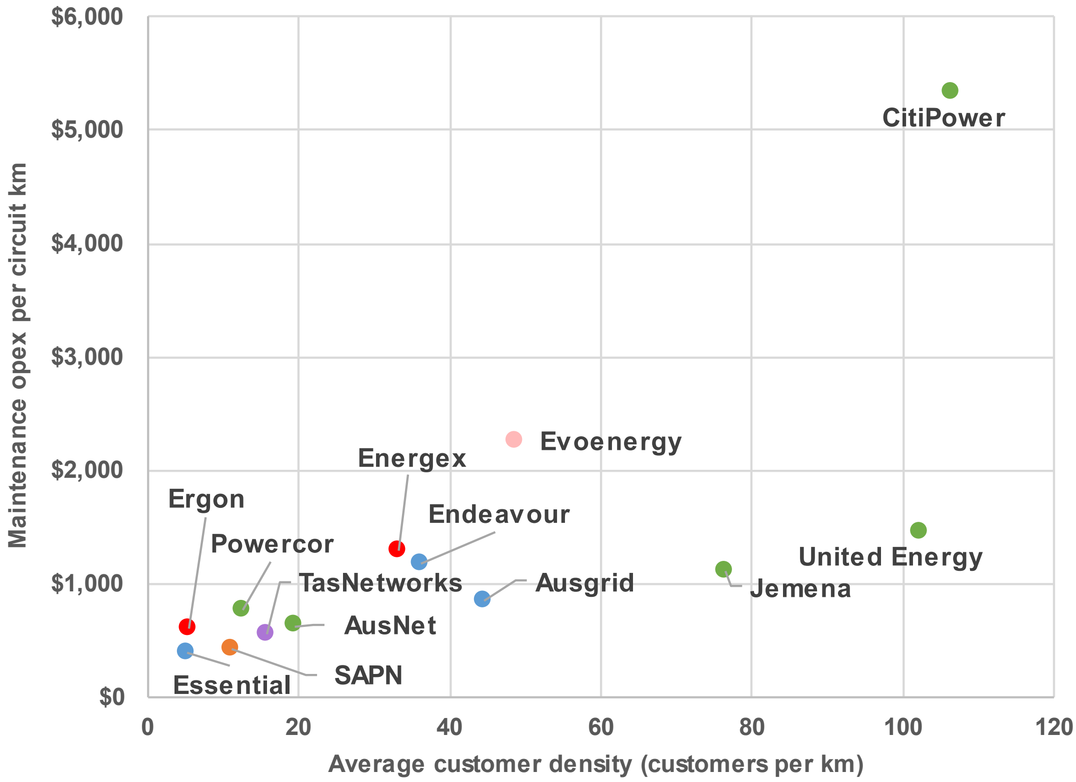
6.2.2 Maintenance

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.[67] 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 24 shows that it has one of the highest maintenance opex spends 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 kilometre’ metrics. However, even compared to other customer-dense networks in the NEM, CitiPower still performs relatively poorly on this measure.

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

Figure 24 Average maintenance opex spend per circuit km ($2022) (average 2018–2022)



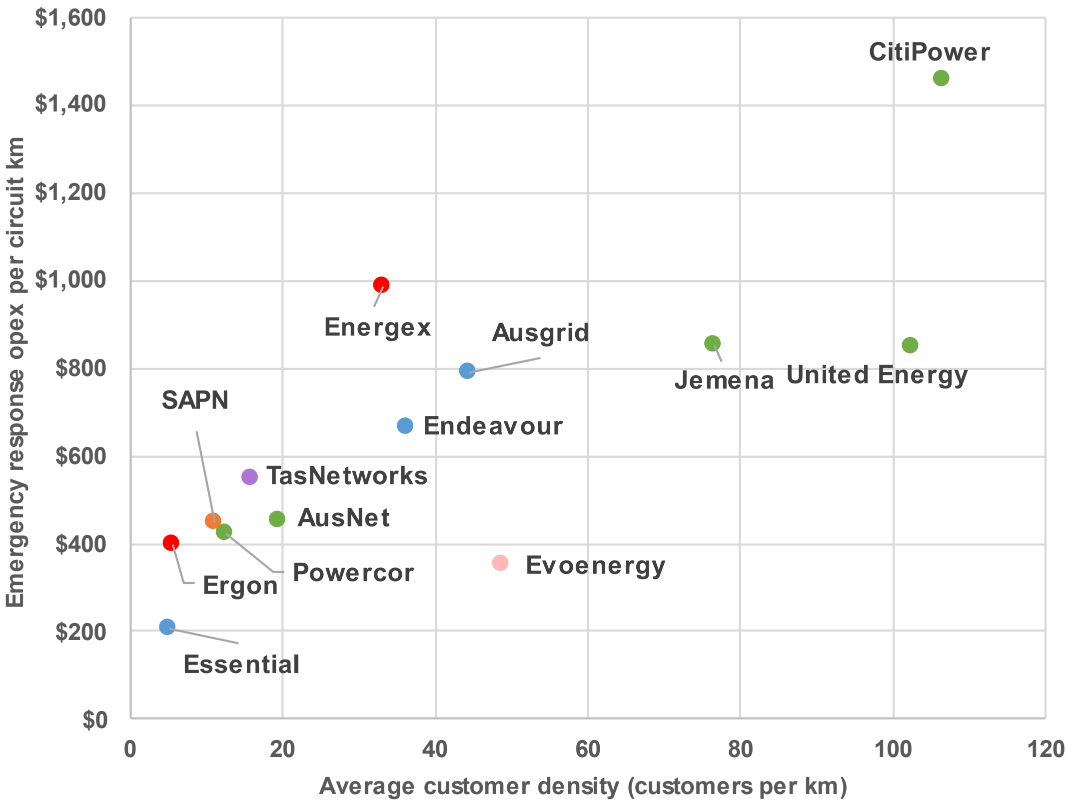
Source: AER analysis; Category Analysis RINs; Economic Benchmarking RINs.

6.2.3 Emergency response

Emergency response expenditure is the direct opex incurred in responding to network emergencies. We measure emergency response costs per circuit kilometre because network emergencies primarily affect power lines 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 kilometre and vegetation management opex per overhead kilometre. 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 25 shows that CitiPower, United Energy, Jemena, Ausgrid and Energex have higher emergency response cost per kilometre relative to other DNSPs in the NEM. Similar to its maintenance costs, CitiPower has one of the highest emergency response opex spends per kilometre of circuit length in the NEM. In comparison, Essential Energy, Ergon Energy, Powercor and Evoenergy have relatively low emergency response costs per kilometre. 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).

Figure 25 Average emergency response spend per circuit km ($2022) (average 2018–2022)



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

6.2.4 Total overheads

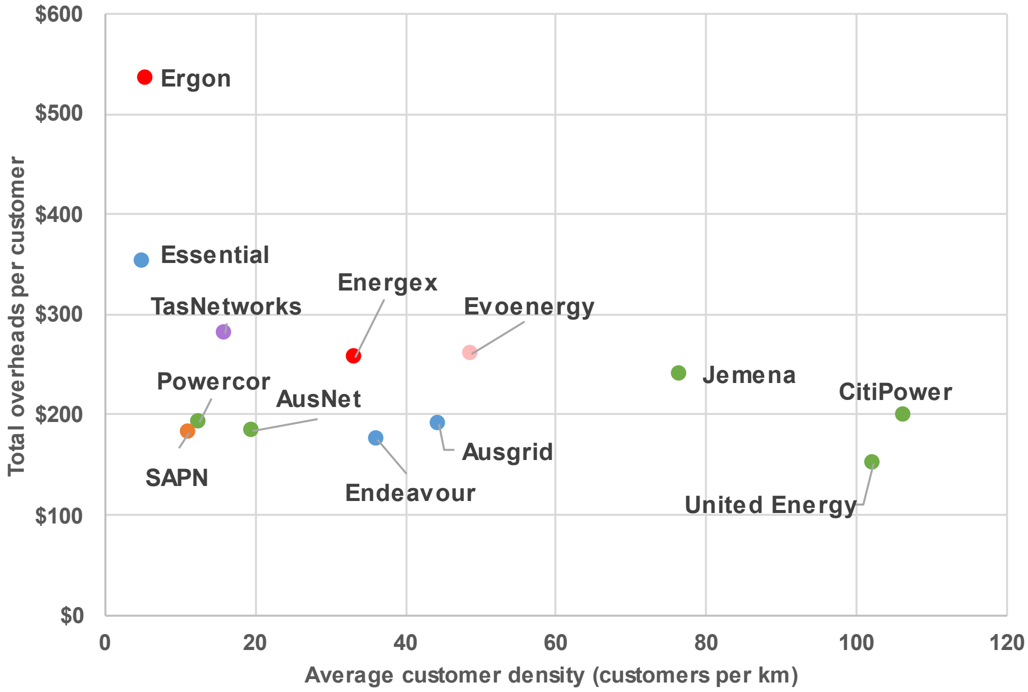
Total overheads are the sum of corporate and network overheads allocated to standard control services. We measure total overheads allocated to both capex and opex to ensure that differences in DNSPs' capitalisation policies do not affect the analysis.[68] It also mitigates the impact of a DNSP's choice 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 26 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

68 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. This is part of the reason for implementing our preferred approach to addressing capitalisation differences outlined in earlier sections.

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.

Figure 26 Total Overheads per customer ($2022) (average 2018–2022)



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 econometric opex cost function models. See the box at the end of this section for more details on how we apply OEF adjustments to the econometric benchmarking model efficiency scores.

DNSPs do not all operate under the same operating environments. When undertaking a benchmarking exercise, it is desirable to consider 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 productivity 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 maximum demand output variables. These are sources of material differences in operating costs between networks.
- The econometric opex cost function 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.[69]

Criteria for identifying relevant OEFs

- **Exogeneity**. 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.
- **Materiality**. 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.
- **Non-duplication**. 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.[70]

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.[71] 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.

69 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. For more details, see: Sapere Research Group and Merz Consulting, *Independent review of Operating Environment Factors used to adjust efficient operating expenditure for economic benchmarking*, August 2018.

70 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.

71 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.

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
- 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.[72]

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.[73] Our benchmarking techniques do not directly account for these differences in costs. This is because our circuit line length and ratcheted maximum 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 some of the NSW and QLD DNSPs require 4 to 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.[74]

[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. 35.

[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. 48.

[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. 55.

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
- 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.[75] 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.[76]

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.[77] However, we were not able to develop any clear conclusions from this analysis due to

75 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.

76 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.

77 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.

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.

While not able to use Sapere-Merz's suggested methodology, we have undertaken further work to quantify the impacts of any differences arising due to vegetation management. This has been undertaken in the context of our revenue determinations for NSW, ACT, Queensland and Victorian DNSPs where we included vegetation management OEFs as a part of our base opex efficiency assessments.[78] These decisions used consistent methods 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.

We have 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 have calculated a division of responsibility OEF for non-Victorian and South Australian DNSPs[79] to reflect the cost disadvantage these DNSPs face in the scale of vegetation management responsibility compared to the benchmark comparator firms in

[78] AER, *Draft Decision Evoenergy, Regulatory proposal 2024 to 2029, Attachment 6 Operating Expenditure*, September 2023, pp. 28-31; 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, pp. 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.

[79] 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.

these states. For example, 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 non-Victorian and South Australian DNSPs face relative to the Victorian and South Australian distribution businesses.

In light of the further work we have done to improve the models setting out the OEF adjustments, and how these are used in our base opex efficiency analysis (noted in Section 5), we have received feedback from several DNSPs in relation to the above approach. Evoenergy, CitiPower, Powercor and United Energy, Essential Energy and AusNet Services have previously raised concerns about the above method and did not consider it appropriate to apply without further refinement.[80] Evoenergy noted that the vegetation management OEF as currently calculated does not reflect the risk of bushfires and impact on vegetation management costs, but rather the impact of bushfire-related regulations imposed on Victorian networks in 2011. Further, that there have been changes to Evoenergy's vegetation management obligations in 2018 that were not taken into account. AusNet Services and CitiPower, Powercor and United Energy did not consider the division of responsibility for vegetation clearance to be a material factor. Jemena recommended that the AER update one of the key numbers used in the calculation of the division of responsibility factor.

As noted in Section 8.1 we will seek to improve the data and quantification of the vegetation management OEF as possible, including in the context of revenue determination processes. In this regard, in the recent Evoenergy draft determination we assessed the changes in Evoenergy's vegetation management obligations in 2018. As a result of this assessment, we updated the OEF quantification for Evoenergy to provide additional adjustment recognising the changes to its vegetation management obligations in 2018.[81]

80 Evoenergy, *Email to AER – Refined benchmarking roll-forward model and OEF spreadsheets,* received on 19 August 2022; Essential Energy, *Email to AER – Refined benchmarking roll-forward model and OEF spreadsheets,* received on 21 August 2022; AusNet Services, *Email to AER – AER 2022 Annual Benchmarking Report for distribution - preliminary benchmarking results,* received on 30 August 2022; CitiPower, Powercor and United Energy, *Email to AER – AER 2022 Annual Benchmarking Report for distribution - preliminary benchmarking results,* received on 26 August 2022.

81 AER, *Draft Decision Evoenergy, Regulatory proposal 2024 to 2029*, September 2023, pp. 28–31.

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 we benchmark that regularly faces cyclones. Sapere-Merz estimated that Ergon Energy requires up to 5% more opex than other DNSPs in the NEM to account for the costs of cyclones.[82]

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.[83]

AusNet Services has previously requested that the AER confirm that the latest taxes and levies data it provided would be used for the calculation of its taxes and levies OEF. This covered seven different categories of taxes and levies across the 2009 to 2015 financial years: land tax, water rates, council rates, an Ombudsman levy, regulator fees, a fire services levy, and other government charges and levies. Currently, only the Ombudsman levy from 2010 to 2015 is used in the OEF calculation. We have applied this approach consistently for all the Victorian DNSPs. As noted in Section 8.1, we will review the appropriateness of this calculation as part of our ongoing incremental improvement of the benchmarking datasets and methods.

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

82 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.

83 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.

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. On the basis of information provided by Evoenergy, Sapere-Merz estimated that Evoenergy requires 1.6% more opex than other DNSPs in the NEM to manage backyard power lines in the ACT.[84]

In its current revenue determination process, Evoenergy proposed updated cost estimates for the activities related to inspecting and maintaining backyard lines.[85] We assessed these to be reasonable and as a result determined that an updated OEF of 3.5% was appropriate to reflect the additional opex Evoenergy requires to manage backyard power lines in the ACT.

Termite exposure

DNSPs incur opex when carrying out termite prevention, monitoring, detection and responding to termite damage to assets. These costs depend on the number of a DNSP's assets (particularly wooden poles) 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.[86] Ausgrid identified a data error in the number of wooden poles it owns that was used in previous calculations of this OEF. We have identified the source of the original data. The revised data will be used in future applications.

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.[87]

In our most recent revenue determination for Ergon Energy, we included a network

84 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.

85 AER, *Draft Decision Evoenergy, Regulatory proposal 2024 to 2029, Attachment 6 Operating Expenditure*, September 2023, pp. 31-32.

86 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.

87 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.

accessibility OEF in our benchmarking analysis.[88] 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.[89] 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.

Workers' compensation

Workers' compensation is a form of insurance payment to employees if they are injured at work or become sick due to their work. It can include payments to employees to cover their wages while they are not fit for work, as well as medical expenses and rehabilitation. Workers' compensation is governed by individual Australian states and territories and employers in each state or territory have to take out workers compensation insurance to cover themselves and their employees.[90]

Our latest draft revenue determination for Evoenergy included a workers' compensation OEF accounting for the differences in the relative cost of workers' compensation between jurisdictions.[91] In support of this new OEF, Evoenergy cited Marsh data which suggested that workers' compensation premium rates for the electricity industry in the ACT are 2.7 times greater than any other state, measured as an average percentage of payroll.[92] We accepted that Evoenergy faces a material cost disadvantage relative to the comparator DNSPs as a result of higher workers' compensation insurance premiums in the ACT. In our draft revenue determination, we assessed an OEF adjustment for Evoenergy of 0.75% was appropriate to reflect these additional costs.[93]

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 comparator point to assess the relative operating

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

[89] AER, *Preliminary decision Ergon Energy distribution determination 2015−20 Attachment 7 - Operating expenditure*, April 2015, p. 248; AER, *Final decision Ergon Energy distribution determination 2015−20 Attachment 7 - Operating expenditure*, October 2015, p. 53.

[90] See: https://www.fairwork.gov.au/employment-conditions/workers-compensation

[91] AER, *Draft Decision Evoenergy, Regulatory proposal 2024 to 2029, Attachment 6 Operating Expenditure*, September 2023, pp. 32–33

[92] Evoenergy, *Marsh – ActewAGL Distribution ACT Workers Compensation, Appendix 2.2*, January 2023

[93] AER, *Draft Decision Evoenergy, Regulatory proposal 2024 to 2029*, September 2023, pp. 32-33.

efficiency of DNSPs (the best possible efficiency score is 1.0.) We adjust the benchmark comparison point for opex for the 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 incremental opex of that factor as a percentage of (efficient) opex is compared with the customer-weighted average 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 comparators.

The application of OEF adjustments as described above is illustrated with the following hypothetical example of a DNSP with a 'raw' opex efficiency score of 0.50 and which faces an exogenous condition unique to its operating environment and its associated costs. As shown below, the 0.75 comparator point is as a result adjusted downwards to 0.68.

Hypothetical example:

A	Raw benchmarking efficiency score	0.5
B	Efficient total opex ($ million)	100
C	Opex due to unique operating environment factor ($ million)	10
D	OEF as a percentage of total opex (C/B)	10/100=0.10
E	Adjusted 0.75 comparator point (0.75/(1+D))	0.75/(1+0.10)=0.68
F	Efficiency adjustment to period average opex (1-(A/E))	(1-0.5/0.68)=27%

We do not expect to be able to quantify and apply OEF adjustments for all operating environment differences between DNSPs; however, we consider that the OEFs we do apply, listed in Section 7 above, capture the most material differences in addition to those already captured in the modelling. More detail on the mechanics of our approach is contained in past decisions and our work in 2022 to improve the models setting out the OEF adjustments.[94]

[94] AER, *Preliminary decision, Ergon Energy determination 2015–20, Attachment 7 –*

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 consider our benchmarking development program taking into account issues arising across both the distribution and transmission reports. There are a variety of factors which inform the development work we progress, including:

- Feedback from stakeholders
- The materiality and impact of the development work on the robustness of the benchmarking
- The materiality and impact of the development work in relation to upcoming revenue determinations in which the benchmarking results will be used
- The ability to progress this work, including any sequencing issues and available data
- The resources available to undertake this work.

We categorise our benchmarking development work as:

- ongoing incremental improvement in data and methods that support our annual benchmarking reporting
- specific issues, changes and improvements that have the potential to materially affect the benchmarking results and the way they are used that should involve consultation with affected stakeholders.

Consistent with the priorities set out in the 2022 Annual Benchmarking Report, over 2022 and 2023 we progressed the following two specific benchmarking development issues.

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; AER, *Draft Decision Evoenergy, Regulatory proposal 2024 to 2029, Attachment 6 Operating Expenditure*, September 2023.

Review of export services impacts on benchmarking

In March 2023 we released a final report on *Incentivising and measuring export service performance.*[95] In the final report we concluded that while the benchmarking results do not fully account for export services, and there is a need for a further review to consider what, if any, changes to the benchmarking models can be made, there is insufficient data currently available to inform such a review. The final report also noted there was insufficient evidence to conclude that the provision of export services was currently impacting the benchmarking results in a way that materially disadvantaged DNSPs in practice.

In this context, the AER committed to a full review of export services impacts on benchmarking by 2027, or earlier if better export services data becomes available. In the interim, we said we would:

- begin collecting additional benchmarking-related data through the AER's annual performance reporting process to inform the future review
- use the annual performance and benchmarking reporting processes to monitor and consult on (if / when more benchmarking-related export services data becomes available that could be used to develop export service metrics) the timing of the 2027 review and if it can be brought forward.
- update the Annual Benchmarking Report for distribution to note that we are working toward a full review of if / how the benchmarking models can be updated for export services and acknowledge that, in the interim, the benchmarking results do not fully account for export services.

The AER's performance reporting team consulted with DNSPs over 2023 on what export services-related data could be collected and the types of metrics we can begin to report for 2020–21, 2021–22 and 2022–23. Export services data currently being collected through this process that we think is most relevant to the future review of benchmarking includes export services-related capex and opex, export service customer numbers as a proportion of total customer numbers, and the quantity of energy exported as a proportion of total energy delivered over the year. We note, however, that for benchmarking purposes we would need a longer timeframe than the three years currently being collected. The first performance report containing this data will be published in December 2023.

Consistent with the above interim actions, the AER has begun collecting export service information and we have monitored this as a part of preparing the 2023 Annual Benchmarking Report. However, at this stage, given the infancy of the data collection process, and the limited nature of the data available, we do not consider there is any

95 AER, *Incentivising and measuring export service performance – Final report*, March 2023.

basis for bringing the 2027 review forward. We will continue to monitor this situation and provide updates in future reports.

Review of how to address the impact of capitalisation differences between DNSPs

In May 2023 we released a final guidance note in relation to *How the AER will assess the impact of capitalisation differences on our benchmarking results*.[96] This ended our consultation process on this issue and we:

- concluded that there are material differences in the application of capitalisation accounting policy and opex/capital trade-offs between DNSPs and these are having a material impact on our benchmarking results
- set out our preferred approach to address these differences, specifically allocating 100% of corporate overhead expenditure to the opex series for benchmarking purposes
- set out that we would implement this approach, starting in the 2023 Annual Benchmarking Report, by using frozen 2022 CAMs as the basis for expenditures and relying on estimated data for 2006–2008 capitalised corporate overhead data which we consulted on with the DNSPs.

As set out in Sections 4 and 5, we have applied our preferred approach to addressing capitalisation differences to the MTFP, MPFP and econometric opex cost function models as part of this year's report. We consider that the method used for AUC data adjustment in order to implement this for the MTFP and MPFP models is fit for purpose for this report. However, given it is a preliminary approach, we will continue to consult and consider if refinement is required in future reports.

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 economic benchmarking RIN data and data issues identified by stakeholders, for example the ongoing treatment of lease and SaaS implementation costs.
- Improving the way we measure the quantity of lines and cables inputs. We collect

96 AER, *How the AER will assess the impact of capitalisation differences on our benchmarking, Final Guidance Note*, May 2023.

DNSP-specific voltage capacity data, measured in megavolt amperes (MVA), 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 to account for year-to-year fluctuations in exogenous factors, primarily weather, that unduly impact reliability performance and productivity growth results. Currently, the reliability output, customer minutes off-supply, enters the models as a negative output and is weighted by the value of customer reliability. It is already calculated exclusive of major event days and 'excluded' outages.
- Continuing to improve and update the quantification of material OEFs working with DNSPs. Improving the data and quantification of the vegetation management OEF will be a future focus, as discussed in Section 7. We also intend to implement any potential incremental refinements to our approach to other OEFs where appropriate However, at this stage it is unlikely that we will undertake a holistic review of all OEFs and will more likely make incremental improvements through the revenue determination processes.
- Following the expected inclusion of emissions reduction as one of the National Energy Objectives, we will consider the impact, if any, on our benchmarking of distribution network service providers. This will likely include if / how emissions reductions are / should be captured in the benchmarking models, particularly on the input side, but also on the output side, including any interdependencies with consumer energy resources hosting capacity and export services.
- If and how the Northern Territory DNSP, Power and Water, should be included in our benchmarking.

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:

- as noted above, continuing to collect and understand export services data ahead of the further review in 2027, or earlier if possible, and fully implementing the proposed approach to addressing capitalisation differences between DNSPs.
- undertaking an independent review of the non-reliability output weights used in the PIN benchmarking – see Section 8.2.1
- further investigating and improving where possible, the reliability performance of the Translog econometric opex cost function models, particularly in relation to satisfying monotonicity – see Section 8.2.2

- considering the choice of benchmarking comparison point when making our opex efficiency assessments – see Section 8.2.2.

These issues are discussed briefly below.

8.2.1 Independent review of the non-reliability output weights in the PIN benchmarking

In the 2020 Annual Benchmarking Report for distribution, we made changes to the non-reliability output weights used in the PIN benchmarking to correct an error identified in how these weights had been calculated in previous years' reports.[97] Following this, and submissions from stakeholders indicating broad support, we noted in the 2021 Annual Benchmarking Report that we considered it was appropriate that an independent review be undertaken that would:

- 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 considered this was an appropriately targeted and manageable scope and an important piece of work. Due to competing priorities, including the other reviews in progress, and resource availability we noted in the 2022 Annual Benchmarking Report that we would aim to initiate this review in 2023–24, which remains our proposed timing.

8.2.2 Investigating the performance of the Translog econometric opex cost function

As set out in Section 5, under the Translog econometric opex cost function models there are a number of instances where the monotonicity property does not hold and the prevalence of monotonicity violations has increased in this year's results compared to last year's. The Translog functional form model is, by design, more flexible than the Cobb-Douglas form, through the addition of 'second-order' terms in the output specification.[98] The downside of this flexibility is that monotonicity is not necessarily

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

[98] 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.

satisfied for all observations in the data sample, which is what we are seeing again in this year's results.

In preparing this year's report, several DNSPs raised concerns around this issue and in addition to raising an option for addressing the monotonicity violations, suggested that as a result of the prevalence of these violations they should not be used, or caution exercised in how they are used.[99] In addition, some DNSPs suggested that monotonicity violations could be addressed by incorporating into the Translog models different time trends between jurisdictions to allow for diverging efficiency changes.[100] Further, Evoenergy and Ausgrid raised concerns in relation to the performance of the SFA Translog model in terms of the results potentially being a local rather than global maximum.[101] Some DNSPs also considered a program of work should be developed to address the issues occurring with the econometric models.[102]

As in past years, investigating and improving, where possible, the performance and reliability of the Translog econometric opex cost function models, particularly in relation to satisfying monotonicity, is important and ongoing development work. We have

99 Evoenergy, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023; Ausgrid, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023; Ausgrid, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 20 October 2023; Jemena, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023; Energex and Ergon Energy, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 27 October 2023.

100 Evoenergy, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023; Ausgrid, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023; Ausgrid, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 20 October 2023.

101 Evoenergy, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023; Ausgrid, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023; Ausgrid, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 20 October 2023

102 Ausgrid, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 20 October 2023; Evoenergy, *Email to AER – Preliminary Annual Benchmarking Report 2023 – Electricity distribution network service providers – Consultation stage 1*, 4 September 2023; Energex and Ergon Energy, *Email to AER – Draft AER 2023 Annual Benchmarking Report – Electricity distribution network service providers – Consultation stage 2*, 27 October 2023.

continued to examine this issue with our benchmarking consultant, Quantonomics, who has undertaken some additional work to consider possible options for improving the performance of these models. This is set out in a Quantonomics memo that we are publishing alongside this report.[103]

Key options in the Quantonomics memo that we propose to prioritise over the next year in terms of further consideration and engagement are as set out below:

- Considering further the use of a 'hybrid' model in circumstances where the Translog model has prevalent monotonicity violations.[104] As outlined in previous reports, the hybrid model removes some of the cross-product and squared output coefficients (which may be correlated) and to date has shown some promise in terms of minimising / removing the monotonicity violations.
- Considering modifications to the econometric opex cost function in terms of including a time trend variable specific to the Australian jurisdiction in order to allow the underlying time trend of opex to differ on average for the Australian DNSPs compared to those in New Zealand and Ontario. The time trend in the models is intended to capture the effects of technical change on opex over time. However, it may also capture a range of other factors that vary over time but are not explicitly accounted for in the model. For this reason, the time trend effect may differ between jurisdictions.

We will consult with stakeholders over 2024 with a view to examining these options and improving the performance of these models, where possible, for the 2024 Annual Benchmarking Report. This will include providing stakeholders with opportunities to make submissions, attend bi-lateral discussions and as required, industry-wide workshops. These discussions and workshops would involve our benchmarking consultant, Quantonomics. This work will involve theoretical consideration of the issues and options, as well as empirical testing of those options considered theoretically appropriate and practical to implement.

While this development work is ongoing, we also note that we do not use the Translog model efficiency score results for a DNSP in determining its average efficiency score when there are monotonicity violations for a majority of observations for the DNSP. Further, the efficiency score results are not used when the majority of Australian DNSPs have excessive monotonicity violations. We consider it appropriate to not use the results of models that do not produce valid, economically principled, results. However, where they do produce valid results we consider it is appropriate to include

103 Quantonomics, *Opex Cost Function-Options to Address Performance Issues with Translog models*, October 2023.

104 This approach was also considered in Quantonomics, *Opex Cost Function Development*, October 2022.

them in the reported average efficiency scores.

8.2.3 Benchmarking comparison point

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 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.

Historically, the AER's Consumer Challenge Panel advocated for the raising of our benchmark comparison point and a tightening of the analysis of whether a DNSP is "not materially inefficient".[105] Further, in the AER's recent *Review of incentives schemes for Networks* it was noted that one of the issues raised by consumers was whether we should use benchmarking more aggressively in setting our expenditure forecasts. In the final decision for that review we noted that as we refine our benchmarking techniques there may be a case to revise the 0.75 comparison score so that benchmarking is applied at a point closer to the efficiency frontier.[106] We also noted in final guidance note for how we will address capitalisation differences between DNSPs, that under our preferred approach any narrowing of the gap between efficiency scores of the benchmark comparators and other DNSPs raises the question of whether the benchmark comparison point of 0.75 remains appropriate.[107]

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

However, in light of the above reviews we are proposing to commence a review of the benchmarking comparison point from 2025–2026. This would be after the Victorian distribution revenue determinations have been settled, and in preparation for the next 'round' of determinations.

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

106 AER, *Review of incentives schemes for networks, Final decision*, April 2023, p. 5.

107 AER, *How the AER will assess the impact of capitalisation differences on our benchmarking, Final Guidance Note*, May 2023, p. 21.

As noted in Section 3, given the sustained opex productivity growth since 2012 observed for DNSPs is higher than the opex productivity growth rate assumption of 0.5% per year used in regulatory decisions, this may also be an area for review.

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
MW	Megawatt
NEL	National Electricity Law
NEM	National Electricity Market
NER	National Electricity Rules
Opex	Operating expenditure
PCR	Powercor
RAB	Regulatory Asset Base
RIN	Regulatory Information Notice
SAP	SA Power Networks
TND	TasNetworks (distribution)
UED	United Energy

Glossary

Term	Description
Efficiency	A DNSP's 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.
OEF	Operating Environment Factor. 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.
RMD	Ratcheted Maximum Demand. RMD 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 Quantonomics, and previously by Economic Insights.

Quantonomics publications

The following publication explains in detail how Quantonomics applied the economic benchmarking techniques used by the AER:

- Quantonomics, *Economic Benchmarking Results for the Australian Energy Regulator's 2023 DNSP Benchmarking Report,* November 2023
- Quantonomics, *Economic Benchmarking Results for the Australian Energy Regulator's 2022 DNSP Benchmarking Report*, November 2022 (link)

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*, 12 November 2021 (link)
- Economic Insights, *Economic Benchmarking Results for the Australian Energy Regulator's 2020 DNSP Benchmarking Report*, 13 October 2020 (link)
- 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*, 16 October 2019 (link)
- Economic Insights, *Economic Benchmarking Results for the Australian Energy Regulator's 2018 DNSP Benchmarking Report*, 9 November 2018 (link)
- 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 (link)
- Economic Insights, *Memorandum – DNSP MTFP and Opex Cost Function Results*, 13 November 2015 (link)
- 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, Draft Decision, *Evoenergy distribution determination 2024–29 - Attachment 6 - Operating Expenditure*, September 2021 (link)
- AER, Final Decision, *Jemena 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, Final Decision, *AusNet Services distribution determination 2021–26 - Attachment 6 - Operating Expenditure*, April 2021 (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, Final Decision, *Ausgrid distribution determination 2014–15 to 2018–19,* January 2019 (link)
- AER, Final Decision, *Jemena distribution determination 2016 to 2020 - Attachment 7 - Operating Expenditure*, May 2016, p. 7–22 (link)
- AER, Final Decision, *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.

B.1 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,[108] 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. It allows partial productivity levels to be compared between networks.

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

108 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.

econometric models also account for the degree of network undergrounding.

- Output variables. The econometric opex cost function 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.
- 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.[109] 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.

Quantonomics' 2023 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.

B. 2 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

109 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.

been selected to reflect this goal.[110]

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.[111]
- 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 opex cost function models.

110 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.

111 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.

- Reliability (Customer 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 customer reliability. This output is included only in the PIN models, not in the econometric opex cost function models.
- Share of undergrounding: The econometric opex cost function models also include a 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. When the economic benchmarking program commenced, 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) indicated that the addition of the overseas data improved the robustness of the econometric opex models (by allowing better estimation of the opex cost function parameters) without distorting the estimation of individual DNSPs' efficiency results. Appendix A contains references to further reading on how Economic Insights incorporated overseas data into the econometric models and the sensitivity analyses. This approach with the international data continues to be used in the benchmarking work undertaken by Quantonomics to update for the 2022 data.

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 RINs. The economic benchmarking 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. Quantonomics prepared the benchmarking results using the set of agreed benchmarking techniques.[112] We provided the DNSPs with a draft version of the benchmarking report to allow each network to provide feedback on the data and results before we publicly released the final benchmarking report.[113]

The complete data sets for all inputs and outputs from 2006 to 2022, along with the Basis of Preparation provided by each DNSP, are published on our website.[114]

Outputs

112 The Quantonomics 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.

113 NER, cll. 8.7.4(c)(1) and 8.7.4(c)(2).

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

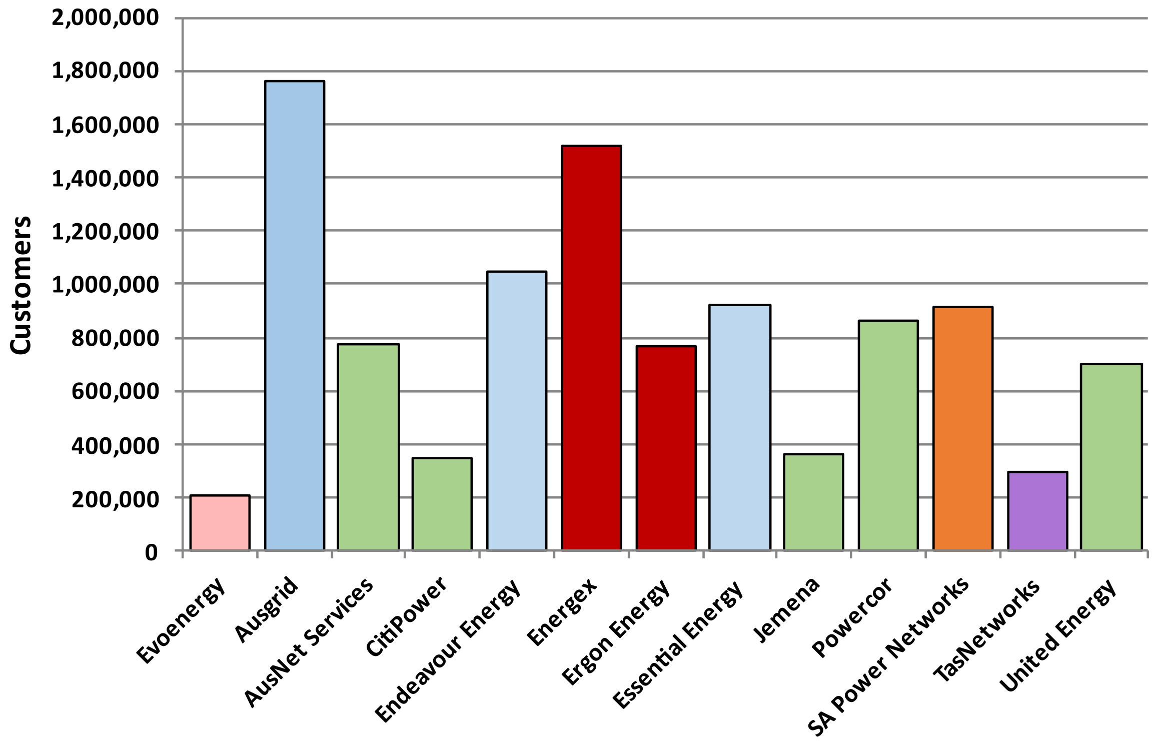
The techniques in this report measure output using some or all of customer numbers, circuit line length, maximum demand, energy throughput and reliability.

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.[115]

Figure B.1 shows the average customer numbers of each DNSP over the five-year period from 2018 to 2022.

Figure B.1 Five-year average customer numbers by DNSP (2018–2022)



Source: Economic Benchmarking RIN.

Circuit line length

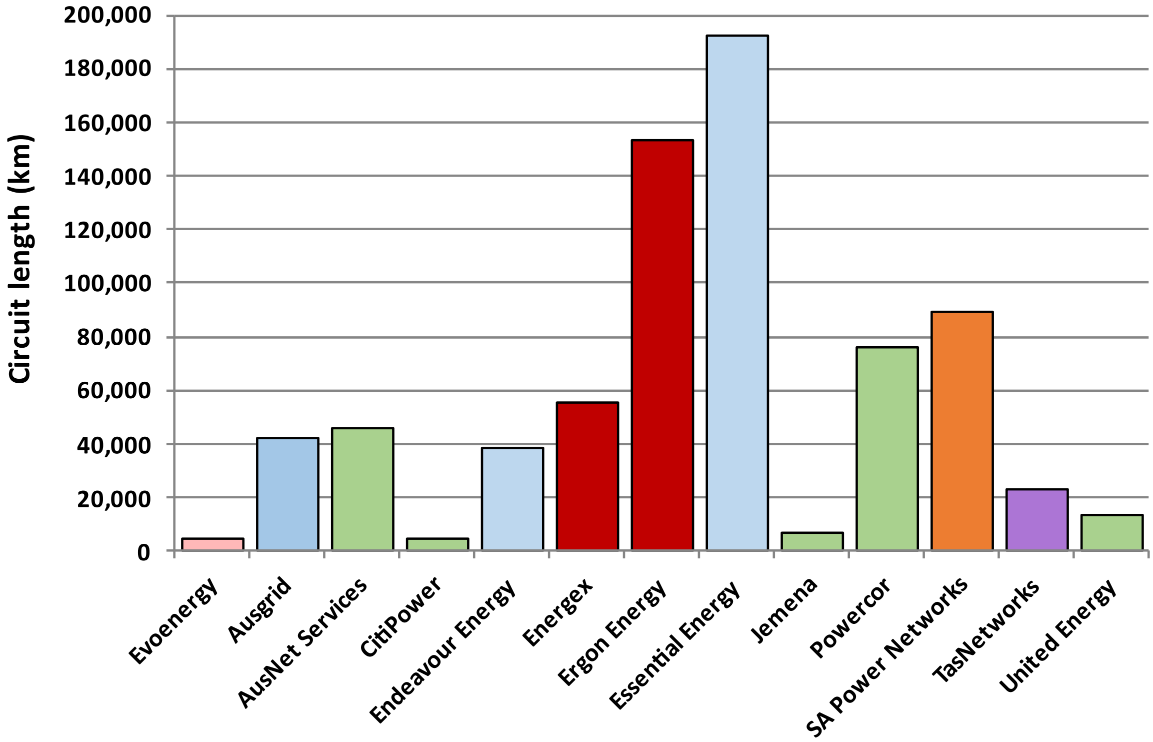
Line length reflects the distances over which DNSPs deliver electricity to their customers. To provide their customers with access to electricity, DNSPs must transport electricity from the transmission network to their customers' premises. DNSPs will typically operate networks that transport electricity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

115 We measure the number of customers as the number of active connections on a network, represented by the sum of energised national metering identifiers and unmetered connections excluding those for public lighting.

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 2018 to 2022.

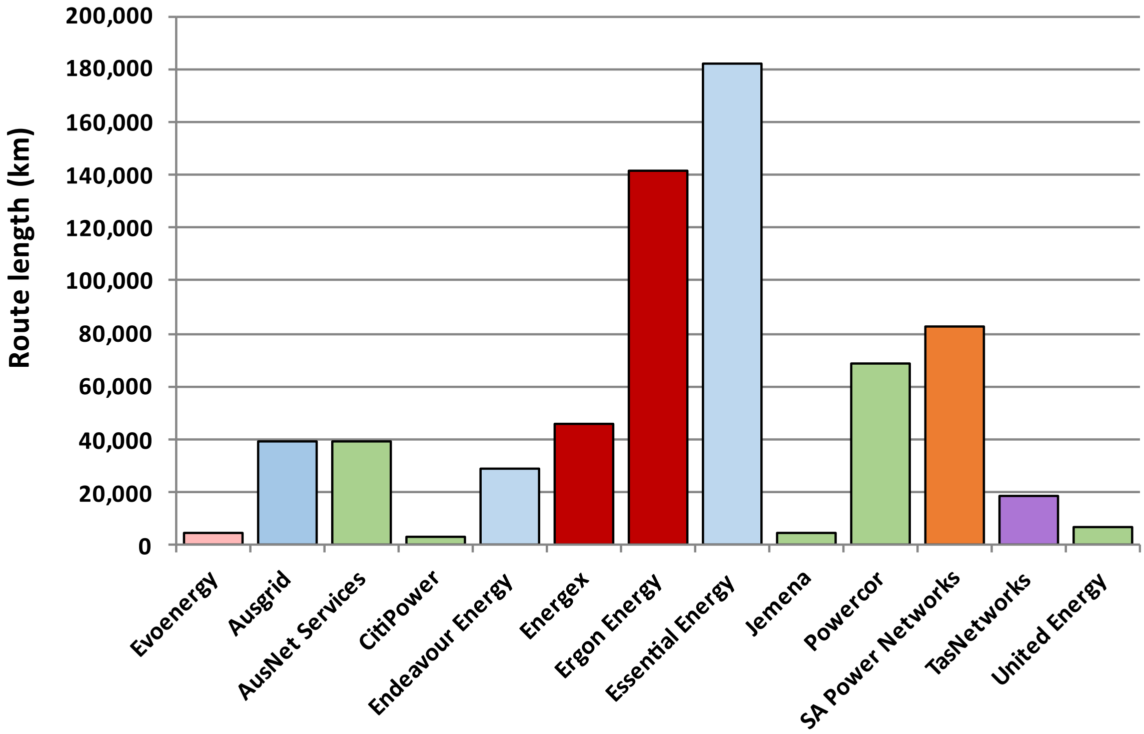
Figure B.2 Five-year average circuit line length by DNSP (2018–2022)



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). Comparison between Figures B.2 and B.3 demonstrates that, for all DNSPs, route length is always shorter than, but closely related to circuit length. The ratio of route length to circuit length, however, varies by DNSP.

Figure B.3 Five-year average route line length by DNSP (2018–2022)



Source: Economic Benchmarking RIN.

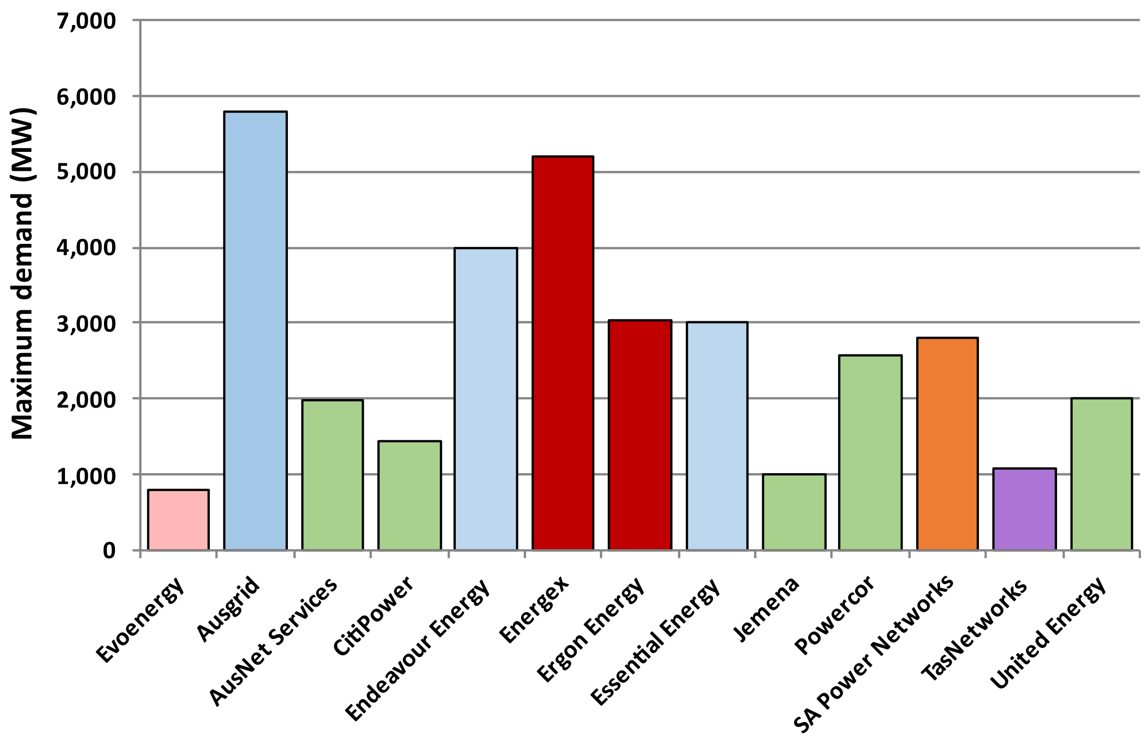
Maximum demand

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). Evoenergy submitted corrected maximum demand figures dating back to 2015 in its 2024-29 revenue determination process after discovering an error in how non-coincident maximum demand was summated across its transmission connection points.[116] The updated maximum demand figures are higher in most years compared to those originally submitted by Evoenergy as part of its annual RIN responses. This has resulted in a noticeable increase to Evoenergy's 5-year maximum demand in Figure B.4 compared to previous Annual Benchmarking Reports.

Figure B.4 shows each DNSP's maximum demand, on average, over the five years from 2018 to 2022.

[116] Evoenergy, Appendix 2.1: Operating expenditure base year efficiency, Regulatory proposal for the ACT electricity distribution network 2024-29, January 2023, pp. 18-22.

Figure B.4 Five-year average maximum demand by DNSP (2018–2022)

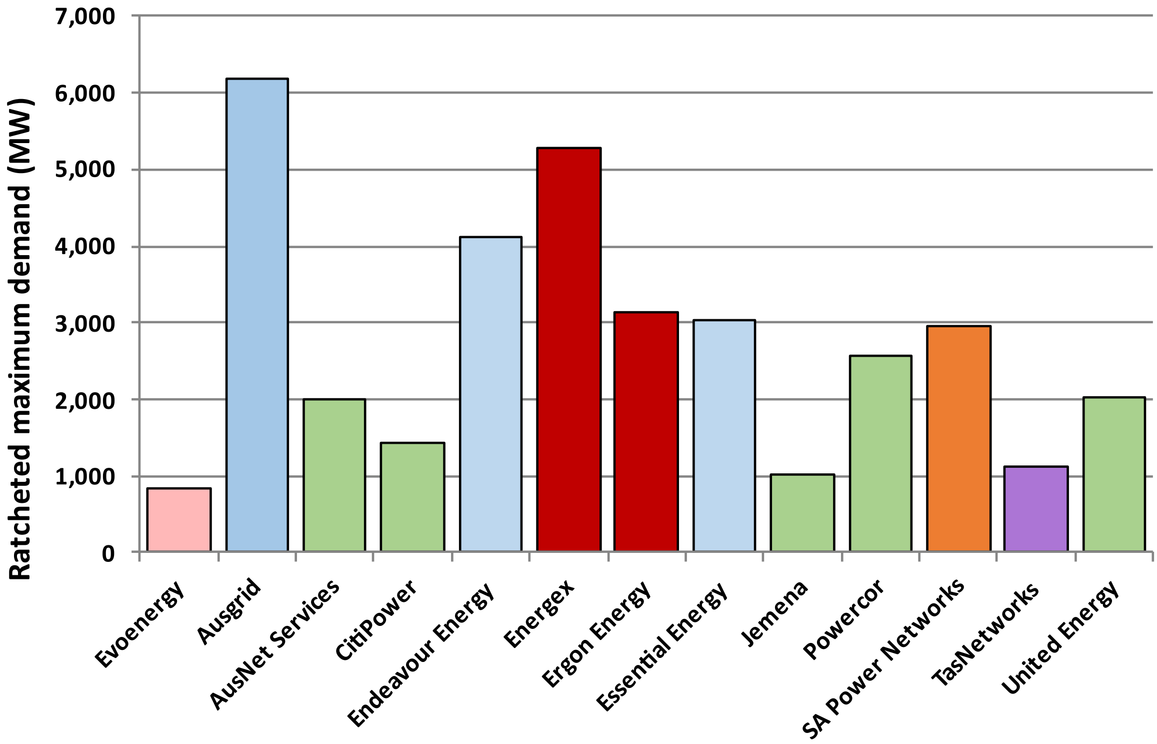


Source: Economic Benchmarking RIN.

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. As discussed above, Evoenergy's updated (higher) maximum demand figures have resulted in a noticeably higher ratcheted maximum demand in Figure B.5 compared to previous ABRs.

Figure B.5 shows each DNSP's ratcheted maximum demand, on average, over the five years from 2018 to 2022.

Figure B.5 Five-year average ratcheted maximum demand by DNSP (2018–2022)



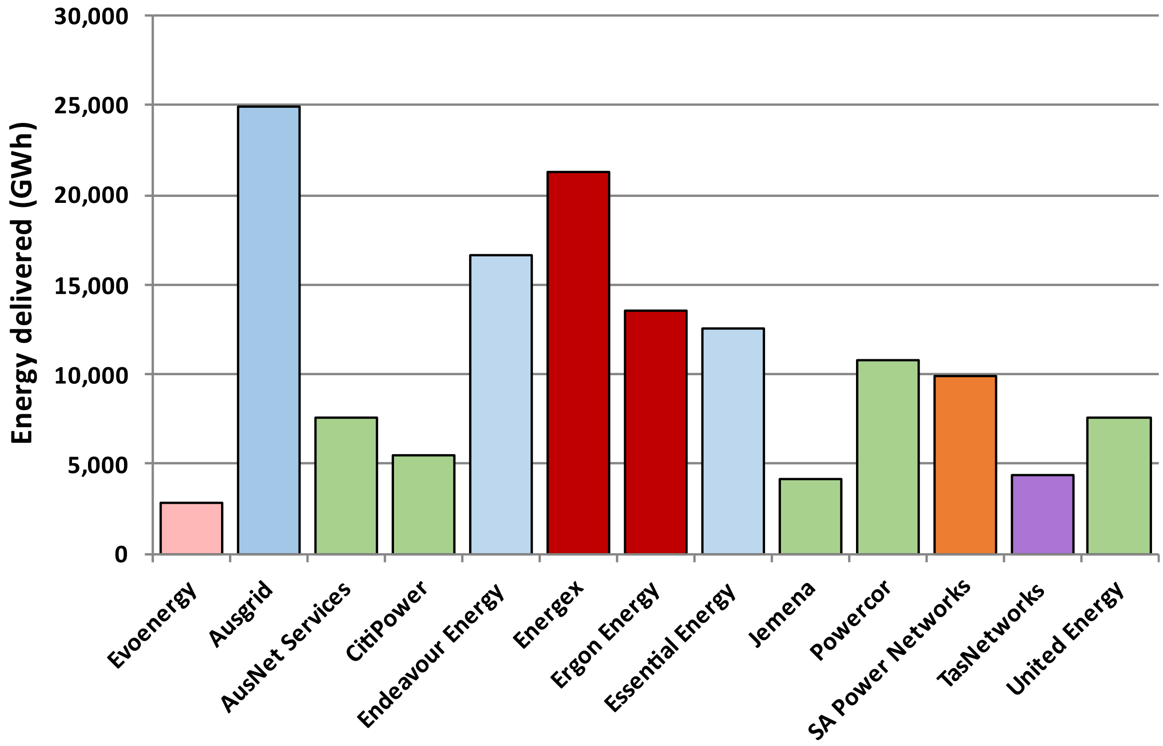
Source: Economic Benchmarking RIN.

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 2018 to 2022.

Figure B.6 Five-year average energy delivered by DNSP (2018–2022)

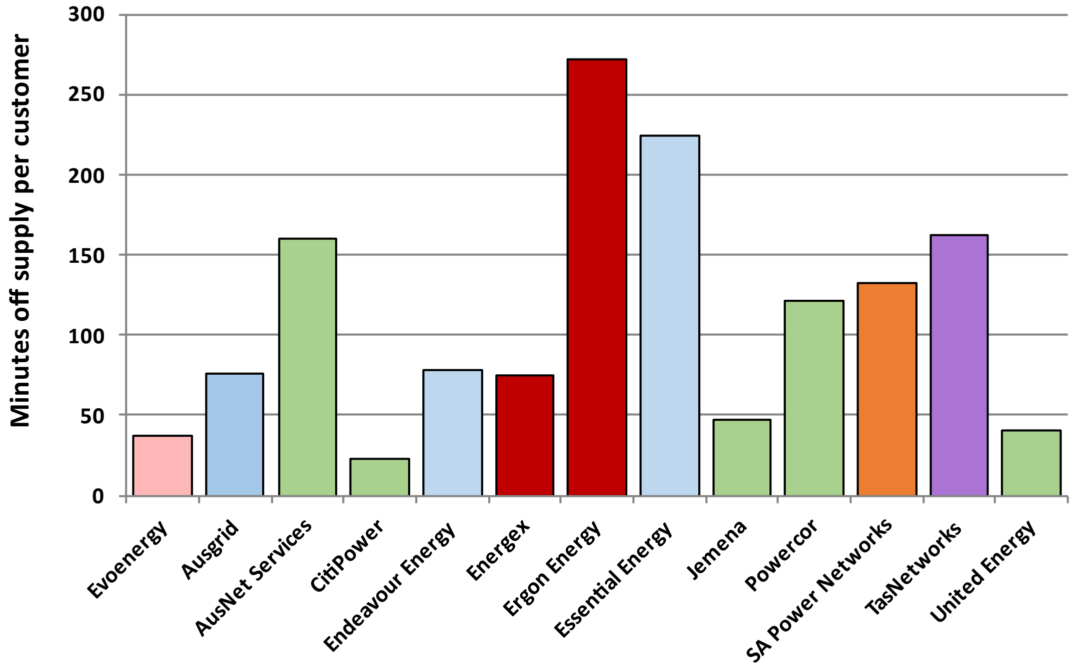


Source: Economic Benchmarking RIN.

Reliability

Another dimension of the outputs of DNSPs is the reliability of their electricity supply. This is commonly measured as the average number of customer minutes off-supply (per customer, per annum) or the average annual number of interruptions per customer. Figure B.7 presents for each DNSP the average number of minutes off-supply (per customer, per annum) over the 2018–2022 period, excluding the effects of major events, planned outages and transmission outages.

Figure B.7 Average annual minutes off-supply per customer (2018–2022)

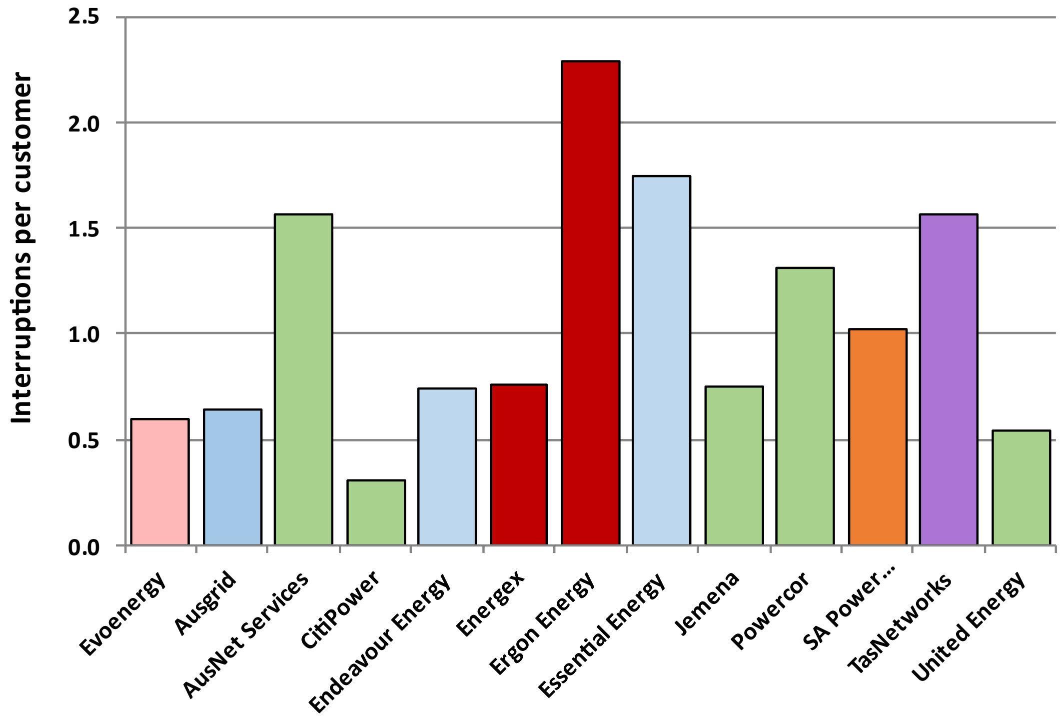


Source: Economic Benchmarking RIN.

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 (2018–2022)



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.

We use physical measures of capital inputs in our time series multilateral TFP and panel MTFP analysis. Using physical values for capital inputs has the advantage of best reflecting the physical depreciation profile of DNSP assets. Our time series multilateral TFP and panel MTFP measures 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 multilateral TFP and MTFP 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 these measures.

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' and Quantonomics multilateral TFP and MTFP analyses, and in response to a submission by Ausgrid,[117] we have adjusted the PPI analysis to remove assets associated with the first step 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.

117 Ausgrid, *Submission on the draft distribution benchmarking report 2016*, 14 October 2016, p. 3.

Asset cost is the sum of annual depreciation and return on investment and is referred to as the AUC.[118] 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.1 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.1 Average annual input costs for 2018–2022 ($m, 2022)

	Opex	Annual user cost of capital
Evoenergy (EVO)	60.6	99.2
Ausgrid (AGD)	445.4	939.4
AusNet Services (AND)	231.1	358.1
CitiPower (CIT)	55.4	152.0
Endeavour Energy (END)	265.9	396.7
Energex (ENX)	405.1	590.9
Ergon Energy (ERG)	396.0	605.0
Essential Energy (ESS)	410.2	551.7
Jemena (JEN)	78.2	121.0
Powercor (PCR)	200.6	311.1
SA Power Networks (SAP)	274.2	436.4
TasNetworks (TND)	93.1	144.0
United Energy (UED)	125.9	216.5

Source: Economic Benchmarking RIN; AER analysis.

[118] To calculate the AUC relevant to PPIs, multilateral TFP, Capital PFP, MTFP and Capital MPFP, 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. The calculation of the AUC reflects the AER's Rate of Return Instrument 2018 for regulatory year 2022. In earlier years AUC calculations broadly reflected the 2013 rate of return guideline. For more details, see: https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/rate-of-return-instrument-2018/final-decision.

C. Anomalous time series multilateral TFP results

C.1 Background and drivers of the issue

In the context of considering the time series multilateral TFP results in 2022, and the contributions of each input and output to the change, we identified some results that were anomalous and did not reflect the expected direction of the impact / change. At the distribution industry level these were not significant but related to the two underground inputs making very small positive contributions to TFP change in 2022, despite these two inputs increasing in 2022 (by 1.0 and 2.1 percentage points respectively).

As can be seen below, there were also some anomalous results for some DNSPs. For example, in 2022 Evoenergy's underground distribution input makes a positive contribution to TFP despite this input increasing over this period. We also identified this issue when preparing the 2023 Annual Benchmarking Report for Transmission Network Service Providers (TNSPs).[119]

We further investigated these anomalous results to understand how widespread they are, including amongst the DNSP results underpinning the distribution industry results, and whether they had appeared previously.

The TFP results are currently determined using a multilateral Törnqvist index. This index computes output / input quantity changes, and therefore TFP changes, between two observations via an indirect comparison of those two observations with the sample average observation. The weight used to weigh the quantity change of an output / input (from the sample average), is the output / input cost share based on the average of the observation in comparison and the sample average observation. As a result, the weights vary between the two observations being compared (as observation-specific cost share is not fixed, although the component of the weight that represents sample average value/cost shares is fixed within a given data sample). This means that under the multilateral Törnqvist index the TFP change (and any contributions) are affected by both the output/input quantity changes and weight changes.

We have used the multilateral Törnqvist index for time series analysis since the 2020 Annual Benchmarking Report. We shifted to using this index, rather than the traditional time series indexes, in order to more accurately capture the impact of large percentage changes that were continuing to occur in the reliability output (CMOS for DNSPs and energy not supplied for TNSPs). We considered that this would assist in addressing drifting issues[120] and produce more accurate TFP results. This reflected the advice of our benchmarking consultant at the

119 AER, *2023 Annual Benchmarking Report for Transmission network service providers*, November 2023, pp.24–25

120 'Drifting' refers to large changes in outputs / inputs, particularly reliability, leading to systematic deviations from the expected trend.

time, Economic Insights.[121] As a result, we decided to apply this index to both the time series and panel data to determine distribution industry and DNSP productivity changes.

In considering possible reasons for the anomalous results, it is useful to understand the output / input weight changes under the multilateral Törnqvist index. In general, the weights for outputs are relatively constant for the same network service provider over time. For example, the non-reliability output weights (derived from Leontief Functions) are fixed. Further, the reweighted output weighting incorporating the impact of reliability outputs is relatively constant. However, the weights for the inputs (opex and capital) are not constant over time.

Inflation changes impact the relative opex and capital input weights as the capital input weights are based on the average user cost of capital (AUC) which is affected by inflation, WACC and other parameters. In particular, the AUC equals the return on capital plus the return of capital plus the benchmark tax liability. The return of capital reflects straight-line depreciation net of an 'inflation addition' component which reduces regulatory depreciation, decreasing the return of capital. The significant increases in the inflation rate dating back to 2021 result in a larger 'inflation addition' which results in a lower return of capital and therefore a lower AUC for each capital input. This in turn means that the opex input comprises a larger share of total cost in an accelerating inflation environment, resulting in a higher weighting with opex relative to capital inputs in 2022. We also notice a greater divergence in AUC between the Victorian and non-Victorian DNSPs in an accelerating inflation environment as the Victorian DNSPs historically apply a further 1-year lag to their inflation rate calculation. In the case of the 2023 Annual Benchmarking Report, the implied inflation rate derived from inflation adjustments across non-Victorian DNSPs is 3.5% (the rate of inflation in December 2021) while the implied inflation rate for Victorian DNSPs was 0.86% (the rate of inflation in December 2020).

We consider a key driver of the anomalous results in the 2023 Annual Benchmarking Report is the variable nature of input weights and the impact of the changing inflation environment. These inflation changes have led to more significant changes in the opex to capital input shares than in previous years when we have used the multilateral Törnqvist index.

We have tested this by undertaking sensitivity analysis using an alternative indexing approach for TFP analysis. Specifically, the traditional Törnqvist index. Under this method, the two observations in comparison, the two consecutive years for a DNSP or the industry, are directly compared to each other. The input weights applied to the consecutive years in comparison are the relevant cost shares averaged across the comparison years and thus the same between the two years in comparison. The contribution of an individual input to the TFP change, being positive or negative, will solely depend on the directional change in the input quantity. This sensitivity analysis allows us to examine how sensitive the measured output / input contribution is to the index number method used, particularly in the presence of large inflation changes in 2022. The results of this sensitivity analysis at both the industry and DNSP level are set out in section C.2.

[121] Economic Insights, *Economic Benchmarking Results for the Australian Energy Regulator's 2020 DNSP Annual Benchmarking Report*, 13 October 2020, pp. 6-7.

C.2 Distribution industry index sensitivity analysis

In Tables C.1 to C.11 we have set out the time series TFP change and individual input contributions for the distribution industry, and each DNSP for which we observed anomalous results in at least one input in 2022. We have calculated TFP change and individual input contributions using the multilateral Törnqvist index (our current benchmarking methodology) and the traditional Törnqvist index. What can be seen is that in those circumstances where anomalous results were identified (shaded cells), using the traditional Törnqvist index results in a change in the sign of the contribution reported for the relevant input.

For example, in Table C.1 it can be seen that for the distribution industry the positive contributions the increase in the two underground inputs were making to the TFP change under the multilateral Törnqvist index become negative contributions under the traditional Törnqvist index, as would be expected. Further, in Table C.2 it can be seen that for Evoenergy, the positive contribution an increase in the underground distribution input was making to the TFP change under the multilateral Törnqvist index becomes a negative contribution under the traditional Törnqvist index. We have shaded cells grey in all instances for the 2022 results where the multilateral Törnqvist index produced the opposite signs to the traditional Törnqvist index. Tables C.1 to C.11 show that the underground distribution input had the highest frequency of anomalous results, including for the whole of industry TFP growth contribution.

We consider that beyond the change in input weights, there are also possibly other interactions with the input contributions that are leading to anomalous results in some cases.

Our broader testing suggests these anomalous results are infrequent in other years across the benchmarking times series (2006-2022), likely due to the relatively stable inflation rate and AUC in those years.

We consider that this sensitivity testing using an alternative indexing approach illustrates that under the multilateral Törnqvist index the changing inflation environment has had an impact on a small proportion of TFP results. This is particularly in terms of opposite directional change in the measured individual input contributions from what is expected and measured under the traditional Törnqvist index. The opposite directional changes appear to be counter-intuitive and are considered to be anomalous results with the multilateral Törnqvist index. There were no instances where a DNSP’s overall TFP change was observed to have a different sign when comparing the results from the two indexing methods.

We further note, from Table C.1 to C.11, that using alternative indexes also impacts the magnitude of the TFP changes and the input contributions measured, even if there are not directional changes. The sensitivity of the measured TFP changes and input/output contributions is heightened in the 2022 results due to the large rise in the annual inflation rate, resulting in substantially different reliability and input weights being applied to the two consecutive years in comparison.

Table C.1 Distribution industry TFP change and input contributions 2021 to 2022 (percentage points)

	TFP Change	Opex	O/H Sub transmission	O/H Distribution	U/G Sub transmission	U/G Distribution	Trans-formers
Multilateral Törnqvist Index	-0.23	1.00	-0.01	-0.04	0.02	0.05	-0.02
Traditional Törnqvist Index	-1.07	0.66	-0.03	-0.06	-0.02	-0.20	-0.18

Source: Quantonomics; AER Analysis.

Table C.2 Evoenergy TFP change and input contributions 2021 to 2022 (percentage points)

	TFP Change	Opex	O/H Sub transmission	O/H Distribution	U/G Sub transmission	U/G Distribution	Trans-formers
Multilateral Törnqvist Index	-2.3	-2.3	-0.3	0.0	0.0	0.2	-0.1
Traditional Törnqvist Index	-3.0	-2.6	-0.4	0.0	0.0	-0.1	-0.3

Source: Quantonomics; AER Analysis.

Table C.3 Ausgrid TFP change and input contributions 2021 to 2022 (percentage points)

	TFP Change	Opex	O/H Sub transmission	O/H Distribution	U/G Sub transmission	U/G Distribution	Trans-formers
Multilateral Törnqvist Index	7.1	7.5	0.1	-0.4	0.0	0.3	0.1
Traditional Törnqvist Index	3.9	4.8	0.1	-0.4	0.0	-0.1	0.0

Source: Quantonomics; AER Analysis.

Table C.4 Endeavour Energy TFP change and input contributions 2021 to 2022 (percentage points)

	TFP Change	Opex	O/H Sub transmission	O/H Distribution	U/G Sub transmission	U/G Distribution	Trans-formers
Multilateral Törnqvist Index	-1.2	1.7	0.0	0.0	-0.1	0.3	0.8
Traditional Törnqvist Index	-3.3	0.9	0.0	0.0	-0.1	-0.5	0.4

Source: Quantonomics; AER Analysis.

Table C.5 Energex TFP change and input contributions 2021 to 2022 (percentage points)

	TFP Change	Opex	O/H Sub transmission	O/H Distribution	U/G Sub transmission	U/G Distribution	Trans-formers
Multilateral Törnqvist Index	-1.7	-2.7	-0.0	0.0	0.1	0.3	0.3
Traditional Törnqvist Index	-2.6	-2.3	-0.1	-0.0	0.0	-0.1	-0.2

Source: Quantonomics; AER Analysis.

Table C.6 Ergon Energy TFP change and input contributions 2021 to 2022 (percentage points)

	TFP Change	Opex	O/H Sub transmission	O/H Distribution	U/G Sub transmission	U/G Distribution	Trans-formers
Multilateral Törnqvist Index	-4.0	-0.1	-0.0	0.1	0.0	0.1	0.7
Traditional Törnqvist Index	-5.5	-0.8	-0.0	-0.1	0.0	-0.0	0.4

Source: Quantonomics; AER Analysis.

Table C.7 Essential Energy TFP change and input contributions 2021 to 2022 (percentage points)

	TFP Change	Opex	O/H Sub transmission	O/H Distribution	U/G Sub transmission	U/G Distribution	Trans-formers
Multilateral Törnqvist Index	4.7	4.4	0.1	0.0	0.0	0.1	-0.3
Traditional Törnqvist Index	4.3	4.2	0.0	-0.1	0.0	-0.1	-0.2

Source: Quantonomics; AER Analysis.

Table C.8 Jemena TFP change and input contributions 2021 to 2022 (percentage points)

	TFP Change	Opex	O/H Sub transmission	O/H Distribution	U/G Sub transmission	U/G Distribution	Trans-formers
Multilateral Törnqvist Index	3.7	3.4	-0.0	-0.1	-0.0	-0.1	-0.2
Traditional Törnqvist Index	4.0	3.7	0.0	-0.1	-0.0	-0.1	-0.4

Source: Quantonomics; AER Analysis.

Table C.9 SA Power Networks TFP change and input contributions 2021 to 2022 (percentage points)

	TFP Change	Opex	O/H Sub transmission	O/H Distribution	U/G Sub transmission	U/G Distribution	Trans-formers
Multilateral Törnqvist Index	-3.7	-3.0	0.0	0.0	0.0	0.1	-0.2
Traditional Törnqvist Index	-4.1	-2.8	-0.0	0.0	-0.0	-0.2	-0.5

Source: Quantonomics; AER Analysis.

Table C.10 TasNetworks TFP change and input contributions 2021 to 2022 (percentage points)

	TFP Change	Opex	O/H Sub transmission	O/H Distribution	U/G Sub transmission	U/G Distribution	Trans-formers
Multilateral Törnqvist Index	-2.5	-0.1	-0.0	0.2	0.0	-0.1	-0.1
Traditional Törnqvist Index	-2.6	0.3	0.0	0.1	0.0	-0.2	-0.3

Source: Quantonomics; AER Analysis.

Table C.11 United Energy TFP change and input contributions 2021 to 2022 (percentage points)

	TFP Change	Opex	O/H Sub transmission	O/H Distribution	U/G Sub transmission	U/G Distribution	Trans-formers
Multilateral Törnqvist Index	-2.9	-1.2	-0.0	-0.3	0.1	-0.3	-0.1
Traditional Törnqvist Index	-2.7	-1.2	0.0	-0.3	0.1	-0.3	-0.3

Source: Quantonomics; AER Analysis.

C.3 Conclusion

Through sensitivity testing we have established that our current multilateral Törnqvist indexing method, under which the input weights are not held constant between the two observations in comparison, is sensitive to the current changes in inflation which impact the input weights. This testing, which used the traditional Törnqvist indexing approach, under which the input weights are held constant between the two observations in comparison, removed the impact of the current changing inflation environment. Under the two alternative indexing methods, TFP results of a different magnitude are produced, as well as contributions from reliability and individual inputs of a different magnitude. While the traditional Törnqvist indexing approach has no anomalous results in terms of directional change in input contributions, it does not have the same methodological advantage of the multilateral Törnqvist index method, which prevents significant volatility in outputs, such as reliability, having undue impact on the TFP results. Further, when we return to a more stable inflation environment, we consider that the frequency of anomalous results generated by the multilateral Törnqvist method will decrease.