Annual Benchmarking Report

Electricity transmission network service providers

November 2024

AUSTRALIAN ENERGY REGULATOR

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Executive Summary

We report annually on the productivity growth and efficiency of transmission network service providers (TNSPs) in the National Electricity Market (NEM). This meets the requirement under the National Electricity Rules (NER) that we prepare annual benchmarking reports.[1] These network service providers operate high voltage transmission lines which transport electricity from generators to distribution networks in urban and regional areas. Combined, transmission and distribution network costs typically account for between 35–45% of what customers pay for their electricity (with the remainder covering generation costs, retailing and environmental policies).

We undertake economic benchmarking to measure how productively efficient the networks are at delivering electricity transmission services over time and compared with their peers. This has several uses and benefits as the benchmarking results:

- inform our assessment of proposed network expenditures, and whether they are efficient, when setting the maximum revenues TNSPs can recover from customers
- provide transmission network owners with information about the productivity of their business, which along with the incentives under the framework, provides financial and reputational incentive to improve their efficiency
- provide consumers with accessible information about the relative efficiency of the networks they rely on
- provide policy makers with information about the impacts of regulation on network costs and productivity.

Below we set out our key findings in this year's report. This includes a focus on productivity trends over time and changes in the most recent year of 2023. Examining trends can help to account for volatility, allow for any delayed effects of inputs on outputs, and draw out any cycles.

Transmission industry productivity improved briefly after 2016 but has now largely stabilised

Electricity transmission industry productivity, as measured by the total factor productivity (TFP) decreased over the 2006–16 period at an average annual rate of 1.8%. This declining trend was followed by improvement in transmission industry productivity between 2016 and 2018 (an average annual rate of 3.2%), before it broadly stabilised. See Figure 1 below.

Over the 2006–16 period, declining capital partial factor productivity (PFP) largely explained the overall downward trend in transmission industry productivity (higher growth in capital assets relative to outputs). Capital PFP stabilised over the 2016–23 period. The long-term decline in capital PFP is comparable to that of most other industries in the Australian market economy and is reflective of an increase in the amount of capital per worker.[2] In contrast,

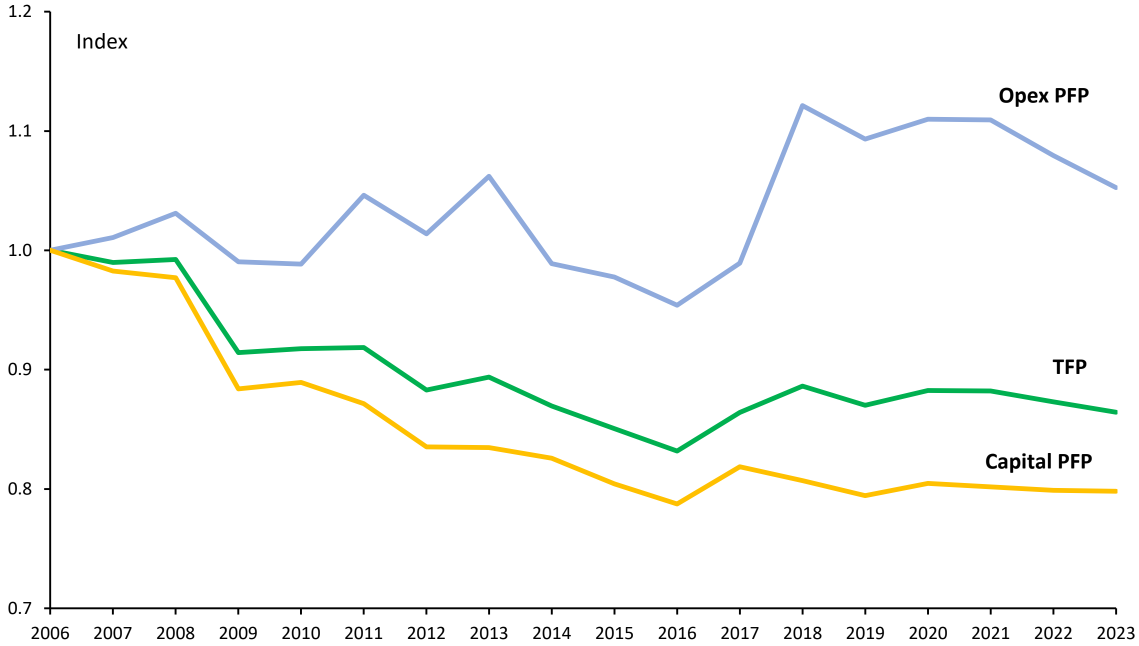
1 NER, cll. 6A.31(a) and 6A.31(c).

2 Australian Bureau of Statistics, *Tables 1-19: Estimates of Industry Multifactor Productivity*, December 2023.

operating expenditure (opex) PFP has been more volatile over time. Over the 2006–16 period we observed an average annual opex PFP decline of 0.5%, followed by significant increases of 3.6% and 12.5%, in 2017 and 2018 respectively. As can be seen in Figure 1, in more recent years, including 2023, the decrease in opex PFP has driven TFP productivity downwards.

In 2023, the decrease in transmission industry productivity of 1.0% was primarily due to an increase in the opex input, which was largely driven by higher maintenance costs across the industry. Growth in the capital inputs for transformers and overhead lines also negatively contributed to the TFP change. Partly offsetting this were increases to the circuit length output and improved reliability (reduced outage events relative to last year).

Figure 1 Transmission industry TFP, opex PFP and capital PFP over 2006–23



Source: Quantonomics; AER Analysis

Over the period 2006–23 the transmission industry performed as well as, if not better than, the broader utilities sector. As can be seen in Figure 2, the transmission industry and utilities sector had similar productivity trends until 2016, after which the productivity of the utilities sector declined while the productivity of the transmission industry remained relatively stable. The continued long-term decline in utility sector productivity is likely to be a result of structural changes driving higher input costs whilst not necessarily being reflected as higher output.[3] These structural changes include regulatory requirements designed to improve reliability and safety and reduce the negative environmental impact. Over the period 2006–23 the transmission industry has not performed as well as the Australian economy, which experienced average annual productivity growth of 0.2%.

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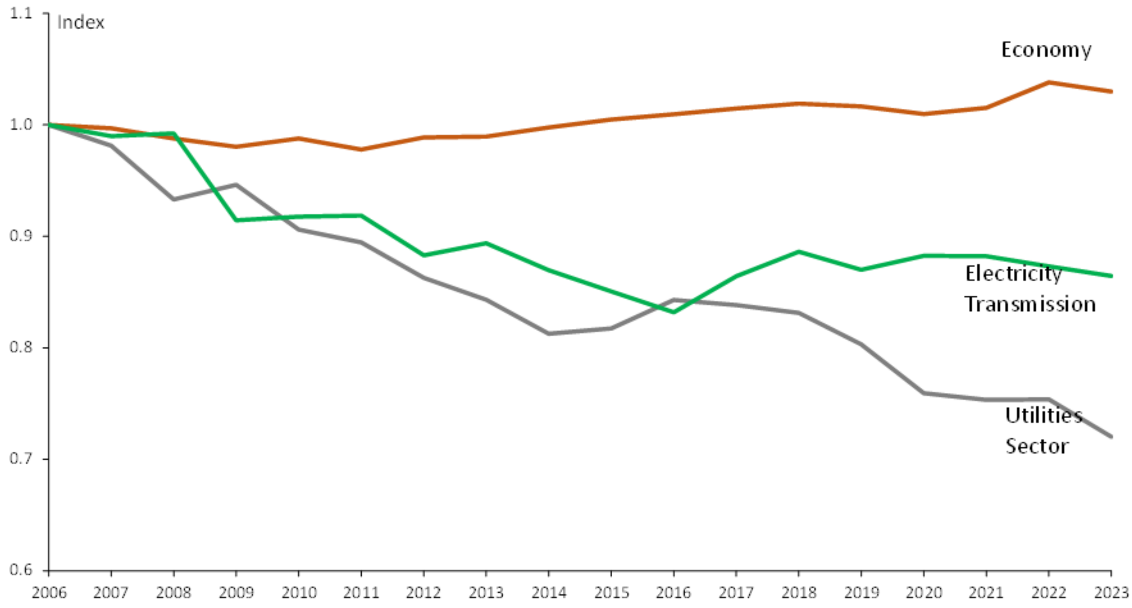
3 Productivity Commission, *Productivity Update*, May 2013, pp. 33-34.

Figure 2 Electricity transmission industry, utilities sector and economy TFP, 2006–23

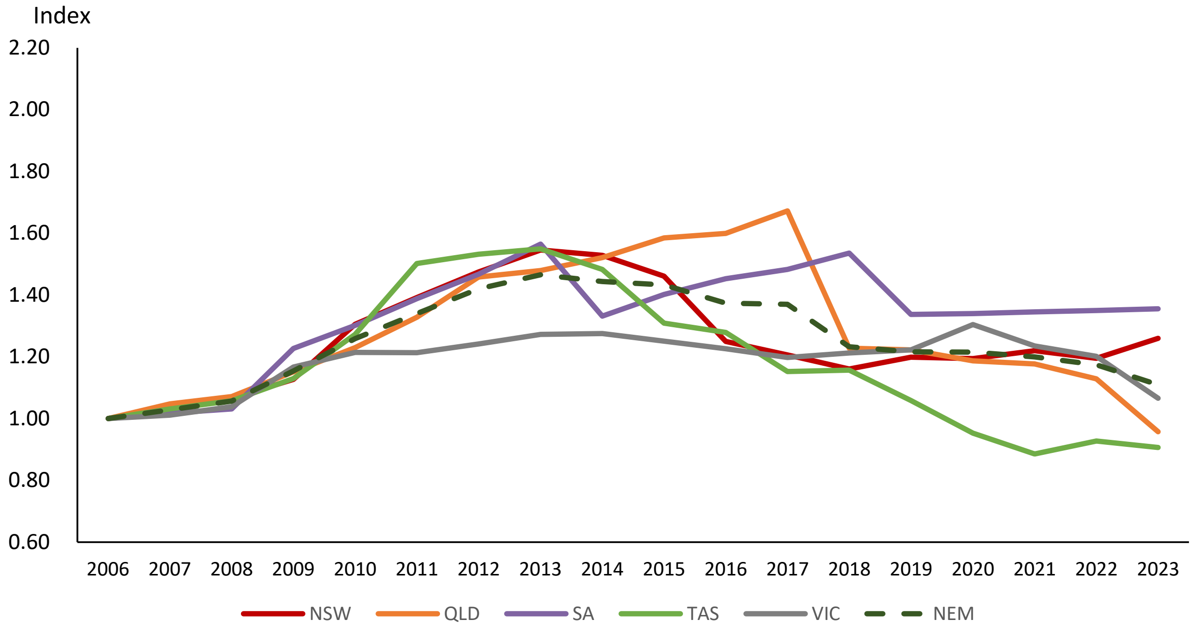


Source: Quantonomics; AER Analysis

These productivity movements have been one contributor[4] to the reductions in network costs and revenues for TNSPs. Figure 3 shows that transmission network revenues (and consequently network charges paid by consumers) have broadly fallen across the NEM from around 2016.

[4] Other contributors to declining revenue include but are not limited to declining cost of capital and lower capex resulting from lower demand growth forecasts.

Figure 3 Indexes of transmission network revenues by jurisdiction, 2006–23



Source: Quantonomics; AER Analysis

Changes in relative productivity of TNSPs over time and in 2023

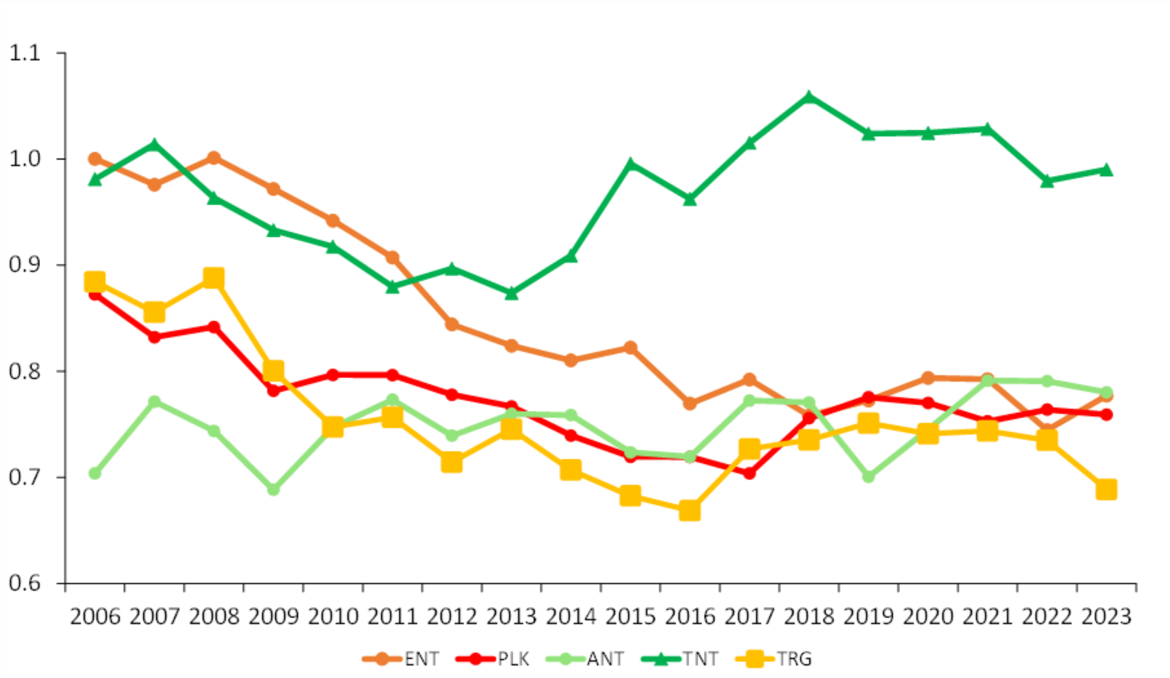
There are five transmission networks in the NEM, with one in each state. Their relative productivity as measured by panel data multilateral total factor productivity (MTFP) can be seen in Figure 4. Over the 2006–23 period, there has been convergence in the productivity of all TNSPs except TasNetworks. The productivity of TasNetworks improved significantly from 2013. This likely reflects efficiencies from the merger of distribution and transmission services to form TasNetworks.[5]

Over the 2006–23 period AusNet's productivity as measured by MTFP also improved. In contrast, over this period the productivity of ElectraNet, Powerlink and Transgrid deteriorated, largely due to decreases in capital multilateral partial factor productivity (MPFP) reflecting increases in capital inputs.

Figure 4 highlights the variability in productivity observed for individual TNSPs over time and emphasises the importance of considering the changes in productivity in 2023 in the context of longer-term trends.

5 TasNetworks was formed on 1 July 2014 from a merger between Aurora and Transend.

Figure 4 Electricity transmission MTFP indexes by TNSP, 2006–23



Source: Quantonomics; AER Analysis

Continuing to improve our economic benchmarking

We operate an ongoing transparent program to review and incrementally refine elements of the benchmarking methodology and data. This includes where necessary considering if, and how, the changing environment TNSPs operate in (the broader economy and within the context of the energy transition) impacts the benchmarking methodology and data.

As a part of this, we consult with stakeholders and value the feedback they provide in both reviewing the annual report and providing views around specific development issues. There can be diversity in the feedback provided. This contributes to our thinking and ongoing improvement in the benchmarking, even in instances where we do not necessarily agree with points raised or adopt the specific suggestions.

We prioritise the benchmarking development work, balancing a variety of factors and associated costs and benefits, including stakeholder feedback. In addition, we consider the materiality and impact of the development work and the potential for errors, particularly in relation to upcoming revenue determinations where the benchmarking is a part of our assessment, and the ability to progress this work from sequencing, data availability and resourcing perspectives. This work is often complex and resource intensive, therefore we exercise judgement in identifying the relative priorities and progressing the program of work.

In this year's report, we prioritised and progressed the following benchmarking refinements and development work:

- We have refined the way we calculate the annual user cost (AUC) of capital which we use to determine the weights applying to our capital inputs. This was because of unintended impacts of the changing inflation environment, which drove changes in the results that were not related to movements in efficiency.

- We completed an independent review of the non-reliability output weights we use in our TFP and MTFP benchmarking. This responded to stakeholder feedback after a computation error was corrected for in our 2020 Annual Benchmarking Reports. The review found that there were no further errors in the way these weights are computed, generally endorsed our approach, and suggested some minor modifications to our method to improve its numerical stability.

Beyond this, we acknowledge the broader changes occurring in the transmission network environment, particularly driven by increasing connection of large-scale renewable generation and storage and the need to manage how the transmission system is operated, suggest an increasing need to consider the benchmarking output specification. This will also reflect the fact our benchmarking accounts for some, but not all, possible differences in the operating environment of transmission networks. We will monitor developments in the transmission network environment and consider the validity of current outputs, as well as any potential additions to the output variables. This will help to inform any future transmission benchmarking development work in relation to the appropriate model specification.

Contents

1 Our benchmarking report

The National Electricity Rules (NER) require the AER to publish network benchmarking results in an annual benchmarking report.[6] This is our 11th annual benchmarking report for TNSPs. This report is informed by expert advice provided by Quantonomics.[7]

> **National Electricity Rules reporting requirement**
>
> 6A.31 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 Transmission Network Service Provider in providing direct control services over a 12–month period.

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

Our benchmarking report considers productive efficiency. TNSPs are considered productively efficient when they produce their goods and services at the least possible cost of inputs, given their operating environments and prevailing input prices. We examine trends in productivity over the full period of our benchmarking analysis (2006–23), two shorter time periods (2006 to 2012 and 2012 to 2023) and between 2022 and 2023.[8]

1.1 Benchmarking techniques

Our benchmarking report presents results from two types of 'top-down' benchmarking techniques.[9] Each technique uses a different method for relating outputs to inputs to measure and compare TNSP's efficiency:

- **Productivity index numbers (PIN).** These techniques use a mathematical index to measure the relationship between multiple outputs relative to multiple inputs, enabling comparison of productivity levels and trends over time. We use these PIN techniques for our:
  - Times series multilateral TFP and capital and opex multilateral PFP. TFP and capital and opex PFP results are used in this report to measure and compare changes in

6 NER, cll. 6A.31(a) and 6A.31(c).

7 The supplementary Quantonomics' report outlines the full set of results for this year's report, the data we use, the updates and our benchmarking techniques. It can be found on the AER's website – see the Annual Benchmarking Reports 2024 web page.

8 Throughout this report we refer to regulatory years. For example, for simplicity we use 2023 for 2022–23 which is April–March for AusNet, and July–June for all other TNSPs.

9 Top-down techniques measure a network's overall 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 more resource intensive in that they examine each input component separately. Bottom-up techniques do not take into account potential efficiency trade-offs that may exist between input components of a TNSP's operations.

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 MTFP and capital and opex multilateral 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).
- **Partial performance indicators (PPIs).** These simple ratio methods relate one input to one output. In this respect they are partial efficiency measures. We use PPIs to examine relative performance across TNSPs.

Being top-down measures, each benchmarking technique cannot readily incorporate every possible exogenous factor that may affect a TNSPs performance. For example, as further explained in section 2.2, certain factors in a TNSPs operating environment are beyond its control and not all of these have been captured in the benchmarking models. Therefore, the performance measures reflect, but do not precisely represent, the underlying efficiency of TNSPs. For this benchmarking report, our approach is to derive ‘raw’ benchmarking results and where possible, explain drivers for the performance differences and changes.

The time-series and panel data-based PIN techniques used in this report both rely on multilateral productivity indexes. These indexes allow comparisons of absolute levels and growth rates of the measured productivity. Multilateral total factor productivity examines the overall productivity of using all inputs in producing all outputs we measure. Multilateral partial factor productivity examines the productivity of either opex or capital inputs in isolation.

What is multilateral total factor productivity?

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

The inputs we measure for TNSPs are:

- Three types of physical capital assets TNSPs invest in to replace, upgrade or expand their networks:
  - Transformers and other capital (quantity proxied by transformer MVA)
  - Overhead lines (quantity proxied by overhead MVAkms)
  - Underground cables (quantity proxied by underground MVAkms)
- Opex to operate and maintain the network.

The non-reliability outputs we measure for TNSPs, and the relative weighting we apply to each non-reliability output, are:

- Circuit line length (52.8%). Line length reflects the distances over which TNSPs transport electricity and is a significant driver of the services a TNSP must provide.

- Ratcheted maximum demand (RMD) (24.7%). TNSPs endeavour to meet the demand for energy from their customers when that demand is greatest. RMD recognises the highest maximum demand the TNSP has had to meet in the time period examined.
- Energy delivered (14.9%). Energy delivered or throughput is a measure of the amount of electricity that TNSPs deliver to their customers.
- End users (7.6%). The number of end users is a proxy for the complexity of the TNSP’s network.

Reliability (energy not supplied (ENS)) is also an output. Reliability measures the extent to which networks can maintain a continuous supply of electricity. ENS enters as a negative output and is weighted by the value of customer reliability capped by 2.5% of total revenue.

The November 2014 Economic Insights report referenced in Appendix A details the rationale for the choice of these inputs and outputs. In its August 2017 report, Economic Insights updated the output specification and the weights applied to each output.[10] This output specification is used in this report, with the output weights as updated in 2020.[11]

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

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 TNSP structures its prices.[12] It was also noted that the outputs included should reflect services provided to customers, rather than activities undertaken by the TNSP which do not directly affect what the customer receives, even if, given the characteristics of transmission services they are also somewhat removed from the final interface with end users. In terms of the outputs being used in the benchmarking analysis and the services provided:

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10 Economic Insights, *Review of Economic Benchmarking of Transmission Network Service Providers - Position Paper*, 9 August 2017, pp. 29–33.

11 AER, *Annual Benchmarking Report 2020 – Electricity transmission network service providers, November 2020*, pp. 3–5; Quantonomics, *Economic Benchmarking Results for the Australian Energy Regulator’s 2024 TNSP Benchmarking Report*, July 2024.

12 The AER generally sets the revenue requirement for TNSPs and then separately prices are set to recover this revenue requirement.

- Energy delivered reflects the energy delivered to the end-user and is the transmission service directly consumed by end users.
- End users is a measure of the services and benefits ultimately provided to end users of the distribution networks, which connect to the transmission networks, even though not a direct output of transmission networks. It is an indicator of network complexity and connectivity.
- Circuit length has output related dimensions because it reflects the geographic distribution of end users that TNSPs need to construct networks to connect to deliver energy. In combination with end users, it reflects the impact of different levels of network density within an area on transmission costs.
- RMD reflects the (non-coincident system) maximum demand from customers on the transmission network. The highest 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.
- Reliability (ENS) 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 benchmarking data used.

1.2 Updates in this benchmarking report

The 2024 Annual Benchmarking Report largely uses the same methods set out in previous reports. The main methodological change in this year's report relates to the underlying basis for how the capital inputs (outlined above) are weighted.

The capital inputs are weighted using the AUC of capital, which reflects the costs TNSPs face for their capital inputs, i.e. asset costs.[13] In our initial calculations, we observed sharp declines in the AUC for the different capital inputs and in some instances, negative AUCs. Our analysis indicated these outcomes were driven by rapid changes in the inflation environment and growing divergence between actual inflation and the long run expected inflation used in the AUC calculation. These changes were material enough to drive changes in the productivity results that would not be related to movements in efficiency.

To address these issues, and derive more stable AUCs which still reflect movements in fundamentals, we have made the following methodological refinements to the AUC of capital calculation:

- Moving from using a nominal Weighted Average Cost of Capital (WACC) to a real WACC
- Removing the inflation addition term from the calculation of regulatory depreciation

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13 The AUC of capital is the return on and return of the regulatory asset base, and the benchmark tax liability component.

- Moving from a fixed 2.5% expected inflation rate to calculating expected inflation based on Reserve Bank of Australia forecasts.

The end impacts of these refinements on the historical PIN results are minor, reflecting that on a period-average basis, the relative shares of opex and the AUC of capital see limited changes as a result of these methodological refinements. We consulted the TNSPs on these refinements and no concerns were raised. More detail on the methodological refinements and the impact of these changes are in Appendix C.

In relation to benchmarking data, as in previous years we have used adjusted data provided by AusNet in relation to its lease and Software as a Service (SaaS) non-recurrent implementation costs. AusNet informally provided this amended economic benchmarking RIN (EB RIN) data using legacy accounting standards and guidance.[14] Specifically, it provided lease costs as opex, rather than as reported on a capitalised basis, and SaaS implementation costs as capital expenditure (capex) rather than opex.[15] These changes resulted in increases to its opex in 2023, with the opex addition of leases offsetting the reduction to opex by SaaS costs.

The amendment of AusNet's EB RINs ensures consistency with the current reporting basis of the other TNSPs. This is due to new accounting standards generally being adopted at the start of new regulatory control periods and the staggered starting dates of the regulatory control periods for TNSPs in the NEM. We consider having this data consistency is important for the purpose of benchmarking. However, we note that when most or all TNSPs have transitioned to the new basis of reporting these costs we will need to consider this further, including an approach to recasting historical costs to be on a consistent basis with the more recent years.

This report also includes several other minor updates in the benchmarking data. These updates reflect refinements to the current and historical TNSP dataset, consistent with previous years' benchmarking reports, and are set out in the consolidated benchmarking dataset published on our website.[16]

1.3 Benchmarking development program

We operate an ongoing transparent program to review and incrementally refine elements of the benchmarking methodology and data. This includes where necessary considering if, and how, the changing environment TNSPs operate in (the broader economy and within the context of the energy transition) impacts the benchmarking methodology and data.

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14 AusNet, *Response to AER considerations on mid-period accounting changes (SaaS and leases)*, 3 May 2024.

15 AusNet's EB RINs for 2021, 2022 and 2023 reflect treatment of leases under accounting standard AASB16, which became effective on or after 1 January 2019, and require leases to be considered as capex. They also reflect guidance from the International Financial Reporting Standards (April 2021) that SaaS configuration costs, under some circumstances are considered as opex.

16 Refinements are outlined in the '2024 Data revisions' sheet of the consolidated benchmarking data file.

Our benchmarking development program takes into account issues arising across both the distribution and transmission reports. There are a variety of factors, and associated costs and benefits, which inform the development work we prioritise and progress, including:

- Feedback from stakeholders, which can often contain a range of views
- The materiality and impact of the development work and potential for errors 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.

With this development work often being complex, we exercise judgement in coming to a realistic view on relative priorities. We value the stakeholder feedback provided in relation to development issues. This contributes to our thinking and ongoing improvement in the benchmarking, even in instances where we do not necessarily agree with points raised or adopt the specific suggestions.

This year the main development issue we progressed is a review of the non-reliability output weights used in the TFP and MTFP benchmarking techniques. The outcomes of this review are set out below, along with our views on future development work priorities.

1.3.1 Independent review of TFP/MTFP non-reliability output weights

Background

In the 2020 Annual Benchmarking Reports we corrected an error identified in the non-reliability output weights used in our TFP and MTFP models. We also committed to have these output weights independently reviewed in the future.[17] This year we engaged the University of Queensland's Centre for Efficiency and Productivity Analysis (CEPA) to undertake this review. Specifically, whether there were any further errors in the way these weights are currently calculated, the advantages and disadvantages of the approach we currently use to estimate these weights (econometric modelling of the Leontief cost function (Leontief method)) and whether there were any other options to estimating these weights.

Key findings

CEPA's review based on its final report found that:[18]

- There are no errors in the way in which the AER computes these output weights using the Leontief method, for both transmission and distribution.

[17] AER, *2020 transmission network service provider benchmarking report*, November 2020, pp. 3–7.

[18] CEPA, *Final report - Review of AER's estimated non-reliability output weights used in the TFP and MTFP benchmarking models*, November 2024, pp.12–17.

- The Leontief method is likely to be suitably robust and flexible enough for its purpose. Further, there may not be a better method for deriving these output weights, other than moving away from an index-number-based approach.
- Under the Leontief method, there are two potential concerns (not yet tested) around the numerical stability of the non-linear least square estimation method used. Namely:
  - the potential that the estimation method may not be obtaining a global optimum
  - the possibility that there may be multiple alternative values in terms of the underlying parameter estimates that could support an optimal solution.
- If these potential concerns are found to exist, there are some minor practical modifications that could be made to the Leontief method:
  - linearising the time trend in the Leontief method to guarantee that a global optimum is always obtained
  - using quadratic programming to estimate the Leontief model and the minimisation of mean absolute deviations approach (or least absolute deviations), to help mitigate some of the risk of there being multiple solutions (noting that this latter risk may not be entirely eliminated under the current TFP/MTFP framework).
- While outside the scope of this review, 'direct-cost benchmarking' (such as data envelopment analysis) was suggested as an alternative approach to measuring productivity without constructing output weights.

Consultation

We invited submissions on CEPA's draft report from relevant stakeholders. We received 3 submissions from Ausgrid, Evoenergy and Jemena.[19]

All submissions endorsed the review and raised no issues with CEPA's findings that there were no errors in the way in which the AER computes these weights. Submissions advocated for the AER to update these weights to incorporate all available years of data, noting that these weights were last updated in 2020.

In their submissions, Ausgrid and Evoenergy both:

- Did not support the AER incorporating CEPA's proposed modifications to the Leontief method, as they considered the potential concerns CEPA raised were not likely common in practice and the modifications would only serve to convolute the AER's existing Leontief method. CEPA considered these arguments in its final report but maintained that its suggested modifications would still have utility.
- Raised two further potential issues in relation to the Leontief method it considered CEPA had not covered:
  - Multicollinearity: where some of the explanatory variables in the Leontief method are correlated with one another. CEPA considered that the effects of any potential multicollinearity on the computation of these output weights was unclear, and that

19 Ausgrid, *Submission to CEPA draft report*, September 2024; Evoenergy, *Submission to CEPA draft report*, September 2024; Jemena, *Submission to CEPA draft report*, September 2024.

AER's current approach aligned with generally accepted standard econometric practice.
- Non-linear changes in opex over time: where the Leontief method may not account for non-linear movements in opex over time. CEPA considered that the only practical way to address this issue would be for the AER to consider CEPA's suggestion of a direct cost benchmarking approach (which Ausgrid and Evoenergy were against).

- Did not support CEPA's suggestion of direct cost benchmarking as they preferred the current TFP/MTFP framework for making productivity comparisons over time and against their peers. CEPA acknowledged this aspect was out of scope for its review but considered that such an approach would allow for a similar analysis to the AER's current approach using the PIN technique.

Evoenergy's submission also endorsed CEPA's suggestion of using quadratic programming to estimate the AER's Leontief function, and suggested that this could be done without linearising the time trend as assumed by CEPA. CEPA agreed with this alternative.

Jemena's submission also advocated for adding a fixed cost/intercept component to the Leontief method. CEPA considered that this point by Jemena would be addressed by CEPA's suggestion to linearise the time trend, which would add an intercept to the current approach.

Next steps

Based on CEPA's review, and the submissions we received, we will further explore the potential concerns CEPA raised with the Leontief method and the validity of its proposed modifications. We will do this for the 2025 Annual Benchmarking Report. We also agree with stakeholders that the output weights should be updated to include all available years of data and will do this for the 2025 Annual Benchmarking Report.

1.3.2 Other development work

As we have previously noted, we are aware that substantial investments in transmission networks will change the landscape (through increasing connection of large-scale renewable generation) and potentially affect the potency of the benchmarking results. We recognise that while this new transmission network investment is likely to be largely captured through the current economic benchmarking model inputs (opex and capital), it is less clear that this is the case for all relevant outputs. We will closely monitor developments in the transmission network environment and consider the validity of current outputs, as well as any potential additions to the output variables. This will help to inform any future transmission benchmarking development work in relation to the appropriate model specification.

1.4 Consultation

In developing this report, we consulted with external stakeholders in two stages. Firstly, in relation to the preliminary benchmarking results and report prepared by our consultant, Quantonomics, and secondly in relation to a draft of this year's annual benchmarking report. As noted in section 1.3Annual Benchmarking Report, we value the stakeholder feedback and the benefits it can bring.

The feedback we received, and our responses, are as follows:

- TasNetworks raised a specific issue in relation to the methodological refinement of the AUCs of capital (outlined in section 1.2). It suggested that the AUC calculation use expected inflation that aligns with the inflation calculation method utilised in the Post Tax Revenue Model.[20] It considered this would improve standardisation and understanding, but noted the impact of this change would be minimal. We consider the approach we have used is appropriate given it is consistent with the prevailing AER methodology that applied in the respective periods in determining the rate of return. However, we acknowledge this is approach is a possibility, and will consider it as a part of any future AUC refinements.
- In relation to the methodological refinement of the AUC of capital, Powerlink suggested that given the technical nature of the matter, explanatory notes be included in the AER's and Quantonomics reports.[21] We have done this, including the description provided in section 1.2 and further information in Appendix C.
- Both Powerlink and ElectraNet reiterated views they have previously expressed that there is a need for a broader review of the transmission economic benchmarking specification.[22] Powerlink noted that this would ensure that the range of services transmission networks provide is captured more effectively. ElectraNet has also previously noted that the current outputs do not appropriately reflect those of a modern TNSP and that this will worsen over time as new investment occurs to support the transformation of the transmission system. As set out in section 1.3, we acknowledge the changes occurring in the transmission system and will closely monitor these to inform our future development work.
- Powerlink raised potential issues with the reporting period of its data for the reliability output. It noted its calendar year 2022 reliability data should be used for 2022–23 instead of 2021–22.[23] We investigated this issue and found that Powerlink's historical reliability data had all been provided on the later basis. Given there would be potential breaks and inconsistencies in the data if this change was applied, we have elected to not make it this year. We acknowledge the reporting basis of reliability data requires further analysis and will consider this as a potential item in the benchmarking development program.
- Powerlink also raised the possibility of data discrepancies in the preliminary benchmarking report and results. We investigated these with Quantonomics and determined the results were based on the correct data, but an incorrect supporting data file was originally provided to stakeholders. The correct supporting file was provided in the second round of consultation.

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20 TasNetworks, *Email to AER – Preliminary Annual Benchmarking Report 2024 – Electricity transmission network service providers – Consultation stage 1*, 13 August 2024.

21 Powerlink, *Email to AER – Preliminary Annual Benchmarking Report 2024 – Electricity transmission network service providers – Consultation stage 1*, 14 August 2024.

22 Powerlink, *Email to AER – Preliminary Annual Benchmarking Report 2024 – Electricity transmission network service providers – Consultation stage 1*, 14 August 2024; ElectraNet, *Email to AER – Preliminary Annual Benchmarking Report 2024 – Electricity transmission network service providers – Consultation stage 1*, 13 August 2024.

23 Powerlink, *Email to AER – Preliminary Annual Benchmarking Report 2024 – Electricity transmission network service providers – Consultation stage 1*, 14 August 2024.

- Powerlink also considered there was a need to develop customer friendly benchmarking information sheets that are available on the AER's website to assist stakeholders.[24] This was a step we took last year, and have continued this year, by publishing an accompanying fact sheet. This summarises the benchmarking process in simple terms and presents trends and results.
- Transgrid suggested that in the future beyond sending the preliminary results and reports it would be useful for the AER to hold a session to take the TNSPs through the data inputs and results.[25] We will test this idea with TNSPs next year prior to the release of the preliminary results and reports.
- We also received feedback related to improving the drafting and clarity of specific sections of our 2024 Annual Benchmarking Report and accompanying fact sheet. [26] In response to these suggestions, we have made minor clarifying changes to the report and fact sheet.

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24 Powerlink, *Email to AER – Preliminary Annual Benchmarking Report 2024 – Electricity transmission network service providers – Consultation stage 1*, 14 August 2024.

25 Transgrid, *Email to AER – Preliminary Annual Benchmarking Report 2024 – Electricity transmission network service providers – Consultation stage 2*, 29 October 2024.

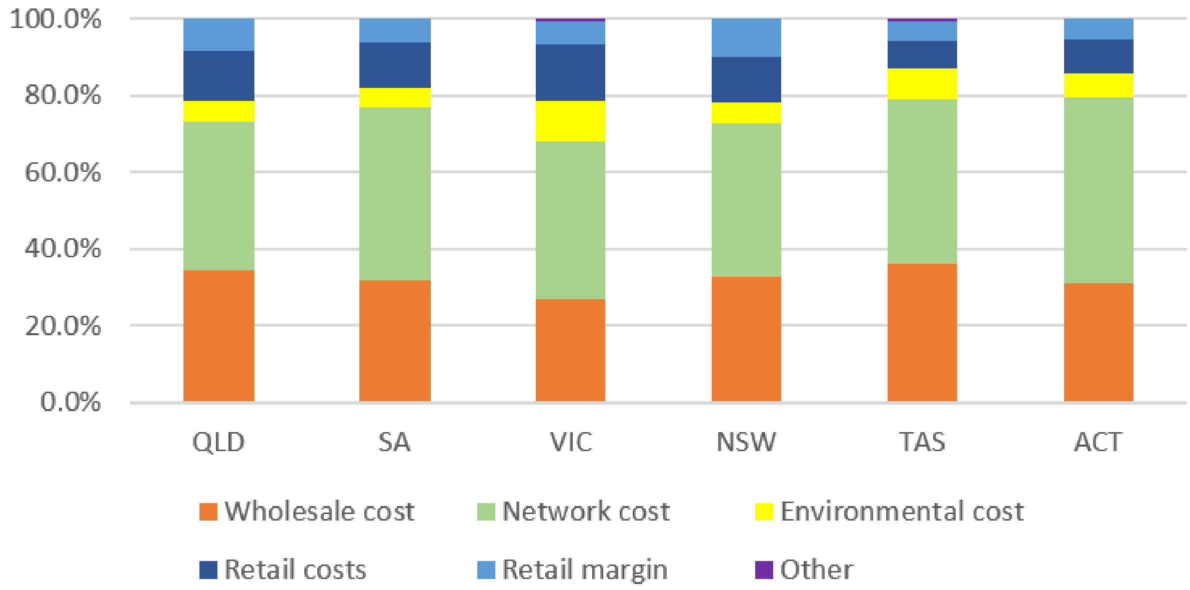
26 Energy Users Association of Australia (EUAA), *Email to AER - Annual Benchmarking Report 2024 – Electricity transmission network service providers – Consultation stage 2,* 29 October 2024.

2 Economic benchmarking and its uses

Electricity networks are 'natural monopolies', which do not face the typical commercial pressures experienced by firms in competitive markets. Unregulated network operators could increase their prices above efficient levels and would face limited pressure to control their operating costs or invest efficiently. As a result, electricity networks are regulated, and economic benchmarking is one tool we use to examine how efficiently they are operating.

Consumers pay for electricity network costs through their retail electricity bills. Transmission and distribution network costs typically account for between 35–45% of what consumers pay for their electricity. The remainder covers the costs of generating, and retailing electricity, as well as various regulatory programs related to environmental policies. Figure 5 provides an overview of the typical electricity retail bill. Network costs in Figure 5 cover both transmission and distribution costs. Based on historical data, distribution costs account for a larger proportion (around 75%) of the network costs compared to transmission costs (around 25%).[27]

Figure 5 Network costs as a proportion of residential electricity bills, 2022–23



Source: AER, *Default market offer prices 2022-23 cost assessment model*, 26 May 2022; ESC, *VDO calculation model 2022–23*, 27 May 2022; OTTER, *Approved Aurora Energy 2022 revised proposal period*, 31 May 2022; ICRC, *Retail electricity price recalibration 2022–23: standing offer prices for the supply of electricity to small customers*, 6 June 2022.

Note: Figures may differ slightly from the source due to rounding. Simple averages across the multiple NSW and VIC DNSPs were used to calculate cost proportions. Data for QLD only covers the costs in urban Queensland as data for rural areas is not available. Categorisation of costs vary from state to state, we have assigned the costs to like categories in the creation of Figure 5.

Under the National Electricity Law and the NER, the AER regulates electricity network revenues with the goal of ensuring that consumers pay no more than necessary for the safe

27 AEMC, *Residential electricity price trends 2021*, *Final Report*, November 2021; AER analysis.

and reliable delivery of electricity services. This is done through a periodic (5 yearly) revenue determinations. Each electricity network provides the AER with a revenue proposal outlining its forecast expenditures. The AER assesses and, where necessary, amends each proposal to ensure it reflects efficient costs. On this basis, the AER then sets each network's revenue for the five-year period, which is the maximum amount the network can recover from its customers. This provides a network with the incentive to outperform and improve its productivity over its regulatory period. The lower costs ultimately provide benefits to customers through lower expenditure forecasts in future periods.

In 2012, the Australian Energy Market Commission (AEMC) amended the rules to strengthen the AER's power to assess and amend network expenditure proposals.[28] The rule changes were made in response to concerns raised by the AER and other industry participants that restrictions in the NER had resulted in expenditure increases for network service providers that were not necessarily efficient and resulted in higher charges for consumers.[29]

The rule changes required the AER to develop a benchmarking program to measure the relative efficiency of all electricity networks in the NEM and to have regard to the benchmarking results when assessing expenditure proposals. The rules also required the AER to publish the benchmarking results in an annual benchmarking report.[30]

2.1 The uses of economic benchmarking

We use the economic benchmarking techniques described in section 1.1 in a variety of holistic and targeted ways when assessing and amending network revenue proposals.[31] The TFP and MTFP techniques are primarily used to measure total input efficiency, opex PFP and MPFP techniques to test opex efficiency, while the capital PFP and MPFP results provide information on the efficiency of capital inputs. The PPIs provide supplementary information on how efficiently a network may be using particular 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. We also use them to understand the drivers of trends in network efficiency over time and changes in these trends. This can help us understand why network productivity is increasing or decreasing and where best to target our expenditure reviews.[32] These results inform our assessment of proposed network expenditures, and whether they are efficient when setting the maximum revenues TNSPs can recover from customers, but

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28 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. vii.

29 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. vii.

30 NER, cll. 6A.31(a) and 6A.31(c).

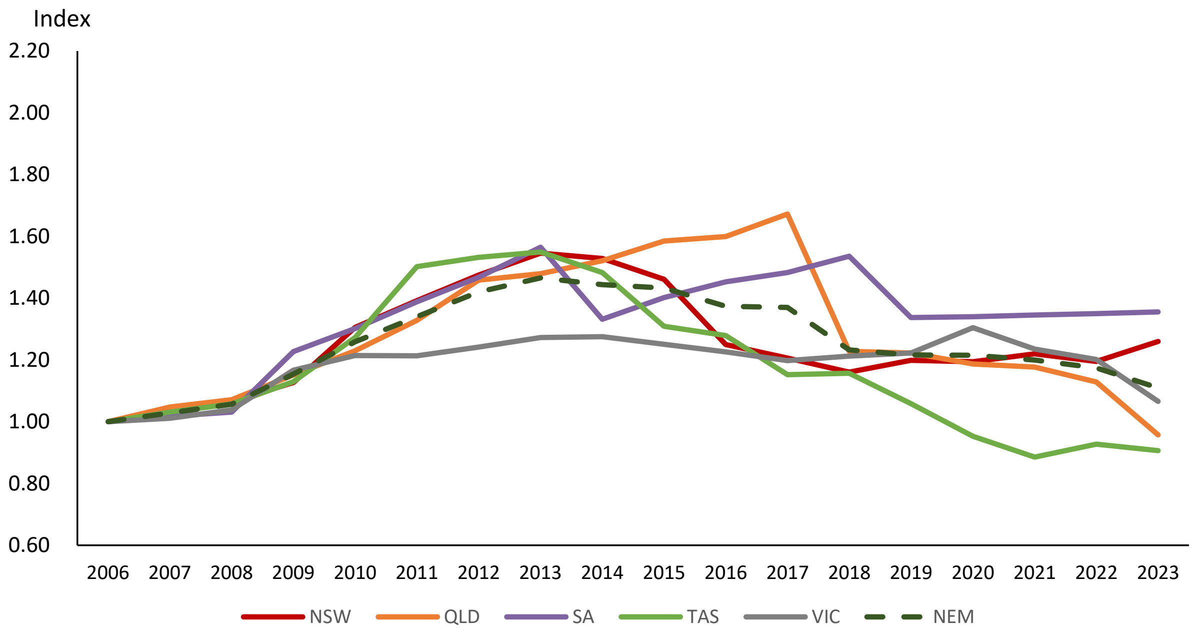
31 The benchmarking presented in this report is one of a number of factors we consider when making our revenue determinations. For a revenue determination, we examine the efficiency of an individual TNSP’s forecast opex and capex. In this report we primarily examine the overall efficiency of TNSPs. Though the efficiency of networks as a whole is relevant to our determinations, we also undertake further analysis when reviewing opex and capex forecasts.

32 AER, *Explanatory Statement - Expenditure Forecast Assessment Guideline*, November 2013, pp. 78–79.

given the limitations noted below we do not solely rely on these results in forming a view on opex inefficiency.

Since 2014, we have used benchmarking in various ways to inform our assessments of network expenditure proposals. It has been one contributor to the reductions in network costs and revenues for TNSPs as shown in Figure 6 (among a range of factors such as falling cost of capital and lower demand forecasts driving lower capital expenditure).

Figure 6 Indexes of transmission revenues by jurisdiction, 2006-23



Source: Economic Benchmarking RIN; AER analysis.

The benchmarking results provide network owners and investors with useful information on the relative productivity 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 businesses' 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 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, in particular, allows consumers to clearly see which factors are driving network efficiency and provides some visibility of the drivers of the network cost component of their retail electricity bills. This helps to inform their participation in our regulatory processes and in broader debates about energy policy and regulation.

2.2 Limitations of benchmarking transmission networks

While we have undertaken benchmarking of transmission network productivity for several years, it is still a developing area. We are aware there have been ongoing studies on transmission. For example, European regulators, through the Council of European Economic Regulators have periodically conducted benchmarking studies of electricity and gas transmission system operators in Europe since 2005.[33] There has been greater use of transmission benchmarking by economic regulators since 2014, but we consider that transmission benchmarking is still less developed than distribution benchmarking. The small number of electricity transmission networks in Australia (five) also makes efficiency comparisons at the aggregate level difficult. Given this, as noted above, we take the results into account but do not solely rely on them in forming a view on opex inefficiency in revenue determinations.

We have primarily used the PIN techniques to measure TNSPs' productivity over time and relative to each other. It is important to recognise that the results do not necessarily account for all relevant, material differences in network operating environments. Certain factors arising from a TNSPs operating environment are beyond its control. These 'operating environment factors' (OEFs) may influence a TNSPs costs and, therefore, its benchmarking performance.

The benchmarking techniques presented in this report capture key OEFs. For example, the MTFP analysis includes as outputs a TNSP's circuit length, number of end users, ratcheted maximum demand and energy throughput, and by doing so we also allow for key network density measures, including throughput per kilometre and maximum demand per customer. However, not all OEFs can be captured in the models. As noted in section 1.3 we are also monitoring developments in the transmission environment which will help to inform any future review of the appropriate benchmarking specification.

However, we consider the benchmarking analysis presented in this report is reasoned and comprehensive. We have collected data on all major inputs and outputs for TNSPs, and we consider that the dataset used is robust.

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33 Economic Insights, *Economic Benchmarking Results for the Australian Energy Regulator's 2021 TNSP Annual Benchmarking Report*, November 2021, pp. 3–4.

3 The productivity of the electricity transmission industry as a whole

Key points

- Electricity transmission industry TFP decreased over the 2006–16 period by on average 1.8% per year. This was largely driven by the long-term decline in capital PFP. There was then an improvement in transmission industry productivity between 2016 to 2018 (at an average annual rate of 3.2%) before it broadly stabilised. This was largely driven by reductions in the opex input, as reflected by improved opex PFP, and slower growth in capital assets relative to outputs compared to earlier years.
- Productivity for the utilities sector declined at a sharper rate than the transmission industry over the 2006–23 period, but grew at a slower rate than the overall Australian economy.[34]
- In 2023, the transmission industry TFP fell by 1.0%. Increases in the opex quantity and transformer and overhead line inputs were the main drivers of this decrease. These were partially offset by an increase in both circuit length and reliability outputs.
- The decrease in transmission industry productivity over 2023 was similar to the slight decline in productivity in the Australian economy (0.8%), but was smaller relative to the 4.6% decline for the utilities sector.

Below we present time series TFP results for the electricity transmission industry from 2006 to 2023 and for the 12–month period to 2023. Examining trends over time can provide insights, such as to any cycles that exist, which may not be available when only looking at the short-term and particularly changes in a single year. This is due to the volatile nature of some inputs and outputs, which can create noise in the short-term, and that there may be delayed effects of changes in inputs on outputs, particularly for the sticky capital inputs.

3.1 Transmission industry productivity over time

Figure 7 presents TFP for the electricity transmission industry from 2006 to 2023.[35] TFP declined at an average annual rate of 1.8% over the 2006–16 period as inputs grew by more than outputs. This was followed between 2016 and 2018 by an average annual improvement in transmission industry productivity as measured by TFP of 3.2%. Reductions in input growth, and particularly for the opex input, were then main contributor to these productivity improvements. Since 2018, productivity growth has slowed to an average annual growth

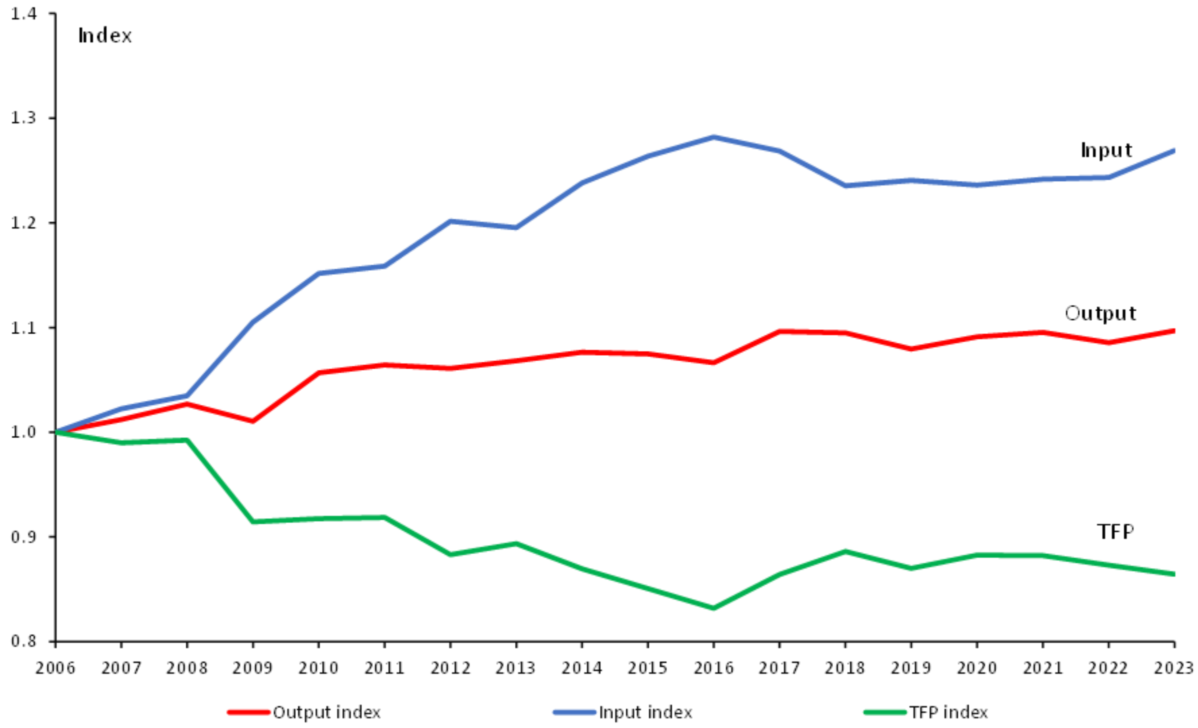
34 Australian economy productivity and the utility sector productivity are measured by the multifactor productivity indexes (in quality adjusted hours worked basis for the labour input). The market sector consists of 16 industries, the full list of the included industries can be found here: https://www.abs.gov.au/statistics/industry/industry-overview/estimates-industry-multifactor-productivity/latest-release/.

35 The annual rate of change in this report is calculated as a logarithm difference, accounting for compounding effects in continuous time, consistent with the literature on TFP growth. The total rate of change over a period, e.g. 2006 to 2023, is calculated as a percentage difference over the discrete time frame.

of –0.5%.

In 2023, the fall in productivity (1.0%) was the result of an increase in total inputs (2.0%) which exceeded the increase in total outputs (1.1%). However, it is still above the historically low level seen in 2016.

Figure 7 Transmission industry input, output and TFP indices, 2006–23



Source: Quantonomics, AER analysis.

Figure 8 shows the reduction in transmission industry productivity, particularly up to 2016, was driven by the long-term decline in capital PFP. Over the last 18 years, capital PFP declined at an average annual rate of 1.3%, primarily driven by greater growth in overhead lines, underground cables, and transformers compared to total outputs. This is compared to opex PFP, which grew at an average annual rate of 0.3% over the 2006–23 period. We also consider that the long-term decline in capital PFP is comparable to that of most other industries in the Australian market economy and is reflective of a trend of declining capital productivity in developed economies. This may be a consequence of capital deepening, that is, the increase in the amount of capital per worker.[36,37]

The improvement in transmission productivity from 2016 was primarily linked to the increase in opex PFP, although stabilisation of capital PFP due to less growth in capital assets also contributed. From 2021 onwards, both opex PFP and capital PFP trended downward, which can be attributed to increases in opex quantity and growth in capital inputs relative to rather constant total outputs. Opex PFP decreased by 2.7% in 2022 and 2.5% in 2023, while capital

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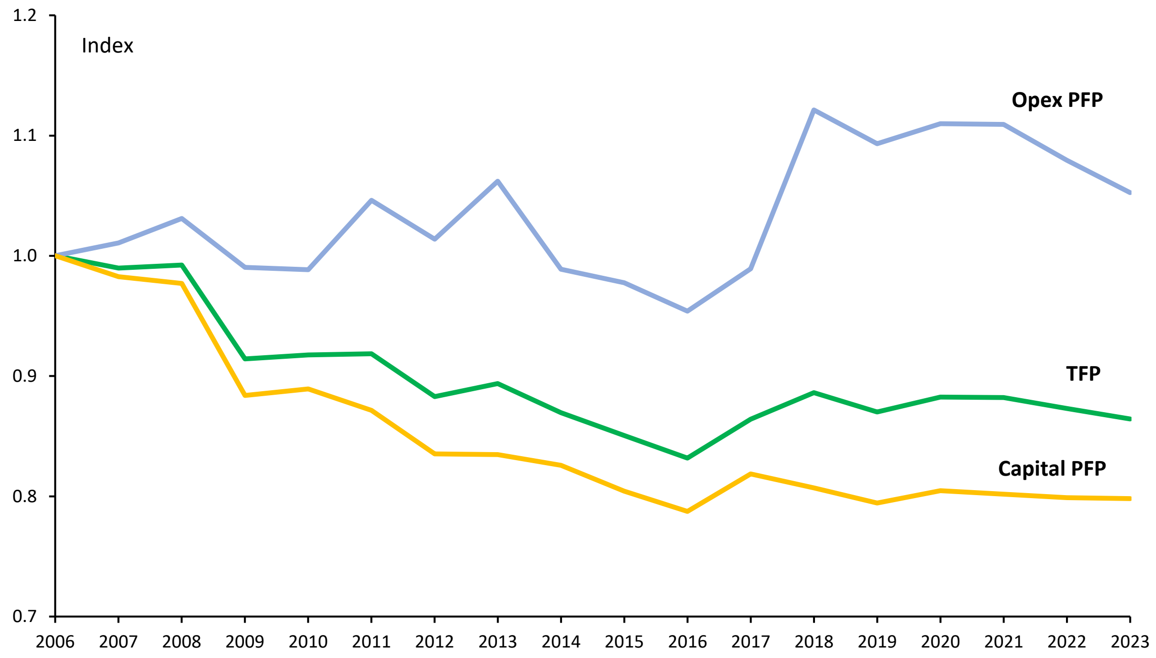
36 Australian Bureau of Statistics, *Tables 1-19: Estimates of Industry Multifactor Productivity*, December 2023.

37 Organisation for Economic Co-operation and Development (OECD), *OECD Compendium of Productivity Indicators 2015*, May 2015, p. 26.

PFP saw smaller declines of 0.4% in 2022 and 0.1% in 2023. The TFP decrease of 1.0% in 2023 can be largely attributable to the decline of opex PFP.

Figure 8 Transmission industry opex PFP and capital PFP, 2006–23



Source: Quantonomics, AER Analysis.

Figure 9 compares the TFP of the electricity transmission industry over time relative to the productivity of the Australian economy and utilities sector. Over the past 18 years both electricity transmission industry and utilities sector productivity declined. However, over the period 2016–23 transmission industry productivity showed an increasing trend before stabilising, which contrasts the continued declining trajectory of utilities sector productivity. This is reflected in the average annual rate of decline of 0.9% for transmission industry productivity, compared to 1.9% for the utilities sector for the 2006–23 period. In contrast, over this period, the Australian economy's productivity grew slightly with an average annual growth of 0.2%. In 2023, the TFP for the economy and transmission industry fell by 0.8% and 1.0% respectively while the utilities sector fell by 4.6%.

As observed by the Productivity Commission, the utilities sector has seen a long-term decline in productivity beginning in 1997–98. This was as a result of continued capital investment in anticipation of future demand, issues in output measurement, exogenous shifts to higher cost technologies, and unmeasured improvements in output quality such as reliability, safety, visual amenity or lower emissions.[38,39] A cyclical pattern of investment associated with replacing ageing network infrastructure assets may have put downward pressure on recent productivity performance.

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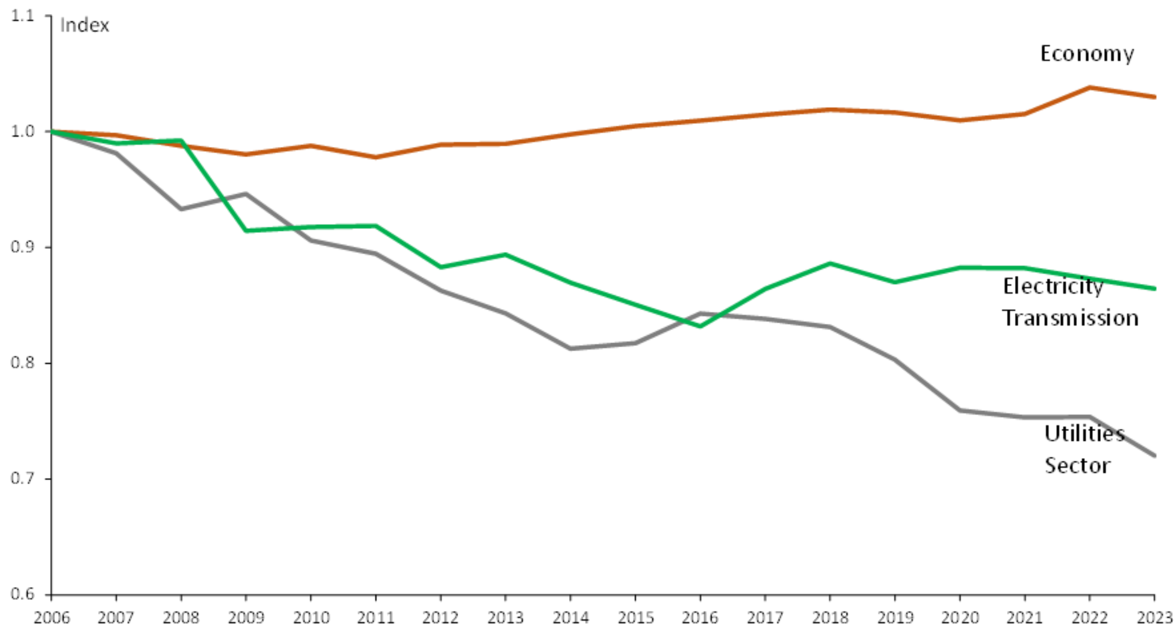
38 Productivity Commission, *Productivity in Electricity, Gas and Water: Measurement and Interpretation*, March 2012.

39 Productivity Commission, *Productivity Update*, May 2013, pp. 33–34.

Figure 9 Electricity transmission industry, utilities sector, and economy productivity indexes, 2006–23



Source: Quantonomics; AER analysis.
Note: The productivity of the Australian market economy and the utility 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 in 2006.

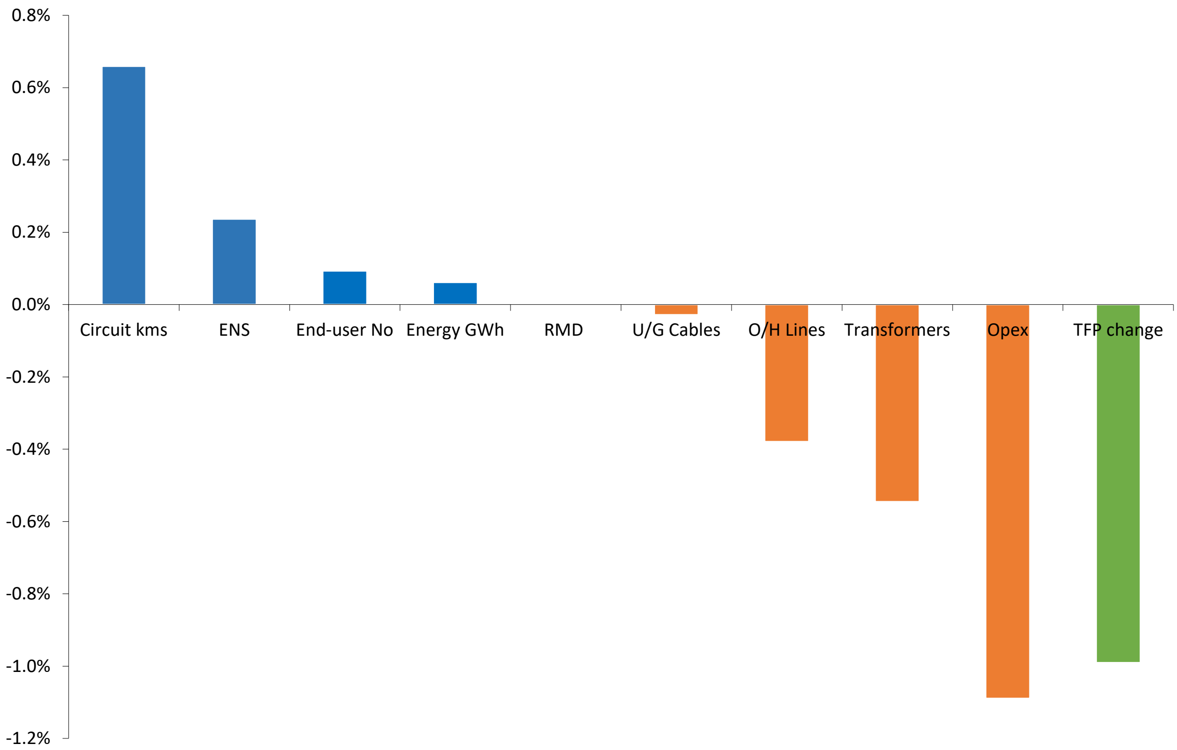
3.2 Transmission industry productivity over 2023

As set out above, transmission industry TFP decreased by 1.0% over 2023. Figure 10 shows the drivers of this in terms of the contributions of each output and each input to the change in TFP. The contributions are ordered from the most positive on the left to the most negative on the right. If all the positive (blue bars) and negative contributions (orange bars) in Figure 10. are added together, they sum to the TFP change given by the red bar on the right of the figure.

The primary driver of decreased productivity for the transmission industry in 2023 was an increase in the opex input. This in isolation contributed a 1.1 percentage point decrease to the TFP change. Four TNSPs saw an increase in the opex input for 2023, with the biggest increases from Transgrid, ElectraNet and Powerlink. The main drivers of the increased opex across the transmission industry were maintenance (asset and field), corporate support and network support.[40]

[40] Transgrid, *Email to the AER – Response to questions on Transgrid's 2022–23 EB RIN data*, 24 April 2023; Powerlink, *Email to the AER – Response to questions on Powerlink's 2022–23 EB RIN data*, 26 April 2023; ElectraNet, *Email to the AER – Response to questions on ElectraNet's 2022–23 EB RIN data*, 24 April 2023.

Figure 10 Transmission industry output and input percentage point contributions to annual TFP change, 2023



Source: Quantonomics, AER analysis.

Other drivers of reduced transmission industry TFP in 2023 were increases in transformer and overhead line inputs, negatively contributing 0.5 and 0.4 percentage points, respectively.

Partially offsetting the negative contributions was an increase in circuit length output and an improvement in reliability (reduction in ENS). They contributed 0.7 and 0.2 percentage points to TFP change respectively. Reliability enters the total output index as a negative output, such that a reduction in ENS represents an improvement in reliability and a higher level of service for end users.[41]

Given reliability can be volatile we also examine TFP excluding ENS. Transmission industry TFP change in 2023 excluding ENS was slightly lower than when ENS is included (−1.2% and −1.0%, respectively). The change in reliability in 2023 reflected the increased reliability performance of three of the five TNSPs (ElectraNet, Powerlink, TasNetworks). AusNet saw minimal change in reliability, while Transgrid reported decreases in reliability.

3.2.1 Output and input contributions to productivity growth over 2023 – by industry and TNSP

Table 1 presents the transmission industry, and each TNSP's TFP growth in 2023, and decomposition into the individual input and output contributions that were most material to

41 Quantonomics, *Economic Benchmarking Results for the Australian Energy Regulator's 2024 TNSP Benchmarking Report*, 26 July 2024, p. 13.

this growth. In this light, we have focused on the outputs of reliability (ENS) and circuit length, as well as the inputs of transformers and opex.

Table 1 Selected input and output contributions to TFP growth rates by TNSP, 2023

	Annual change in TFP (%)	Energy not supplied (ENS) (ppts)	Circuit length (ppts)	Transformers (ppts)	Opex (ppts)
Transmission industry	−1.0	0.2	0.7	−0.5	−1.1
Powerlink	0.2	1.2	0.0	−0.7	−0.6
AusNet	0.1	−0.1	−0.0	0.1	0.3
TransGrid	−5.6	−2.7	0.0	−0.8	−2.2
TasNetworks	0.2	0.8	−0.0	0.0	−0.4
ElectraNet	3.9	2.7	4.8	−0.0	−1.6

Source: Quantonomics
Note: Differences of '0.0' and '−0.0' represent small variances.

The 1.0% reduction in transmission industry productivity in 2023 as measured by TFP growth, was driven by the significant reduction in the productivity of Transgrid. Partly offsetting this was the improved TFP of ElectraNet along with smaller improvements of Powerlink, TasNetworks and AusNet. The four TNSPs with positive productivity change in 2023 all achieved growth at a rate greater than the average annual industry TFP change over the 2006–23 period (−0.9%).

We discuss below the main input and outputs driving the productivity changes for each business (as measured by TFP). This discussion solely compares a business' performance over time relative to its past performance, performance comparisons between businesses are presented in section 4.1.

Transgrid

Transgrid's productivity as measured by TFP declined in 2023 by 5.6%, as compared an average annual decline of 1.6% over the 2006–23 period. The largest contributors to this outcome in 2023 were an increase in the opex input and a decrease in the reliability output.

An increase in opex negatively contributed 2.2 percentage points to TransGrid's TFP change in 2023. This was driven by a range of factors including increased expenditure on maintenance (relating to its network, assets and support). Increased inspections and delivery of replacement and internal work are examples of maintenance Transgrid conducted in 2023.[42]

42 Transgrid, *Email to the AER – Response to questions on Transgrid's 2022–23 EB RIN data*, 24 April 2024.

Lower reliability (i.e. an increase in ENS) contributed 2.7 percentage points. The majority of the increase in ENS was due to a substation outage impacting three towns, causing an electricity outage for 3.7 hours.[43] The TFP growth for Transgrid in 2023 excluding ENS was higher compared to when ENS was included, −2.9% and −5.6% respectively, but still negative.

ElectraNet

ElectraNet's productivity as measured by TFP increased in 2023 by 3.9%, which is higher than its average annual TFP decline of 1.4% over the 2006–23 period. The main contributors to this outcome in 2023 were increases in the outputs of circuit length and reliability, positively contributing 4.8 and 2.7 percentage points to TFP growth respectively.

The significant positive contribution of circuit length in 2023 was due to the high output weight attributed to circuit length (53.6%)[44] and the installation of new circuit lines as part of ElectraNet's EP Link project. ElectraNet's reliability improved significantly, reporting a 78% lower ENS compared to last year.[45] As a result, the growth of TFP for ElectraNet in 2023 excluding ENS was lower compared to when ENS is included (1.2% and 3.9% respectively)

Offsetting this were increases in the inputs of opex and overhead lines. ElectraNet reported that the main drivers of the opex increase were maintenance of substations and network support, specifically the addition of Fast Frequency Response to the network.[46]

Powerlink

Powerlink's productivity as measured by TFP growth improved in 2023 by 0.2%, this is higher than its average annual decline of 0.8% over the period 2006–23. An improvement in reliability was the key driver of improved TFP in 2023, offset by an increase in opex input and transformer growth.

In 2023, improvements in reliability (i.e. a reduction in ENS) contributed 1.2 percentage points to TFP growth. The growth of TFP for Powerlink in 2023 excluding ENS is significantly lower compared to when ENS is included (−1.0% and 0.2%, respectively). The effect of ENS on TFP is driven by an improvement in reliability relative to 2022, not necessarily it having an out-performing year in reliability.

Growth in the inputs opex and transformers had the largest negative contributions of 0.6 and 0.7 percentage points respectively. Powerlink reported that the largest contributors to the increase in the opex input were routine field maintenance and corporate support, specifically due to an increase in superannuation contribution rate that applied to the Powerlink workforce.[47]

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43 Transgrid, *Email to the AER – Response to questions on Transgrid's ENS data*, 30 May 2024.

44 Quantonomics, *Economic Benchmarking Results for the Australian Energy Regulator's 2024 TNSP Benchmarking Report*, 26 July 2024, p. 63.

45 Transgrid, *Email to the AER – Response to questions on Transgrid's ENS data*, 30 May 2024.

46 ElectraNet, *Email to the AER – Response to questions on ElectraNet's 2022–23 EB RIN data*, 24 April 2024.

47 Powerlink, *Email to the AER – Response to questions on Powerlink's 2022–23 EB RIN data*, 26 April 2024.

TasNetworks

TasNetworks' productivity as measured by TFP increased in 2023 by 0.2% which is broadly consistent with its average annual decline of 0.01% over the period 2006–23. Again, an improvement in reliability was the key driver of improved TFP in 2023, offset by an increase in the opex input and a decrease in the energy delivered output.

Improved reliability positively contributed 0.8 percentage points to TFP growth in 2023. This reflected fewer outage events as compared to 2022 and better outage response.[48] The TFP growth for TasNetworks in 2023 excluding ENS is lower compared to when ENS is included (−0.6% and 0.2%, respectively).

Increased opex quantity, and decreased energy supplied, negatively contributed 0.4 and 0.3 percentage points to TFP growth, respectively. TasNetworks stated that the higher opex was due to the high inflation environment in 2023, leading to an increase in equipment and labour costs.[49] Additionally, it noted overhead costs such as maintenance support and network monitoring vary year on year due to TasNetworks' cost allocation methodology, which caused fluctuations in opex.[50]

AusNet

Key drivers for AusNet's 2023 TFP growth of 0.1% were an increase in end users and a decrease in opex quantity, which positively contributed 0.1 and 0.3 percentage points, respectively. This is slightly lower than its average annual increase in TFP of 0.5% over the period 2006–23.

The decrease in opex input was mainly attributed to lower expenditure in network maintenance and corporate services.[51] AusNet's reported decrease in the energy delivered was in contrast to three previous years of growth in energy delivered.

The full set of input and output contributions to TFP for the industry over the 2006–23 period and for 2023 can be found in the Quantonomics report.

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48 TasNetworks, *Email to the AER – Response to questions on TasNetworks' 2022–23 EB RIN data*, 26 April 2024.

49 TasNetworks, *Email to the AER – Response to questions on TasNetworks' 2022–23 EB RIN data*, 26 April 2024.

50 TasNetworks, *Email to the AER – Response to questions on TasNetworks' 2022–23 EB RIN data*, 26 April 2024.

51 AER analysis; AusNet, *Economic Benchmarking RIN 2021–22 and 2022–23*.

4 Relative productivity of individual transmission networks

Key points

- From 2006 to 2023, the productivity of TasNetworks and AusNet as measured by MTFP improved, contributing to their respective 2023 MTFP rankings of 1st and 2nd among all TNSPs. In contrast over the 2006–23 period the productivity of ElectraNet, Powerlink and Transgrid deteriorated.
- TasNetworks continued to be the highest ranking TNSP as measured by MTFP in 2023. Following a MTFP decline in 2022, TasNetworks' MTFP showed a modest increase in 2023. TasNetworks has remained the top ranked TNSP since 2012.
- ElectraNet was the other TNSP with improved productivity as measured by MTFP in 2023. ElectraNet had the largest productivity growth in 2023 relative to other TNSPs. This followed a decline in its productivity in 2022 to its lowest level since 2006.
- Transgrid's productivity as measured by MTFP deteriorated the most in 2023 and it remained the 5th ranked TNSP.
- AusNet, Powerlink and Transgrid's productivity was lower in 2023 compared to 2022, but higher than its 2016 productivity levels.
- Our transmission benchmarking does not account for all possible differences in OEFs.

Below we present the economic benchmarking results that we use to measure and compare the productivity of individual TNSPs over the 2006–23 period and for the 2023 regulatory year. We also provide our key observations on the reasons for changes in the relative productivity of each TNSP in the NEM. In particular:

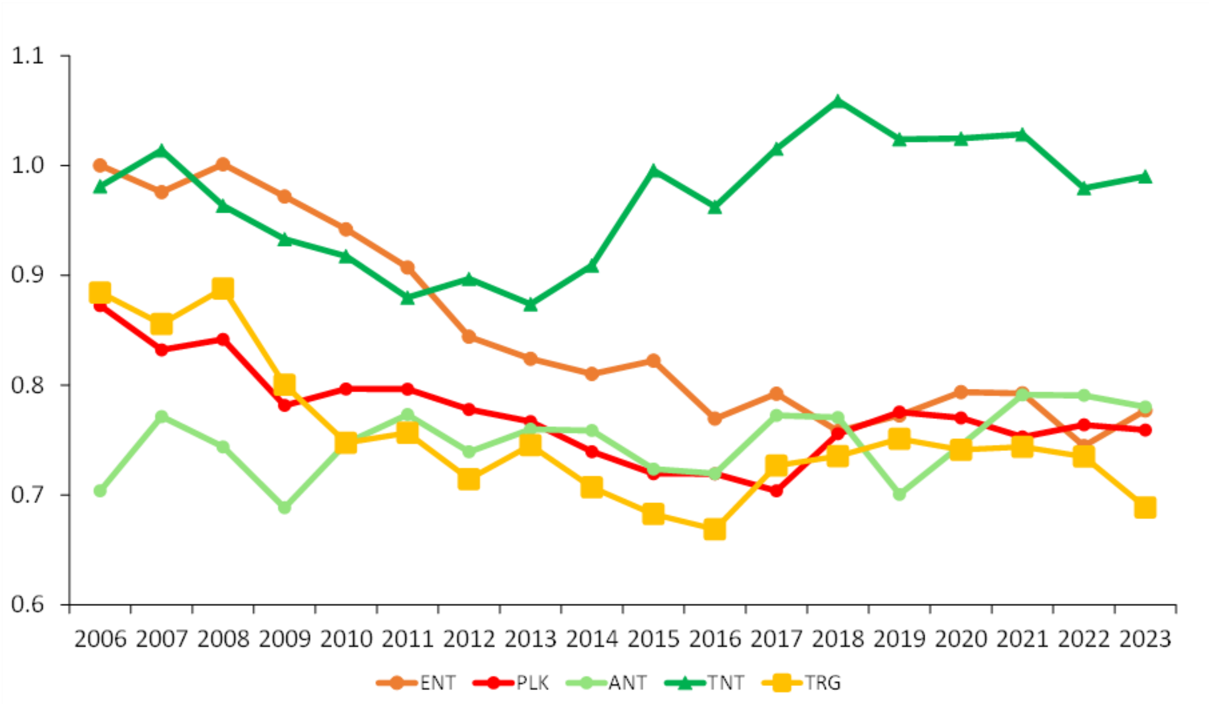
- Section 4.1 presents the results of the panel data MTFP benchmarking, which relates total inputs to total outputs and provides a measure of overall network productivity relative to other networks. MTFP is the headline technique we use to measure and compare the relative productivity performance of individual TNSPs over time. This is supported by the corresponding partial factor productivity measures of opex and capital inputs (i.e. opex MPFP and capital MPFP).
- Section 4.2 presents the PPIs, which provide a general indication of comparative performance in delivering one type of output.

Being a top-down analysis, the results discussed in this section, particularly the MTFP results, are only indicative of relative performance across the TNSPs. While the analysis accounts for some factors that are beyond a TNSP's control, such as network density and some system structure factors, additional OEFs can affect a TNSP's costs and benchmarking performance. At this stage, and as noted in section 2.2, our transmission benchmarking analysis does not incorporate additional OEFs beyond the network density differences.

4.1 MTFP results for TNSPs

The relative productivity levels of TNSPs as measured by MTFP over the 2006–23 period are presented in Figure 11.[52] It shows a general clustering of four TNSPs below TasNetworks, since around 2013. Out of these four TNSPs, three networks (Powerlink, Transgrid, ElectraNet) experienced declining MTFP over this period while AusNet's MTFP improved.

Figure 11 Electricity transmission MTFP indexes by TNSP, 2006–23



Source: Quantonomics, AER analysis.

As can be seen in Table 2, the MTFP rankings of each TNSP remains largely unchanged in 2023, with changes only in the ranking of ElectraNet and Powerlink.[53] ElectraNet has risen to the 3rd ranked TNSP as measured by MTFP, and Powerlink has fallen to 4th. This is due to ElectraNet's 4.3% MTFP increase in 2023, which can be attributed to its increased circuit length output and improved reliability.

Table 2 TNSP MTFP scores, rankings and growth rates, 2022 and 2023

	Rank (2023)	Rank (2022)	MTFP Score (2023)	MTFP Score (2022)	Change between 2022 and 2023
TasNetworks	1	1	0.99	0.98	1.1%
AusNet	2	2	0.78	0.79	−1.3%

52 ElectraNet (ENT) in 2006 is set as the base (i.e. index = 1.00).

53 The rankings in this table are measured by the MTFP productivity scores. They are indicative only because, as outlined earlier, there may be other operating environment variables not captured in the MTFP model.

	Rank (2023)	Rank (2022)	MTFP Score (2023)	MTFP Score (2022)	Change between 2022 and 2023
ElectraNet	3↑	4	0.78	0.74	4.3%
Powerlink	4↓	3	0.76	0.76	−0.6%
TransGrid	5	5	0.69	0.73	−6.5%

Source: Quantonomics, AER analysis.

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

- Capital MPFP, which considers the productivity of the TNSPs' use of overhead lines, underground cables and transformers.
- Opex MPFP, which considers the productivity of the TNSPs' opex.

These partial productivity measures assist in interpreting the MTFP results by examining the individual contribution of capital assets or 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, they do not account for synergies between capital and opex like the MTFP model. These partial measures provide a way of gaining insight into the factors driving MTFP trends.

Figure 12 and Figure 13 present capital MPFP and opex MPFP results respectively for all TNSPs over the 2006–23 period.[54] Figure 12 shows that capital productivity has declined since 2006 for all TNSPs (by between 20.0% to 28.8% in total between 2006 and 2023) except for AusNet where it increased marginally by 2.5% over the 18–year period.

The declining trend in capital MPFP for these TNSPs is due to network capital inputs (length and capacity) growing more than outputs as measured by customers, demand, line length and energy consumption. The consistent decline in capital MPFP for most TNSPs is not dissimilar to the long-run trend of capital productivity decline in other industries resulting from capital deepening.[55]

TasNetworks has remained the highest ranked TNSP in terms of capital MPFP since 2006. We note that TasNetworks operates a relatively lower voltage transmission network compared to other TNSPs. Generally, TNSPs have networks with voltage class at 132kV and above, but the majority of TasNetworks transmission network is of 110kV and 220kV.[56]

ElectraNet achieved positive capital MPFP growth in 2023 of 4.4%. It also had positive opex MPFP growth of 2.1% and was the only TNSP to have growth in both measures. TasNetwork was the other TNSP to achieve positive growth in capital MPFP (1.7%) in 2023, but its opex MPFP declined slightly by 0.1%. Transgrid, AusNet and Powerlink had negative growth in capital MPFP, with Transgrid's decline the largest (–3.8%). Transgrid also had negative

54 ElectraNet in 2006 is set as the base (i.e., index = 1.00).

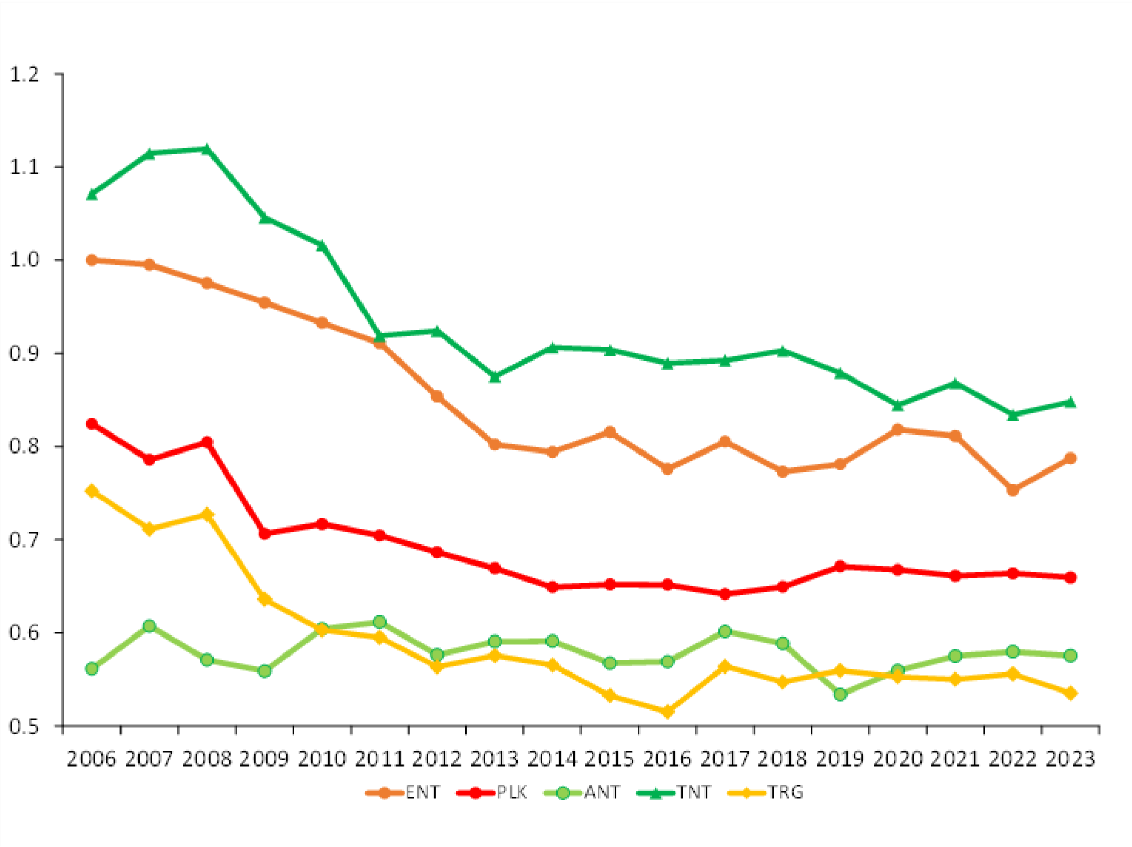
55 Australian Bureau of Statistics, *Tables 1-19: Estimates of Industry Multifactor Productivity*, December 2023.

56 TasNetworks, *Email to the AER containing amended 2022–23 Economic Benchmarking RIN*, 17 May 2024.

growth in opex MPFP, 9.9%, which again was the largest decline of all TNSPs. AusNet achieved a positive growth in opex MPFP over 2023 (1.8%).

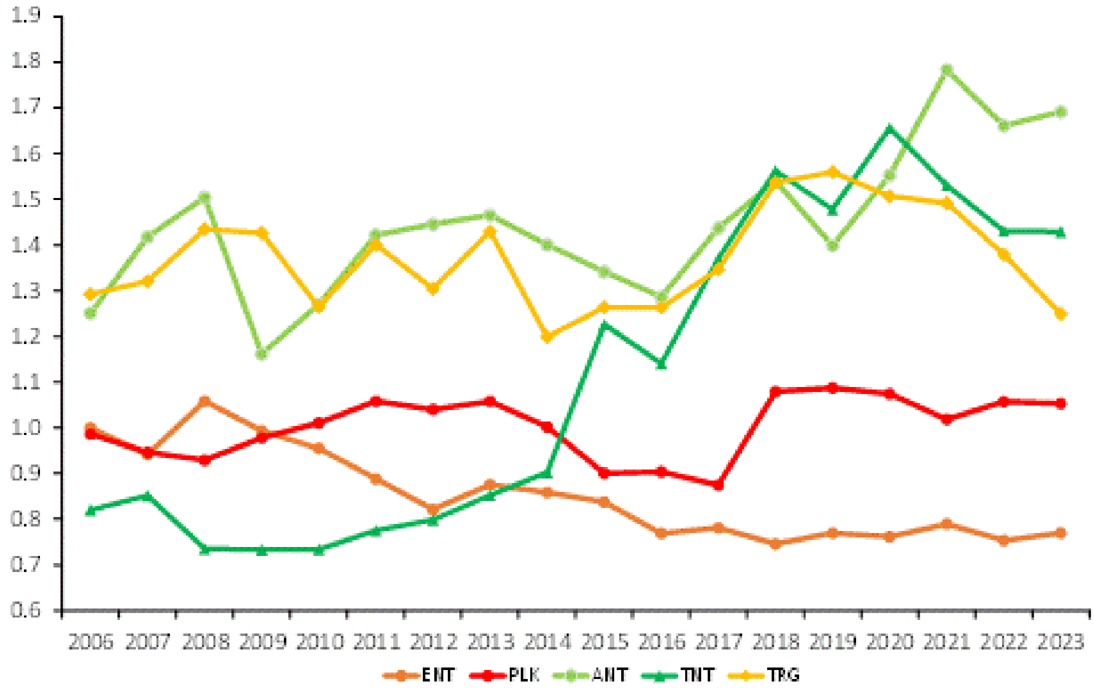
Beyond these opex MPFP results for 2023, Figure 13 shows that over the 18–year period, AusNet, TasNetworks and TransGrid remained relatively higher performers and Powerlink and ElectraNet relatively lower performers in terms of opex MPFP. Transgrid's opex MPFP has been trending downwards since 2019, including the decline of 9.9% in 2023. Despite recording the lowest opex MPFP at the start of the period, TasNetworks joined the higher performing group in 2015, with opex MPFP in 2023 higher than the 2006 level by 74.3%.

Figure 12 Electricity transmission capital MPFP indexes by TNSP, 2006–23



Source: Quantonomics, AER analysis.

Figure 13 Electricity transmission opex MPFP indexes by TNSP, 2006–23



Source: Quantonomics, AER analysis.

4.2 Partial performance indicator results of TNSPs

PPIs provide a simple representation of the input costs relative to a particular output. The PPIs used here support the MTFP analysis by providing a general indication of comparative performance in delivering one type of output. However, PPIs do not take into account the interrelationships between outputs. Therefore, PPIs are most useful when used in conjunction with other top-down benchmarking techniques, such as MTFP.

The inputs we use for the PPIs are the TNSPs' total costs, made up of opex and asset costs. Asset cost is measured by the AUC of capital. The AUC equals the return on capital (return on the TNSPs regulatory asset base) plus the return of capital (straight line depreciation of the TNSPs regulatory asset base) plus benchmark tax liability, as calculated under the building block model approach.[57] [58] The total costs 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 TNSPs and over time.

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57 We have applied to the PPI calculations the same AUC approach we applied to MTFP and MPFP analysis. We updated the calculation of the AUC of capital in 2021 and 2022 to reflect the AER's Rate of Return Instrument 2018. In previous years, the AUC of capital calculations broadly reflected the 2013 rate of return guideline. See: https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/rate-of-return-instrument-2018/final-decision.

58 For this year's report we have used the same methodological refinements to the AUC as set out in section 1.2 and Appendix C.

The outputs we use are the number of end users, circuit line length, maximum demand served and energy transported (see Appendix B for further details). We examine each of these outputs below.

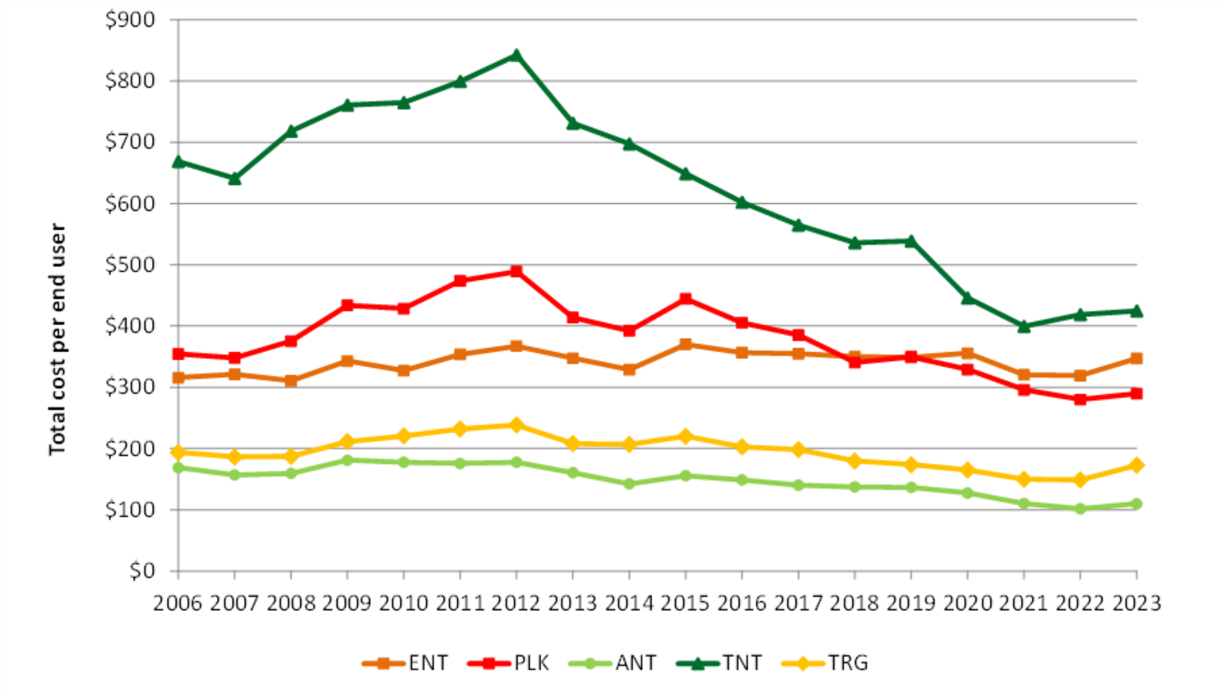
4.2.1 Total cost per end user

We present total cost per end user in Figure 14.[59] Over the period 2006–23, AusNet has consistently maintained the lowest total cost per end user. In contrast, TasNetworks had the highest total costs per end user of all TNSPs throughout the period, although its total cost per end user reduced more than half from 2012 to 2021 before rising modestly.

Total cost per end user for all TNSPs except ElectraNet were lower in 2023 than they were in 2006, ranging from decreases of 10.8% to 36.5%.[60] Over this period ElectraNet's total cost per end user increased by 9.9% due to costs rising faster than end users of the ElectraNet transmission network.

In 2023, all TNSPs had an increase in total cost per end user, ranging from 1.4% to 16.1%. This reflects increases in total user costs outpacing the growth in each TNSP's end users. The industry-wide increase in total costs can be largely explained by increases in the AUC of capital. Higher risk-free rates coupled with higher cost of debt margin, led to higher cost of borrowing in 2023, increasing the annual user costs for all transmission networks. Opex had a varied impact on total costs depending on the TNSP. In 2023, Transgrid and ElectraNet's total costs were further increased by their opex, while this was the opposite for AusNet, TasNetworks and Powerlink.

Figure 14 TNSP cost per end user, 2006–23 ($2023)



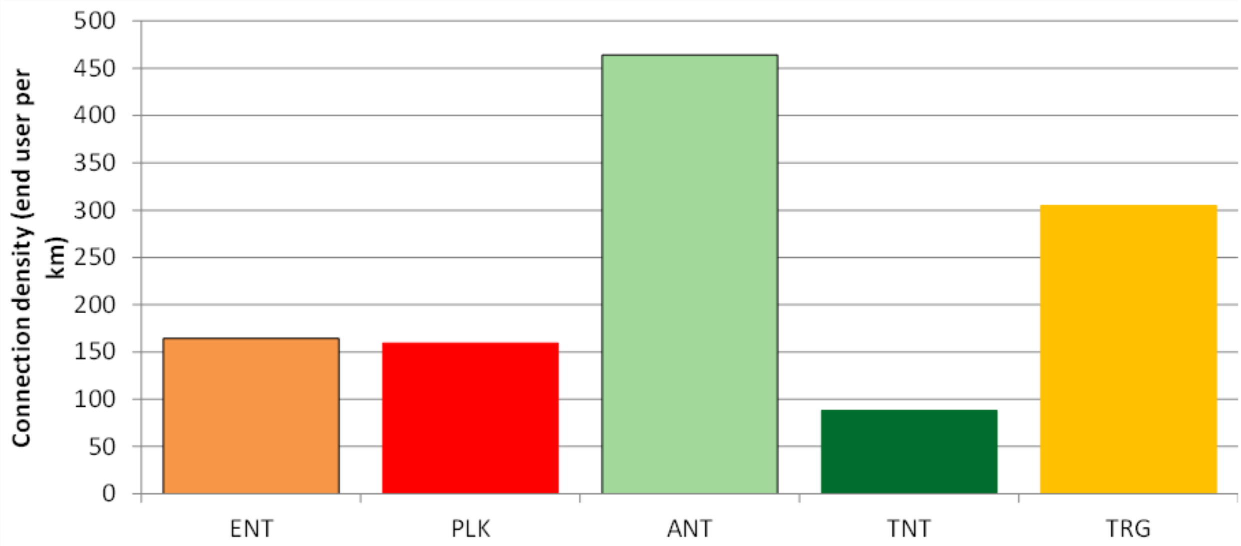
59 This, and all PPIs presented below, are in dollar values as at the end of June quarter 2023.

60 Annual and periodic rates of change in this section are calculated as percentage changes.

Source: Economic Benchmarking RINs; AER analysis.

The total cost per end user PPI potentially favours TNSPs with denser transmission networks (where density is measured in terms of end users per circuit kilometre). This is because denser transmission networks tend to have more customers per kilometre and hence are required to build and maintain fewer lines per end user connection point. The average connection density of TNSPs over 2018–23 is presented in Figure 15. This shows that AusNet has the highest average connection density, followed by TransGrid, ElectraNet, Powerlink and TasNetworks respectively. In line with these connection densities, the TNSP with the lowest cost per end user is AusNet (which has the highest connection density) and the TNSP with the highest costs per end user is TasNetworks (which has the lowest connection density).

Figure 15 TNSP connection density (end user per circuit kilometre, 2019–23 average)



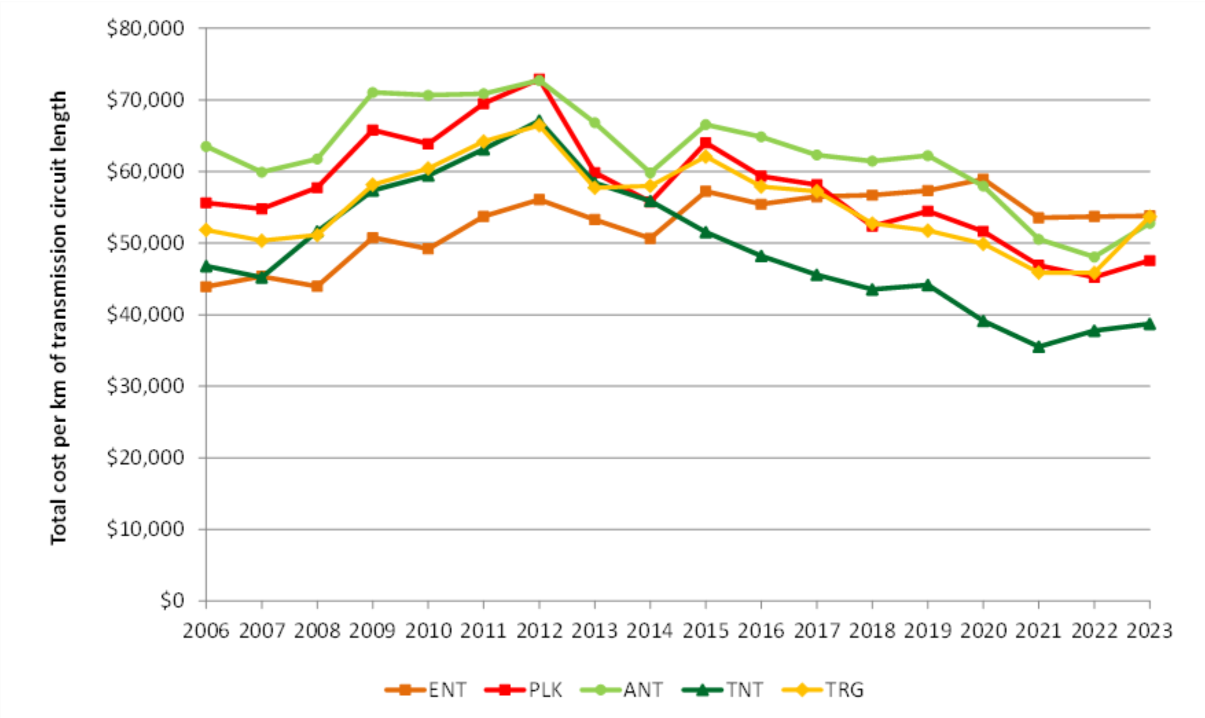
Source: Economic Benchmarking RINs; AER analysis.

4.2.2 Total cost per kilometre of transmission circuit length

As can be seen in Figure 16, from 2015 to 2023, four TNSPs (AusNet, ElectraNet, Powerlink and Transgrid) have been clustered with a similar level of total costs per kilometre of transmission circuit. TasNetworks has had the lowest cost per kilometre, and the gap to it and the rest of the TNSPs has widened over this period. For example in 2023, the difference in total costs per kilometre between the ElectraNet (highest cost) and TasNetworks (lowest cost) is $15,094 ($2023), whereas in 2014 the difference between AusNet (highest cost) and ElectraNet (lowest cost) was $9,159 ($2023).

In 2023, all TNSPs had an increase in total costs per kilometre of transmission circuit length, ranging from 0.2% to 17.1%. As with the total cost per end user PPI, these results are influenced by the large increases in total cost in 2023, mostly driven by significant increases in the cost of borrowing. Although there were increases in circuit length in 2023, the growth in total costs has offset this growth.

Figure 16 TNSP total cost per kilometre of transmission circuit length ($2023), 2006–23



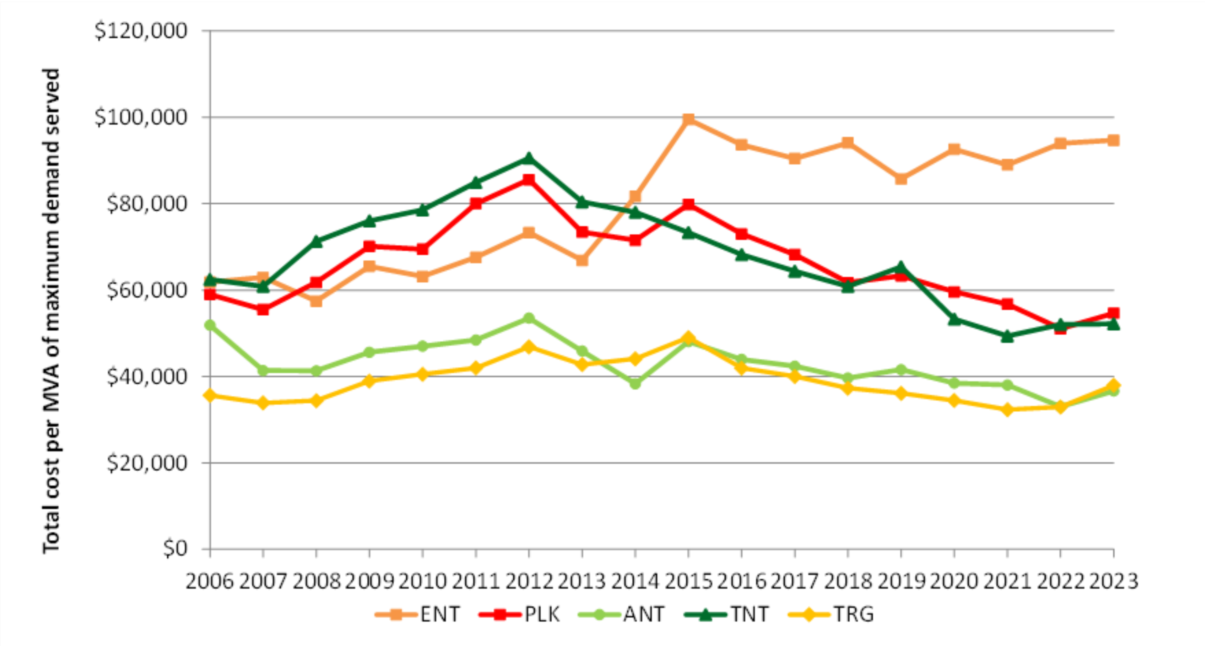
Source: Economic Benchmarking RINs; AER analysis.

4.2.3 Total cost per Mega Volt Amp (MVA) of non-coincident maximum demand

Powerlink, AusNet and TasNetworks had lower cost per MVA of non-coincident demand in 2023 than in 2006, with these reductions ranging from 7.4% to 29.3%. Conversely, ElectraNet and Transgrid experienced higher cost per MVA in 2023 relative to 2006, with 53.1% and 6.5% increases respectively. The significant increase for ElectraNet can be explained by declining maximum demand which mainly occurred between 2013 to 2015. This can be seen in Figure 17.

All TNSPs reported increases in total costs per MVA in 2023, ranging from 0.3% to 15.2%. As with the PPIs reported above, these results are influenced by the large increases in total cost in 2023, which are mostly driven by higher cost of borrowing which increased the asset costs of transmission networks. AusNet had the lowest cost per MVA of non-coincident demand in 2023.

Figure 17 TNSP total cost per MVA of maximum demand served ($2023), 2006–23



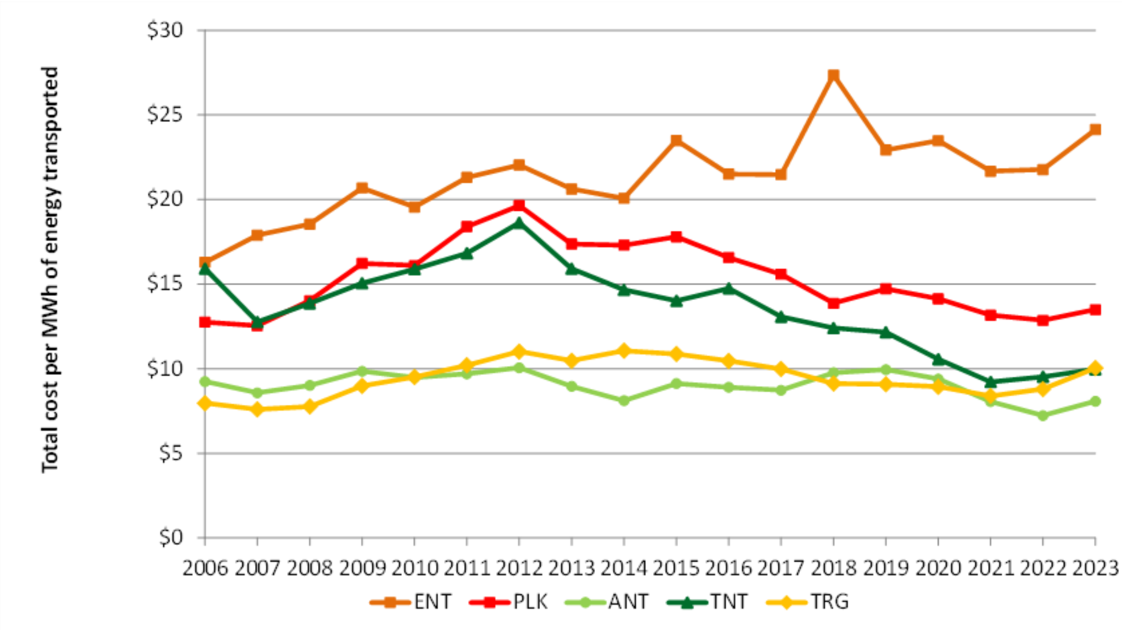
Source: Economic Benchmarking RINs; AER analysis.

4.2.4 Total cost per MWh of energy transported

As can be seen in Figure 18, over the period 2006–23, ElectraNet's cost per MWh of energy transported has increased the most, by 48.2%, and TasNetworks' has decreased the most, by 37.4%. Powerlink, AusNet and Transgrid reported smaller changes at +5.8%, −12.6% and +26.0%, respectively. AusNet and Transgrid were the best performing networks from 2006–23, with the lowest cost per MWh alternating between the two networks.

ElectraNet had the highest cost per MWh of energy transported in 2023 at $24.1/MWh, an 11% increase from the 2022 value. In 2023 ElectraNet's costs were approximately three times larger than AusNet's (the TNSP with the lowest cost per MWh of energy transported). All networks had cost per MWh increases in 2023, ranging from 4.6% to 14.1%. This is explained by industry wide increases in total user costs that outweigh the growth in energy transported. Increases in interest rates and hence cost of borrowing, are the main factors for the increases in total costs in 2023.

Figure 18 TNSP total cost per MWh of energy transported ($2023), 2006–23



Source: Economic Benchmarking RINs; AER analysis.

4.3 Potential differences between the MTFP and PPI results

In previous Annual Benchmarking Reports for transmission, we received feedback that the differences in the MTFP and PPI benchmarking results do not make sense. For example, AusNet noted that in three out of the four PPIs, it had either the lowest or second-lowest costs, but this is in contrast to the MTFP results, where at the time it ranked fourth.[61] While AusNet's MTFP performance has improved since and it ranked second in 2023, we consider it is useful to provide a conceptual explanation of these differences.

The MTFP benchmarking approach examines the efficiency in the use of total inputs to produce total outputs where the TNSPs are multiple-input users and multiple-output producers. The supporting opex or capital partial productivity measures assist in examining the productivity of opex or capital input in isolation. In contrast, the PPI analysis considers the efficiency in terms of the input costs (i.e. total cost, opex and capital cost) relative to a particular output delivered.

The MPFP and PPI analysis are partial as they examine a single input or output in isolation rather than a combination of inputs or outputs. Depending on the output considered, PPIs may favour TNSPs with certain network characteristics and thus need to be normalised for density factors. For example, we have found that PPIs measured in terms of circuit length tend to favour TNSPs with lower customer / connection density and PPIs measured on end user (or maximum demand, energy transported) tend to favour TNSPs with higher end user / demand / energy densities.

In terms of measurement, they differ in the following aspects:

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61 AusNet, *Submission to the AER's 2021 draft Annual Benchmarking Report*, 20 October 2020, pp. 1–2.

- MTFP / MPFP uses five outputs and aggregates them by output weights based on estimated cost share. It therefore accounts for the combination of the five outputs rather than a single output at a time as under the PPIs. Under the PPIs, the per-unit cost is only measured in terms of one output.
- Under the MTFP / MPFP analysis four inputs (i.e. opex, overhead lines, underground cables, transformers) where capital inputs are measured in terms of physical quantity and opex quantity is measured by deflating opex by an opex price index. In contrast, the PPI analysis considers input costs (instead of quantities) and measures the opex and AUC of capital in real dollar value. The cost measure differs from the input quantity measure, particularly in relation to capital.[62]

For the above reasons, we do not expect the MTFP / MPFP and PPI analyses to always present the same or similar results. The use of the PPI analysis as one of our benchmarking tools provides further insights into the efficiency performance of TNSPs, and qualitatively enables us to cross-check and confirm results taking into account these potential differences.

62 We consider that opex input prices and opportunity costs of capital can be expected to be similar between TNSPs, if they source the inputs efficiently.

Shortened forms

Shortened form	Description
AEMC	Australian Energy Market Commission
AER	Australian Energy Regulator
ANT	AusNet (transmission)
Capex	Capital expenditure
ENT	ElectraNet
MW	Megawatt
MWh	Megawatt hour
MVA	Mega Volt Amp
NEL	National Electricity Law
NEM	National Electricity Market
NER	National Electricity Rules
Opex	Operating expenditure
PLK	Powerlink
RAB	Regulatory asset base
RIN	Regulatory Information Notice
STPIS	Service target performance incentive scheme
TNSP	Transmission network service provider
TNT	TasNetworks (Transmission)
TRG	TransGrid

Glossary

Term	Description
Capital deepening	Capital deepening refers to an increase in the capital-labour ratio or an increase in the amount of capital per worker. This can occur through an increase in capital stock or through a decrease in the number of workers.
Efficiency	A TNSPs benchmarking results relative to other TNSPs reflect that network's relative efficiency, specifically their cost efficiency. TNSPs are cost efficient when they produce services at least possible cost given their operating environments and prevailing input prices.
Inputs	Inputs are the resources TNSPs use to provide services.
MPFP	Multilateral partial factor productivity is a PIN technique that measures the relationship between total output and one input. It allows both partial productivity levels and growth rates to be compared between entities (networks) and over time.
MTFP	Multilateral total factor productivity is a PIN technique that measures the relationship between total output and total input. It allows both total productivity levels and growth rates to be compared between entities (networks) and over time. These results are used in this report to measure and compare changes in 'relative productivity' over time.
Prescribed transmission services	Prescribed transmission services are the services that are shared across the users of transmission networks. These capture the services that TNSPs must provide under legislation.
OEFs	Operating environment factors are factors beyond a TNSPs control that can affect its costs and benchmarking performance.
Opex	Operation and maintenance expenditure
Outputs	Outputs are quantitative or qualitative measures that represent the services TNSPs provide.
PIN	Productivity index number techniques determine the relationship between inputs and outputs using a mathematical index.
PPI	Partial performance indicator are simple techniques that measure the relationship between one input and one output.

Term	Description
RMD	Ratcheted maximum demand is the highest value of maximum demand for each TNSP, observed in the time period up to the year in question. It recognises capacity that has been used to satisfy demand and gives the TNSP credit for this capacity in subsequent years, even though annual maximum demand may be lower in subsequent years.
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 of a single entity (e.g. transmission industry or TNSP) to be compared over time.
VCR	Value of Customer Reliability. VCR represents a customer’s willingness to pay for the reliable supply of electricity.

A. References and further reading

This benchmarking report is informed by several sources. This includes ACCC / AER research and expert advice provided by Quantonomics, and previously by Economic Insights as set out below.

Quantonomics publications

The following publications explains in detail how Quantonomics developed and applied the economic benchmarking techniques we used:

- Quantonomics Report – Economic Benchmarking Results for the Australian Energy Regulator's 2023 TNSP Benchmarking Report, July 2024.
- Quantonomics Report – *Economic Benchmarking Results for the Australian Energy Regulator's 2023 TNSP Benchmarking Report*, October 2023 (link)
- Quantonomics Report – Economic Benchmarking Results for the Australian Energy Regulator's 2022 *TNSP Benchmarking Report*, November 2022. (link)

Economic Insights publications

The following publications explain in detail how Economic Insights, our previous consultant, developed and applied the economic benchmarking techniques we used:

- Economic Insights *Report – Economic Benchmarking Results for the Australian Energy* Regulator's *2021 TNSP Benchmarking Report*, November 2021 (link)
- Economic Insights *Report – Economic Benchmarking Results for the Australian Energy Regulator's 2020 TNSP Benchmarking Report*, 15 October 2020 (link)
- Economic Insights, AER Memo Revised 2019 TNSP EB Results, 24 August 2020 (link)
- Economic Insights *Report – Economic Benchmarking Results for the Australian Energy Regulator's 2019 TNSP Benchmarking Report*, September 2019 (link)
- Economic Insights *Report – Economic Benchmarking Results for the Australian Energy Regulator's 2018 TNSP Benchmarking Report*, November 2018 (link)
- Economic Insights *Report – Economic Benchmarking Results for the Australian Energy Regulator's 2017 TNSP* Benchmarking *Report*, November 2017 (link)
- Economic Insights, *Memorandum – TNSP MTFP Results*, November 2016 (link).
- Economic Insights*, Memorandum – TNSP MTFP Results*, 13 November 2015 (link).
- Economic Insights, *Economic Benchmarking Assessment of Operating Expenditure for NSW and Tasmanian Electricity TNSPs*, 10 November 2014 (link).
- Economic Insights, *AER Response to HoustonKemp for TransGrid determination*, 4 March 2015 (link)
- Economic Insights, Economic *Benchmarking of Electricity Network Service Providers*, 25 June 2013 (link).

AER 2017 TNSP Benchmarking Review

All documents related to the AER's 2017 TNSP Benchmarking Review can be found on line here.

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 transmission determinations

The AER uses economic benchmarking to inform its regulatory determination decisions. A full list of these decisions to date can be found on the AER's website here.

B. Benchmarking data

This appendix contains information on the output and input data used in this report.

The inputs and outputs are described in Box 1. The inputs represent the resources (such as capital and labour) a TNSP uses to provide electricity transmission services. The outputs represent the electricity services delivered (such as the line length and how much electricity they transport).

Data for each of these input and output categories is provided each year by the TNSPs in response to EB RINs. The EB RINs require all TNSPs to provide a consistent set of data which is verified by the TNSPs chief executive officer and independently audited. We separately test and validate the data. The complete data sets for all inputs and outputs from 2006 to 2023, along with the Basis of Preparation provided by each TNSP, are published on our website.[63]

Box 1: Categories of inputs and outputs used in TNSP benchmarking

Outputs

Outputs are measures that represent the services the TNSPs provide. The outputs we use to measure service provision are:

- Energy throughput (GWh)
- Ratcheted maximum demand (RMD)
- Circuit length (Circuit kms)
- End–user numbers (End User nos)
- (minus) Energy not supplied (ENS) (weight based on AER's 2023 estimates of the value of customer reliability (VCR) capped at a maximum absolute value of 2.5% of total revenue).

Inputs

TNSPs use a mix of physical assets and operational spending to deliver services.

- Capital stock (assets) include:
  - Overhead lines (quantity proxied by overhead MVAkms) (O/H lines)
  - Underground cables (quantity proxied by underground MVAkms) (U/G cables)
  - Transformers and other capital (quantity proxied by transformer MVA) (Trfs)
- Operating expenditure (expenditure TNSPs spend to operate and maintain their assets) (opex).

63 This dataset is available at www.aer.gov.au/industry/networks/performance.

Outputs

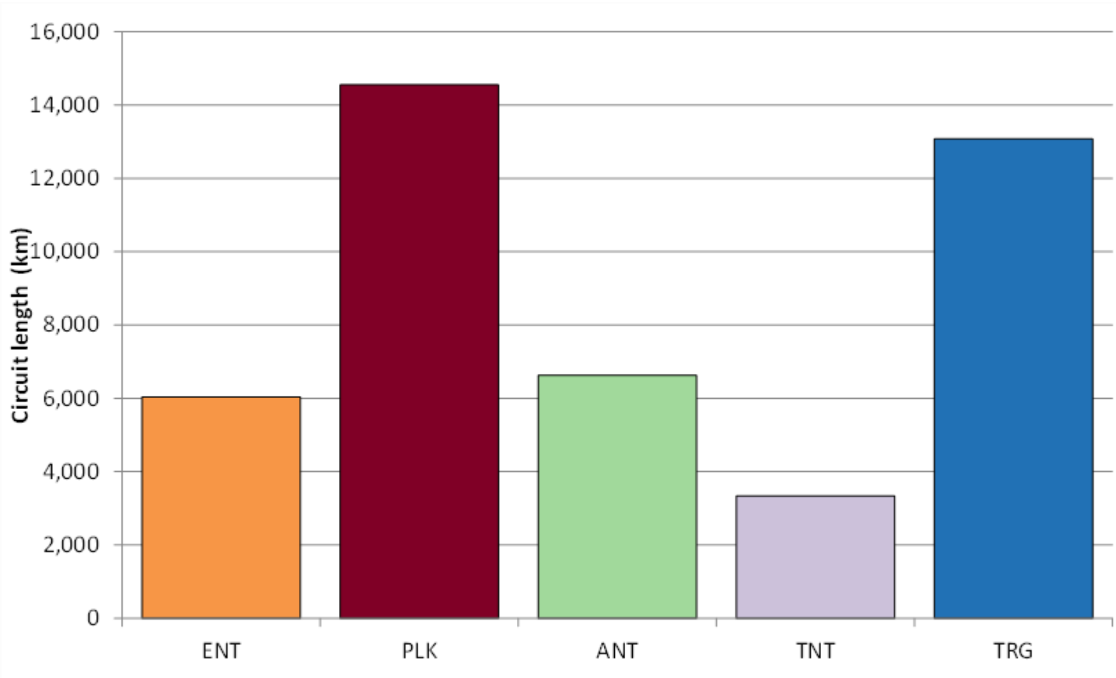
Outputs are measures that represent the services the TNSPs provide. TNSPs exist to provide customers with access to a safe and reliable supply of electricity. We explain the outputs we use in more detail in this section.

Circuit length

Circuit length reflects the distances over which TNSPs deliver electricity to downstream users from generators, which are typically over thousands of kilometres. We measure line length in terms of circuit line length. This is the length in kilometres of lines, measured as the length of each circuit span between poles and / or towers and underground. This represents the distance over which transmission networks are required to transport electricity.

We use circuit length because, in addition to measuring network size, it also approximates the line length dimension of system capacity. System capacity represents the amount of network a TNSP must install and maintain to supply DNSPs, which in turn supply consumers with the quantity of electricity demanded at the places where they are located. Figure B.1 shows each TNSP's circuit length in 2023.

Figure B.1 Circuit length by TNSP in 2023 (kilometre)

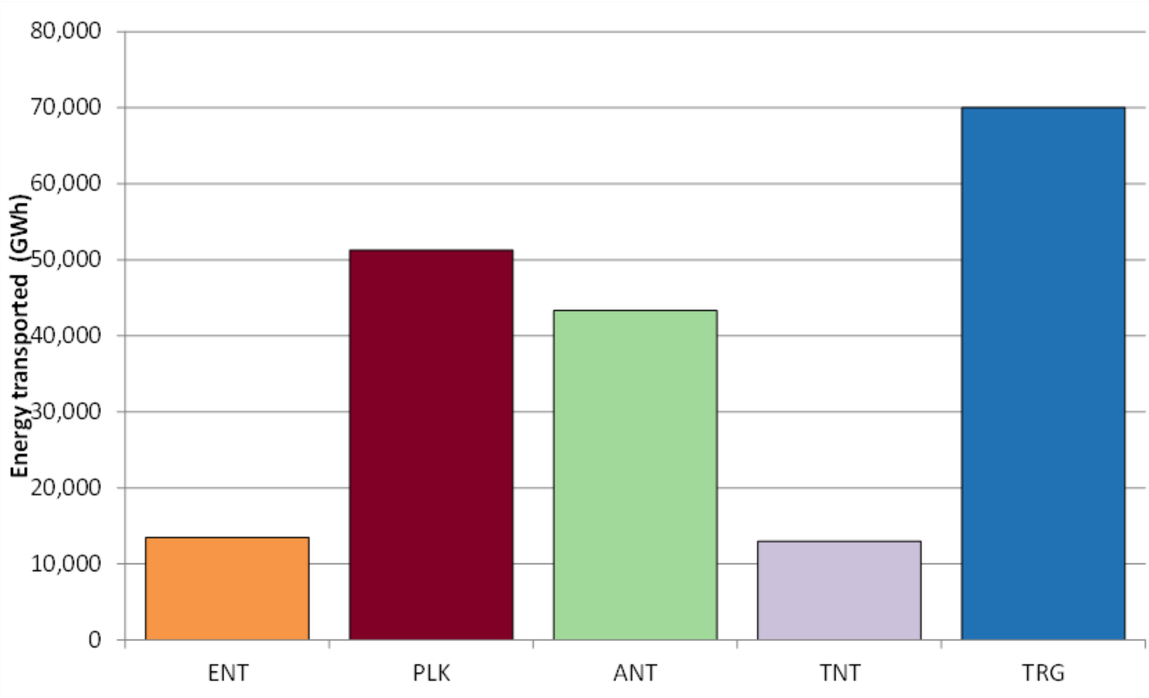


Source: Economic Benchmarking RINs

Energy transported

Energy transported is the total volume of electricity throughput that is transported over time through the transmission network, measured in gigawatt hours (GWh). We use it because energy throughput is the TNSP service directly consumed by end–customers. Therefore, it reflects a key service provided to customers. However, if there is sufficient capacity to meet current energy throughput levels, changes in throughput are unlikely to have a significant impact on a TNSP's costs. Figure B.2 shows each TNSP's energy transported in 2023.

Figure B.2 Energy transported by TNSP in 2023 (GWh)



Source: Economic Benchmarking RINs

Maximum demand

TNSPs are required to meet and manage the demand of their customers. This means 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.

The economic benchmarking techniques use 'ratcheted' maximum demand as an output rather than observed maximum demand. This is the highest value of peak demand observed in the benchmarking period up to the year in question for each TNSP.[64] It recognises capacity that has been used to satisfy demand and gives the TNSP credit for this capacity in subsequent years, even though annual maximum demand may be lower in subsequent years. Figure B.3 shows each TNSP's maximum demand in 2023.

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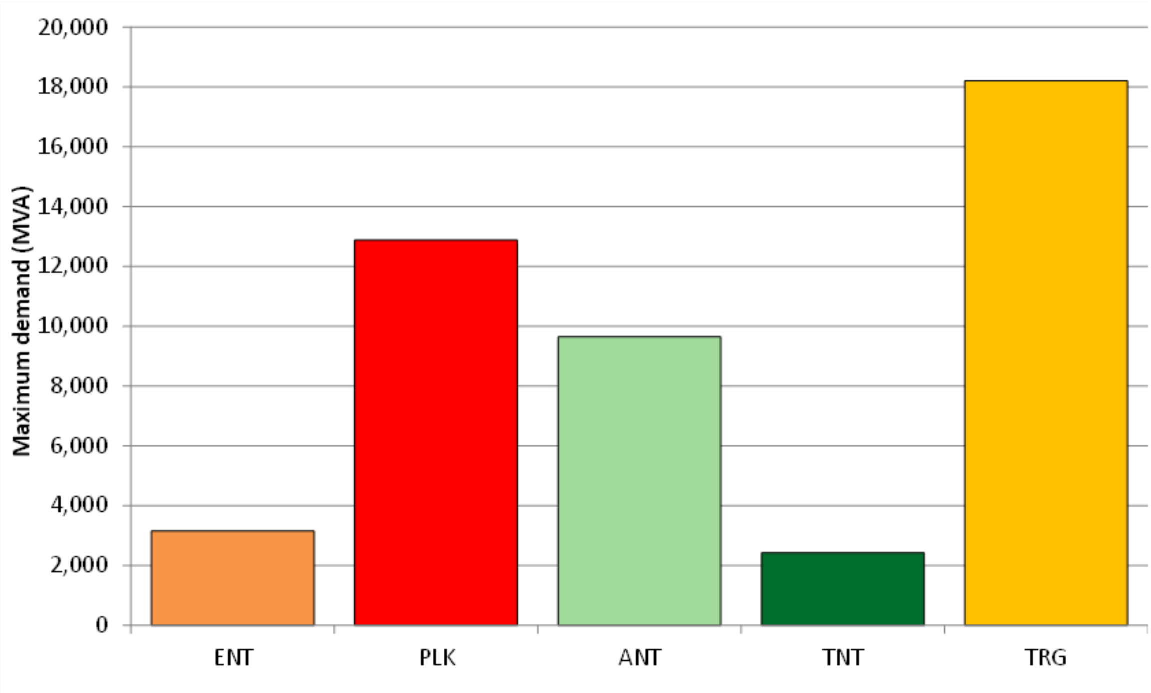
64 For example, in 2023 ElectraNet's maximum demand was 3,435MVA, while its ratcheted maximum demand occurred in 2013 and was 4,403 MVA.

Figure B.3 Maximum demand in 2023 (MVA)



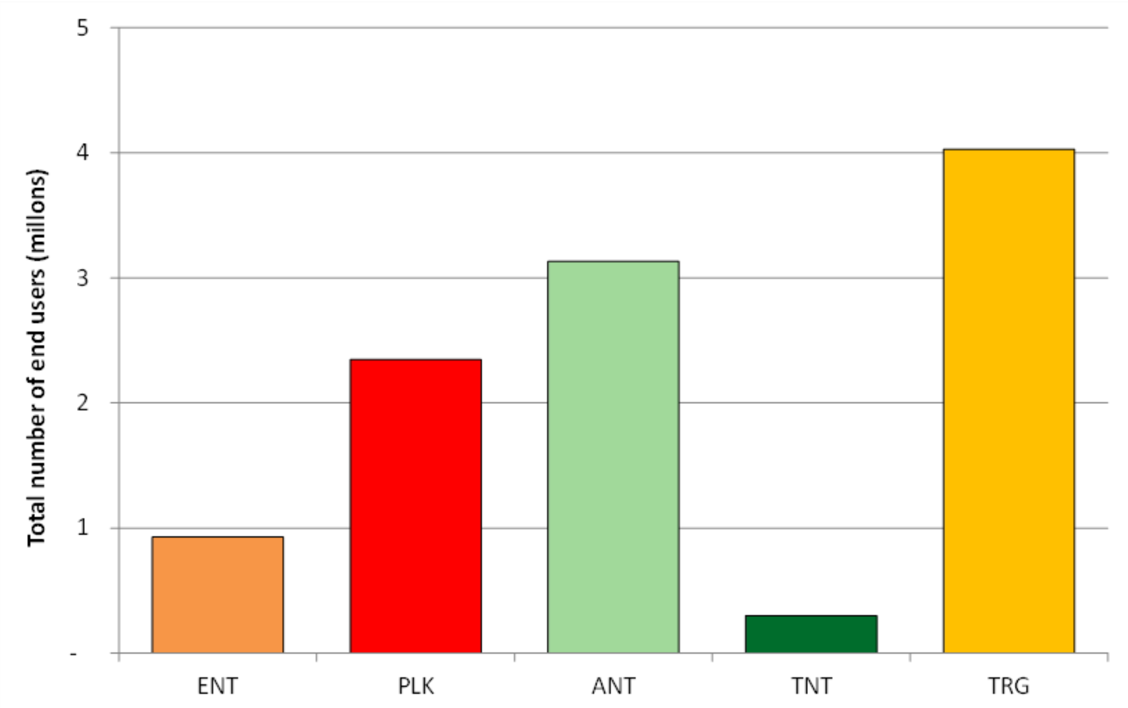
Source: Economic Benchmarking RINs.

End user numbers

The end user number output measures the number of customers for which TNSPs are required to provide a service. This is used to represent the size and complexity of the transmission network. Specifically, the greater the number of end users, the more complex the task facing the TNSP and the larger the market the TNSP serves. More complex networks will typically be more asset-intensive. Figure B.4 presents the number of end users serviced by each of the TNSPs in 2023.

As expected, the size of the network aligns with the population in each state. NSW is the largest network, with TransGrid providing services for 4.1 million end users in NSW, followed by Victoria, with AusNet servicing over 3.2 million end users. Tasmania has the smallest network, with TasNetworks servicing around 0.3 million end users in 2023.

Figure B.4 End user numbers for 2023 (millions)



Source: Economic Benchmarking RINs.

Total outputs

Table B.1 presents the average network outputs over the most recent five-year period from 2019 to 2023 for TNSPs, with the exception of reliability.

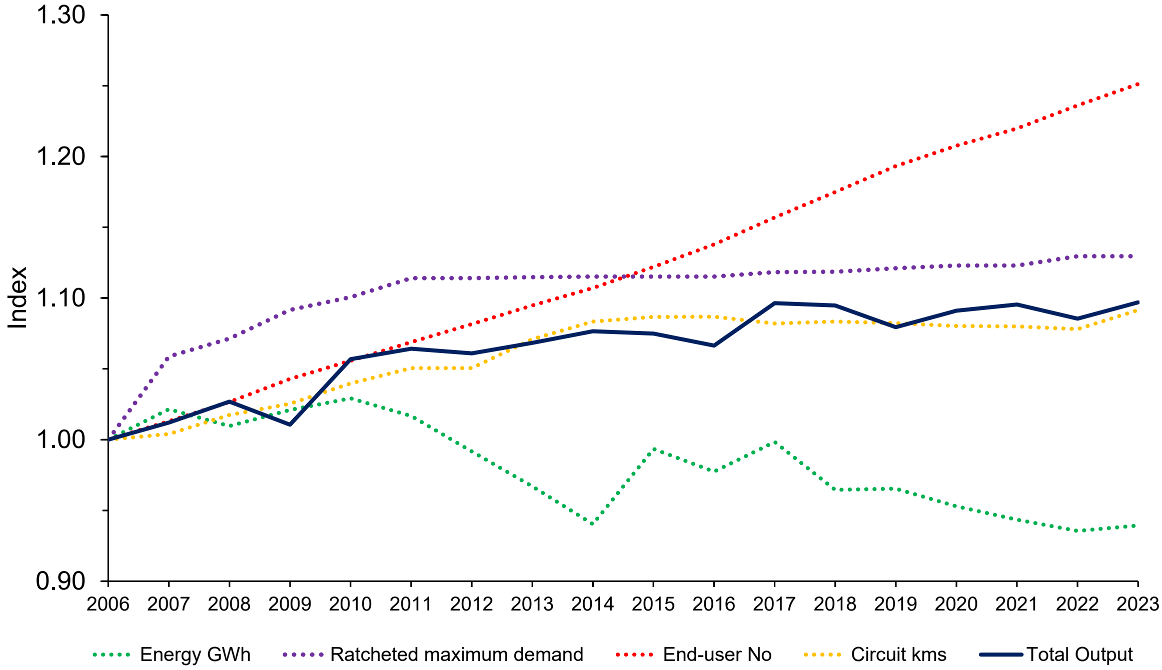
Table B.1 TNSP outputs 2019–2023 average

	Circuit line length (kilometre)	Energy transported (GWh)	Maximum demand (MVA)	Number of end users
ElectraNet	5,621	13,671	3,421	921,406
Powerlink	14,534	52,208	12,527	2,315,730
AusNet	6,670	42,528	9,635	3,093,371
TasNetworks	3,384	12,883	2,432	297,491
TransGrid	13,059	71,360	18,560	3,982,598

Source: Economic Benchmarking RINs.

Figure B.5 presents indexes of the key industry outputs over the 2006–23 period (with the exception of reliability) along with the total output index.

Figure B.5 Components of total output 2006–23



Source: Quantonomics

Inputs

The inputs used in this report are assets and opex. TNSPs 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.

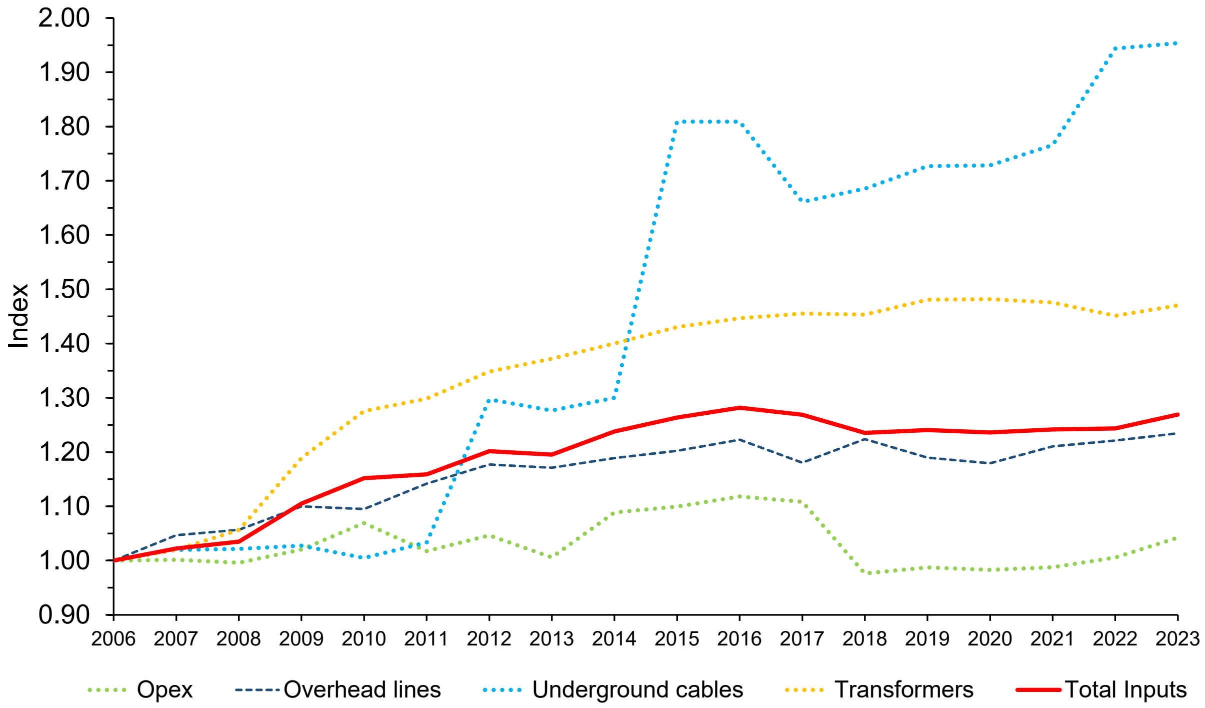
The two inputs we use in our TFP and MTFP techniques are:

- Operating expenditure (opex). This is the expenditure TNSPs spend on operating and maintaining their assets. We use the observed opex spent on prescribed transmission services. Nominal opex is deflated by an index of labour and other relevant prices to obtain a measure of the quantity of opex inputs.
- Capital stock (assets). TNSPs use physical assets to provide services and invest in them to replace, upgrade or expand their networks. We split capital into overhead lines, underground cables and transformers.
  - For our TFP and MTFP analysis we use physical measures of capital inputs. Using physical values for capital inputs has the advantage of best reflecting the physical depreciation profile of TNSP assets.[65]
  - For the PPIs we use the real value of the regulatory asset base as the proxy for assets to derive the real annual cost of using those assets.

Figure B.6 presents the change in industry input over the 2006–23 period.

65 Economic Insights, Memorandum – TNSP MTFP Results, 31 July 2014, p. 5.

Figure B.6 Factors contributing to total inputs, 2006–23



Source: Quantonomics

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

Table B.2 Average annual costs for network inputs for 2019–23 ($'000, 2023)

	Opex	Capex	RAB	Depreciation
ElectraNet	112,081	220,032	2,811,488	143,380
Powerlink	231,313	173,866	7,280,797	337,853
AusNet	92,150	183,078	3,529,118	201,287
TasNetworks	34,524	54,503	1,576,353	67,055
TransGrid	195,150	347,345	7,261,523	318,392

Source: Economic Benchmarking RINs.

C. Refinements to the AUC of capital calculation methodology

This appendix describes the refinements made to the AUC calculation methodology, and the impact of these refinements on observed AUCs of capital across each TNSP. Further technical information on the methodological refinement can be found in Appendix A.4 of Quantonomics' report.[66]

C.1 Changes in the way we calculate AUC

The AUC of capital is comprised of the return on capital plus regulatory depreciation plus the benchmark tax liability. As noted in section 1.2, the capital inputs are weighted using the AUC of capital, which reflect the costs TNSPs face for their capital inputs, i.e. asset costs. In the initial preparation of results for this year's report, we observed declining AUCs and some instances of negative AUCs across asset classes. This was found to be particularly prevalent in 2022 and 2023. Our analysis indicated these outcomes were driven by rapid changes in the inflation environment of recent years, and in particular the recent divergence between actual and expected inflation.

Until recently, actual inflation has tracked expected inflation fairly closely. However, actual inflation since 2021 has been significantly higher than expected inflation. This divergence in inflation rates leads to unduly declining AUCs. This is due to:

- Declining or negative regulatory depreciation, due to the impact of the high recent actual inflation rate applied in calculating the inflation addition component[67]
- Relatively stable return on capital, due to the rate of return component reflecting much lower expected inflation.[68]

Therefore, the return on capital component was not sufficiently offsetting the significantly reduced (and in some cases negative) regulatory depreciation component, leading to the net result of falling or negative AUCs.

A more minor but additional factor to the declining AUCs was a reduced or negative benchmark tax liability component. This reflected the low or negative regulatory deprecation arising from the high inflation addition.

Given that AUCs determine the capital input weights, this was increasing the relative input weight assigned to opex in the PIN modelling. Beyond this impact, rapidly declining AUCs would also impact our total cost PPIs presented in section 4.2 (as they would be reflected in

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66 Quantonomics, *Economic Benchmarking Results for the Australian Energy Regulator's 2024 TNSP Benchmarking Report*, 26 July 2024, p. 63.

67 The deduction of the inflation addition from straight-line depreciation in forming regulatory depreciation is required within a nominal WACC approach to reverse a double count of the impact of inflation.

68 In the nominal WACC, the observed nominal risk-free rate reflects the real risk-free rate and market-expected inflation.

decreasing total cost). We first noted the mechanism by which significant increases in the rate of inflation were impacting AUCs in last year's benchmarking report.[69]

We therefore considered that retaining the AUC methodology was not appropriate as rapid changes in inflation, rather than capital stock, would drive changes in the AUC of capital and resultant input weights used in the PIN modelling as well as the PPI outcomes.

To address this, we refined our AUC methodology by the use of the real WACC, rather than nominal WACC, to calculate the return on capital component. Under this approach, the real WACC is derived using a combination of observed nominal risk-free rates and the expected rate of inflation. With the move to a real WACC approach, there is no longer a need to remove the inflation addition component from regulatory depreciation, and hence the actual inflation rate no longer figures in the AUC calculation. The changes in the AUC of capital formulas are outlined below.

Previous approach (as used in previous benchmarking reports):

$$AUC_t = NWACC_t \cdot RAB_t^B + RegDep_t + Tax_t$$

where:

- RAB_t^B is the RAB at the beginning of period *t*
- $NWACC_t$ is the Nominal Vanilla WACC, and
- Tax_t is the benchmark tax liability, in period *t*
- $RegDep_t$is regulatory depreciation defined as:

$$RegDep_t = SLD_t - IA_t$$

    where:

  - SLD_t is straight-line depreciation and
  - IA_t is the Inflation Addition in period t.

Source: Quantonomics.

Refined approach (as used in the 2024 Annual Benchmarking Report):

$$AUC_t = RWACC_t \cdot RAB_t^B + SLD_t + Tax_t$$

where:

- RAB_t^B is the RAB at the beginning of period *t*
- $RWACC_t$ is the Real Vanilla WACC, and
- Tax_t is the benchmark tax liability, in period *t*
- SLD_t is the straight-line depreciation at time *t*

Source: Quantonomics.

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69 AER, *2023 Annual Benchmarking Report – distribution network service providers*, November 2023, p. 102.

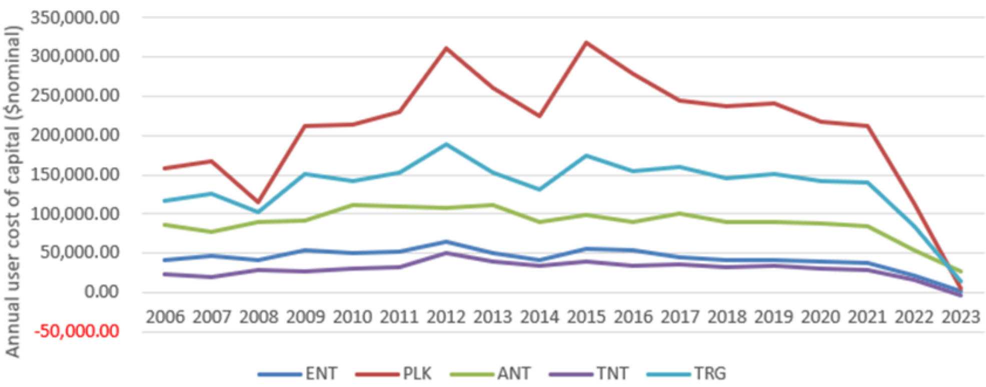
The key consideration in adopting the refined approach was to eliminate the discrepancies that arose from different rates of inflation that applied to the return on capital and return of capital components of AUC. Under the refined approach, the rate of return is derived in an ex-ante manner, consistent with the AER's broader approach to WACC. The revised approach removes the need to deduct the inflation addition component of regulatory depreciation. This circumvents the impact of any divergence between the actual and expected inflation rate. As a result of this change, a greater degree of stability of AUCs over time can be expected.

C.2 Impact of the AUC changes

The impact of the above changes to the AUC methodology is illustrated in Figure C.1 and Figure C.2 using the AUC of capital values for overhead assets as an example. Under the previous approach, shown in Figure C.1, reported AUC values for overhead assets display a sharp downward trend from 2021 to 2023, reporting near-zero or negative values. Under the revised approach, shown in Figure C.2, the AUC of capital appear to be more stable and have reported an increase in 2023, which reflect the underlying market movements.

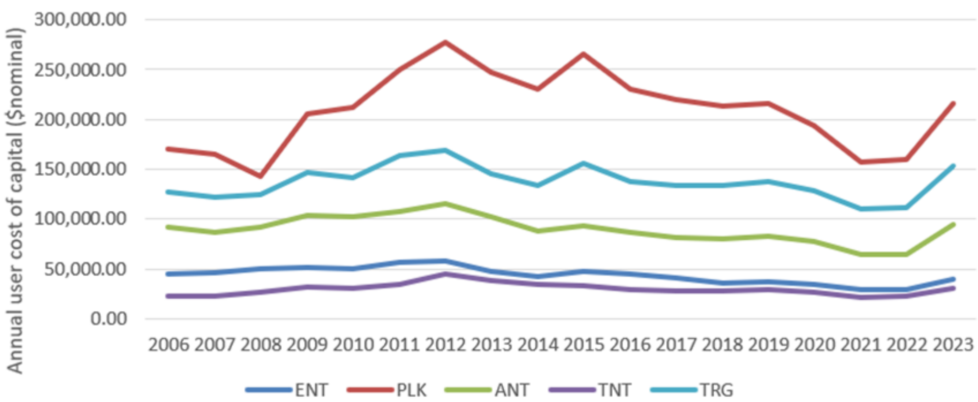
We consider the refined AUC calculation methodology is more fit-for-purpose and serves as a better measure of the cost of TNSPs' accumulated capital stock.

Figure C.1 TNSP AUCs (overhead assets) under our previous approach



Source: AER analysis.

Figure C.2 TNSP AUCs (overhead assets) under our current approach



Source: AER analysis.

D. Map of the National Electricity Market

This benchmarking report examines the productivity of the five TNSPs in the NEM. The NEM connects electricity generators and customers from Queensland through to New South Wales, the Australian Capital Territory, Victoria, South Australia and Tasmania. Figure D.1 illustrates the network areas for which the TNSPs are responsible.

Figure D.1 Electricity transmission networks within the NEM