Annual Benchmarking Report

Electricity transmission network service providers

November 2021

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). These service providers operate high voltage transmission lines which transport electricity from generators to distribution networks in urban and regional areas. Transmission network costs typically account for between 5 to 8% of what customers pay for their electricity (with the remainder covering generation costs, distribution, and retailing, as well as regulatory programs).

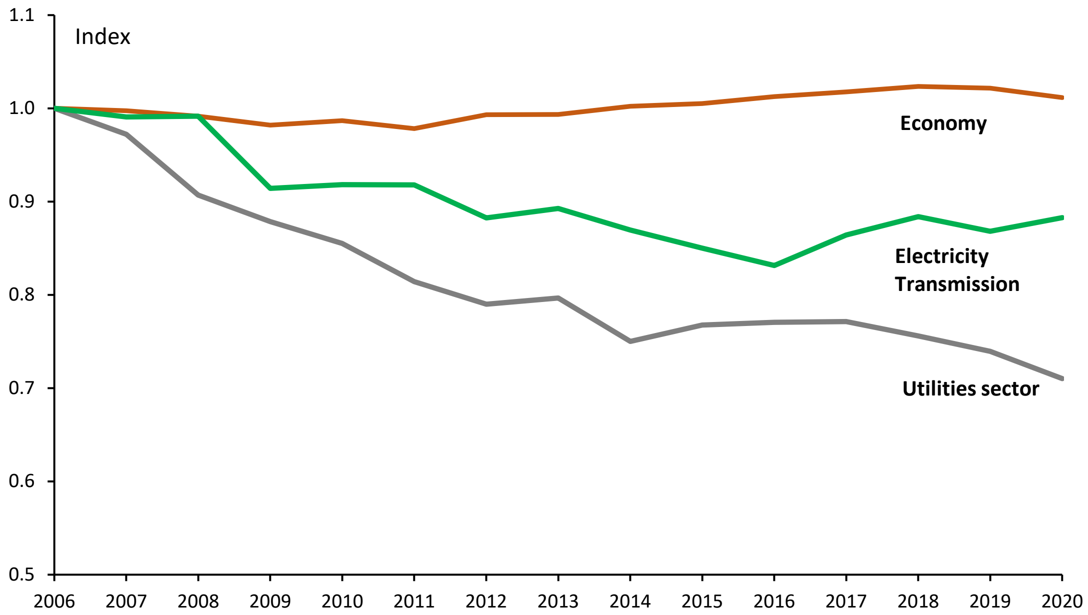
We use economic benchmarking to measure how productively efficient these networks are at delivering electricity transmission services over time and compared with their peers. Where transmission networks become more efficient, customers should benefit through downward pressure on network charges and customer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

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

Transmission network productivity has improved over 2020

Electricity transmission productivity as measured by total factor productivity (TFP) increased by 1.7% over 2020, after a decline in 2019, consistent with the trend of increased productivity since 2016. This increase is noteworthy against the backdrop of declining productivity in the overall economy and the utilities sector (electricity, gas, water and waste services) over the same period (-1.0% and -4.0%, respectively). The increase in transmission network productivity in 2020 is primarily due to improved network reliability, contributing 1.3 percentage points to the overall productivity improvement. Other key factors driving the improvement were a reduction operating expenditure (opex) contributing 0.4 percentage points and a reduction in overhead line capacity contributing 0.3 percentage points.

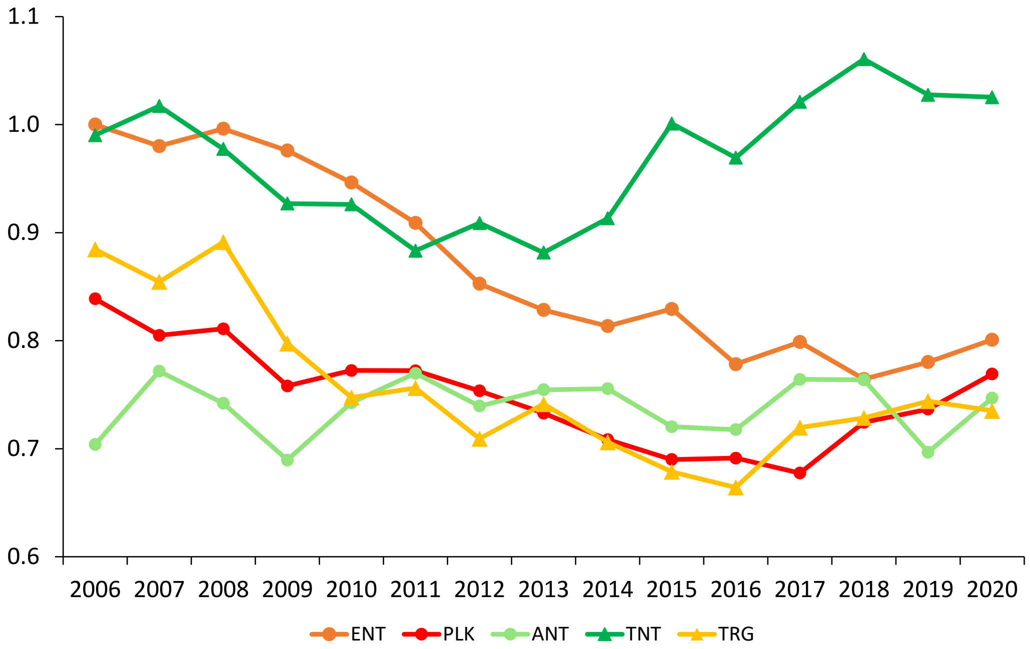
Figure 1 Electricity transmission, utility sector, and economy TFP productivity, 2006–20



Changes in TNSP productivity over 2020

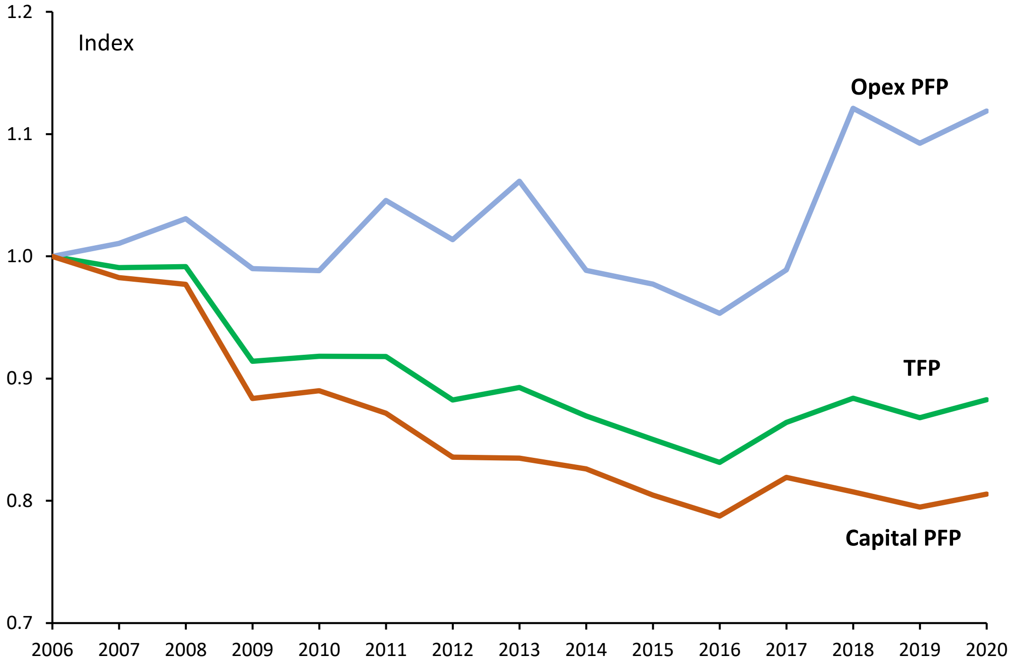
There are five transmission networks in the NEM, with one in each state. In 2020, three TNSPs (AusNet, ElectraNet and Powerlink) improved their productivity as measured by multilateral total factor productivity (MTFP). Two of these TNSPs recorded productivity improvements over the last two consecutive years (ElectraNet and Powerlink). TasNetworks experienced a very slight decrease in productivity over 2020 while TransGrid's productivity decline was more material. TasNetworks remained the highest ranked TNSP in terms of productivity measured by MTFP in 2020, but we note that our transmission benchmarking does not account for all possible differences in operating environment factors.

Figure 2 Electricity transmission MTFP indexes by TNSP, 2006–20



The productivity of transmission networks has declined at an average annual rate of 0.9% over the last 15 years. Capital partial factor productivity (PFP) declined at an average annual rate of 1.5% compared to average annual opex PFP growth of 0.8% over the same period. The improvement in transmission productivity over the past few years, particularly since 2016, can be linked to reductions in opex and stabilisation of capital inputs (that is, less growth in capital assets compared to earlier years).

Figure 3 Transmission network opex PFP and capex PFP over 2006–20



Updates in this year's report

We operate an ongoing transparent program to review and incrementally refine elements of the benchmarking methodology and data. The TFP and MTFP indexes presented in this report reflect three relatively small incremental revisions to the methodology we use to measure productivity. These relate to the methodologies used to calculate the opex price index, the reliability index and the annual user cost of capital. We are also proposing to independently review the non-reliability output weights used in the TFP / MTFP benchmarking and to examine whether the TFP / MTFP benchmarking model specification remains appropriate in the changing transmission environment, including with increasing connection of renewable generation.

Contents

1 Our benchmarking report

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

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 the productive efficiency of TNSPs. TNSPs are productively efficient when they produce their goods and services with the least possible cost inputs given their operating environments and prevailing input prices. We examine the change in productivity in 2020,[3] compared to 2019,[4] and trends in productivity over the full period of our benchmarking analysis (2006–20).

Our benchmarking report presents results from two types of 'top-down' benchmarking techniques.[5] Each technique uses a different method for relating outputs to inputs to measure and compare TNSP efficiency:

- **Productivity index numbers (PIN)**. These techniques use a mathematical index to measure the relationship between multiple outputs relative to inputs, enabling comparison of productivity levels and trends over time.
- **Partial performance indicators (PPIs)**. These simple ratio methods relate one input to one output.

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

[2] The supplementary Economic Insights 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 benchmarking website.

[3] This is the financial year 2019–20 (April-March for AusNet and July–June for all the other TNSPs).

[4] The 2018–19 financial (July–June and April–March) years (as relevant).

[5] 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.

Being top-down measures, each benchmarking technique cannot readily incorporate every possible exogenous factor that may affect a TNSP's performance. For example, as further explained in section 2.2, certain factors in a TNSP's operating environment are beyond its control and not all of these have been captured in the benchmarking models. Therefore, the performance measures are reflective of, 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 primary benchmarking techniques we use in this report to measure the productivity performance of individual TNSPs in the NEM are multilateral total factor productivity (MTFP) and multilateral partial factor productivity (MPFP). The indexes allow comparisons of absolute levels and growth rates of the measured productivity. MTFP examines the overall productivity of using all inputs in producing all outputs. MPFP examines the productivity of either operating expenditure (opex) or capital in isolation.

What is multilateral total factor productivity?

Total factor productivity 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 outputs we measure for TNSPs (and the updated 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 up to that point in the time period examined.
- Energy delivered (14.9%). Energy 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)). Reliability measures the extent to which networks are able to maintain a continuous supply of electricity. (Energy not supplied enters as a

negative output and is weighted by the value of consumer 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.[6] This output specification is used in this report, with output weights updated in 2020.[7]

Appendix A provides reference material about the development and application of our economic benchmarking techniques. Appendix B provides more information about the specific models we use and the data required.

1.1 Updates in this benchmarking report

This benchmarking report includes minor updates relating to:

- *the opex price index* – as with past studies, an opex price index is calculated from published price indexes that approximate components of electricity TNSP costs, and it is used to deflate nominal opex and derive real opex. As applied to individual TNSPs, the approach used in this report is consistent with the previously used approach, whereby the opex price index differs depending on whether the TNSP reports data in financial April-to-March or July-to-June years.[8] For the industry as a whole, this report uses a weighted average regulatory (April-to-March/July-to-June) year opex price index[9], whereas previously the financial July-to-June year opex price index was used for the industry.[10]
- *the reliability index (the value of customer reliability)* – we have recognised that the state-based value of customer reliability estimates published by the AER are the September 2019 value,[11] which are adjusted by CPI to the mid-point of each regulatory year of the TNSP.
- *annual user cost of capital (the return on and of capital) (AUC)*, which is used to determine the cost (and hence cost shares) of the physical capital asset inputs noted above – we have updated the calculation of weighted average cost of capital for 2020 to

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

[7] AER, *Transmission network service provider benchmarking report* , November 2020, pp. 3-5.

[8] AusNet reports on financial year April–March while the other TNSP report on June–July financial year.

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

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

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

reflect the AER's Rate of Return Instrument 2018.[12] In previous years (2006–2019), the annual user cost of capital calculations broadly reflect the 2013 rate of return guideline.[13]

- *transformer MVA capacity data* – we have updated transformer capacity data to account for Powerlink's correction of an error in its data.

1.2 Benchmarking development program

We operate an ongoing transparent program to review and incrementally refine elements of the benchmarking methodology and data.

The key issues that we consider require further examination and potential development, as informed by submissions we received from TNSPs and other stakeholders, are set out below. This year we have progressed our internal thinking in relation to these issues, which will enable us to progress them over the next 12 months:

- an independent review of the non-reliability output weights used in the TFP / MTFP benchmarking following the changes made in the 2020 report after the identification of an error
- examining the TFP / MTFP models specification and whether it remains appropriate in the light of the changing environment in which TNSPs operate.

In our 2020 benchmarking report we flagged our intention to independently review the non-reliability weights and examine the model specification given the changing environment in which TNSPs operate. We have made more limited progress than we would like in advancing these projects because the issues have proved more complex and resource intensive than anticipated. We will progress this work over the next 12 months.

These issues are discussed briefly below. We propose to undertake consultation on these matters with TNSPs and other stakeholders.

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

In the 2020 Annual Benchmarking Report for transmission, we made changes to the non-reliability output weights used in the TFP / MTFP benchmarking to correct an error identified in how these weights had been calculated in previous years' reports. Following this, and submissions from stakeholders, we consider it is appropriate to undertake an independent review that will:

- review whether the data used, and computation undertaken, under the current approach produces the correct non-reliability output weights

[12] AER, *Rate of return instrument*, December 2018, Table 1, column 3 (pages 13–16). We have applied the 2018 Rate of return Instrument in full, that is: Risk free rate – Yield from 10 year CGS; MRP – 6.1%; Equity beta – 0.6; Gamma – 0.585; Return on debt – Weighted average of A and BBB curves from RBA, Bloomberg and Thomson Reuters.

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

- review the current approach used to produce non-reliability output weights setting out the advantages and disadvantages of this approach
- explore whether there are any other feasible and / or improved approaches that could be used to determine the non-reliability output weights and the advantages and disadvantages of the other feasible approaches.

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

1.2.2 TFP / MTFP model specification in light of a changing transmission environment

In the 2020 Annual Benchmarking Report for transmission, we acknowledged stakeholder submissions suggesting it was appropriate to review the TFP / MTFP model specification to account for new obligations relating to TNSPs changing operating environment and outputs.[14] We indicated that we would review the relative priority of addressing it.

Some of the submissions we received during the preparation of this year's report have raised similar concerns relating to TFP / MTFP model specification issues. For example, ElectraNet stated that the current output specification does not reflect the requirements to implement special protection schemes to protect the power system from disturbances in an increasingly complex operating environment and other measures to manage the challenges of declining minimum demand levels.[15] It anticipated that the requirement to provide such services will increase with the greater uptake of variable renewable generators and energy, noting that South Australia is characterised by world-leading levels of variable renewable energy. ElectraNet also noted that the failure of the output measures to capture this increase in outputs shows the measures and benchmarking are not well aligned with the NER.

Powerlink considered it was an opportune time to examine how the TFP / MTFP benchmarking specification can better reflect the full suite of services provided by transmission networks.[16] It considered that through the energy transition, a number of essential system services such as system strength, that were previously bundled with energy, are now being separately identified, procured and paid for. These essential system services still rely on the transmission network to be effective, but their use of the network is not included in the specification of the output measure used for benchmarking.

We acknowledge that there is change occurring in the transmission environment, particularly driven by increasing connection of renewable generation. This is resulting in new transmission network investment and the need to manage how the transmission system is

[14] AER, *2020 Transmission network service provider benchmarking report*, November 2020, p. 7.

[15] ElectraNet, *Letter to AER – re: AER Draft Annual Benchmarking Results 2021*, 3 September 2021, p. 2.

[16] Powerlink, *Response to AER - Preliminary 2021 benchmarking results consultation - stage 1*, email on 7 September 2021.

operated to ensure system strength and reliability requirements are maintained. In this context we consider it is timely to consider whether the benchmarking model specification that is currently being used continues to be appropriate. This will include whether the current outputs included in the model specification are appropriate. We plan to start a consultation process in relation to this issue in 2022 with a scoping paper that seeks to set out the possible issues. Development work on this issue may be ongoing over the following year particularly in terms of advancing any implementation issues where changes are required.

1.3 Consultation

In developing this report we have undertaken consultation with external parties in two stages, consistent with the approach we adopted in 2020. This involved consultation in relation to the preliminary benchmarking results prepared by our consultant, Economic Insights, and then further consultation in relation to the AER's draft of this year's report. The following outlines the key issues raised in submissions to our draft report and our response.[17]

Caution in using MTFP results for comparative purpose

AusNet was concerned that MTFP and MPFP measures were being used to compare productivity levels of TNSPs, and not just a comparison of MTFP trends.[18] It noted that this approach was distinctly different from the caution expressed in past Economic Insights and AER reports in regard to the use of MTFP and MPFP measures.

As set out in section 2.2 of this report, we note that while comparisons of productivity levels can occur this, and the interpretation of the benchmarking results, needs to be done with caution. This is because the different demographic, topographic, economic and physical characteristics of the networks across states may affect network operation, and all of these differences have not been fully accounted for in the modelling.

Specification of TFP / MTFP models

Powerlink, ElectraNet and AusNet submitted that further development work in relation to the TFP / MTFP model specification is required to account for the changing environment in which TNSPs operate.[19] We have outlined our consideration of this matter in section 1.2.2 above.

[17] Economic Insights' final report has addressed issues raised in submissions to the preliminary benchmarking results. For more details, see: Economics Insights, *Economic Benchmarking Results for the Australian Energy Regulator's 2021 TNSP Annual Benchmarking Report*, November 2021, section 1.3, pp. 3–5.

[18] AusNet Services, *Submission to the AER's 2021 draft Annual Benchmarking Report*, 20 October 2021, pp. 2–4.

[19] AusNet Services, *Submission to the AER's 2021 draft Annual Benchmarking Report*, 20 October 2021, p. 6; Powerlink, *Submission on preliminary 2021 Benchmarking results*, email received on 7 September 2021; ElectraNet, *Submission on preliminary 2021 Benchmarking results*, 3 September 2021, pp. 2–3..

Apparent inconsistency between MTFP and PPIs results

AusNet requested a conceptual explanation to the apparent inconsistency between its MTFP and PPI results.[20] It submitted that despite being the top two performers on three of the four PPIs, AusNet and TransGrid are measured as the least two productive TNSPs in the NEM in terms of MTFP. We have addressed this matter in section 4.3 of this report.

The overall purpose of economic benchmarking as set out in the NER (6A.31) is achieved to some extent by the MTFP measures

ElectraNet submitted that the MTFP benchmarking measures achieve the overall purpose of economic benchmaking as set out in the NER, despite their shortcomings.[21] It noted that the two partial measures (opex MPFP and capital MPFP) in isolation add little value and are at risk of creating perverse incentives if seen in this light. ElectraNet added that these partial measures should be given less prominence in the AER's reporting.

We agree with ElectraNet's observation that MTFP benchmarking has been used to examine the comparative efficiency and productivity of TNSPs over time. We also agree that MPFP is more limited as it considers a single input in isolation and does not account for interactions among inputs. We have used MTFP as our primary tool for economic benchmarking of TNSPs while using MPFP and PPI as supporting tools to reveal productivity or productivity changes in some aspects. The MPFP measures are presented in the benchmarking report mainly for the purpose of gaining insight into the factors driving MTFP trends.

[20] AusNet Services, *Submission to the AER's 2021 draft Annual Benchmarking Report,* 20 October 2021, pp. 2–4.

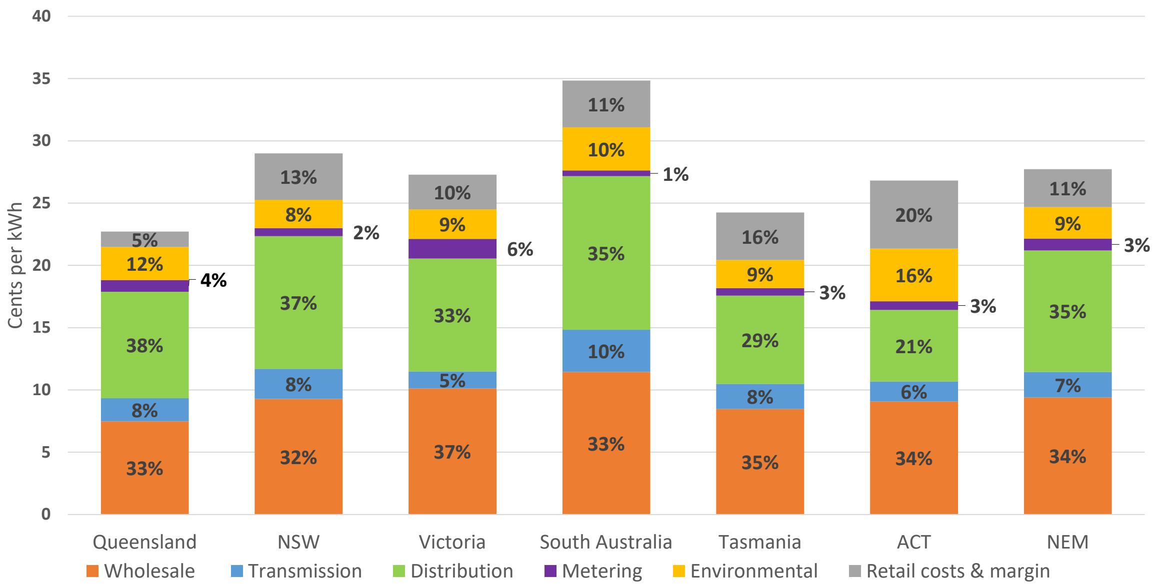
[21] ElectraNet, *Submission to the AER's 2021 draft Annual Benchmarking Report*, 20 October 2021, p. 1.

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 network costs typically account for between 5 to 8% of what consumers pay for their electricity while distribution costs account for around one-third of the total bill in most jurisdictions . The remainder covers the costs of generating, and retailing electricity, as well as various regulatory programs. Figure 4 provides an overview of the typical electricity retail bill.

Figure 4 Network costs as a proportion of retail electricity bills, 2020



Source: AEMC, Residential electricity price trends 2020, Final report, December 2020.

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

Under the National Electricity Law (NEL) and the NER, the AER regulates electricity network revenues with the goal of ensuring that consumers pay no more than necessary for the safe and reliable delivery of electricity services. This is done through a periodic regulatory process (known as revenue determinations or resets) which typically occurs every five years. The electricity network provides the AER with a revenue proposal outlining its forecast expenditures or costs over the following five-year period.

The AER assesses and, where necessary, amends the proposal to ensure it reflects efficient costs. On this basis, the AER then sets the network's revenue allowance for the five-year period, which is the maximum amount the network can recover from their retail customers through electricity bills.

In 2012, the Australian Energy Market Commission (AEMC) amended the rules to strengthen the AER's power to assess and amend network expenditure proposals.[22] 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 increases in capital and opex allowances of network service providers (NSPs) that are not necessarily efficient and resulted in higher charges for consumers.[23]

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 capital expenditure (capex) and opex allowances for network TNSPs. The new rules also required the AER to publish the benchmarking results in an annual benchmarking report.[24]

2.1 The uses of economic benchmarking

The AER uses economic benchmarking in various ways when assessing and amending network revenue proposals.[25] We use it to measure the efficiency of network opex, capex and total expenditures, and changes in the efficiency of these expenditures over time. This gives us an additional source of information on the efficiency of historical network opex and capex and the appropriateness of basing forecasts on them.

We also use benchmarking to understand the drivers of trends in network efficiency over time and changes in these trends. This can help us understand why network productivity is increasing or decreasing and where best to target our expenditure reviews.[26]

The benchmarking results also provide network owners and investors with useful information on the relative efficiency of the electricity networks they own and invest in. This information, in conjunction with the financial rewards available to businesses under the regulatory framework, and 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 ultimately electricity prices. Additionally, benchmarking can provide

[22] 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.

[23] 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.

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

[25] 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 transmission networks. Though the efficiency of networks as a whole is relevant to our determinations, we also undertake further analysis when reviewing opex and capex forecasts.

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

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, allow consumers to clearly see which factors are driving network efficiency and 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 transmission networks have undertaken cost benchmarking for a number of years, top-down (whole-of-business) benchmarking of electricity transmission networks is relatively new. We are aware there have been ongoing studies on transmission. For example, European regulators, through the Council of European Economic Regulators (CEER) have periodically conducted benchmarking studies of electricity and gas transmission system operators in Europe since 2005.[27] There has been greater use of TNSP benchmarking by economic regulators since 2014 but we consider that transmission benchmarking is still less developed than distribution benchmarking.

When undertaking economic benchmarking, it is important to recognise that TNSPs operate in different environments. Certain factors arising from a TNSP's operating environment are beyond its control. These 'operating environment factors' (OEFs) may influence a TNSP's costs and, therefore, its benchmarking performance. The benchmarking techniques presented in this report capture key OEFs. For example, the MTFP analysis accounts for a TNSP's circuit length, number of end users, ratcheted maximum demand and energy throughput. By including these outputs, 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. The small number of electricity transmission networks in Australia (five) also makes efficiency comparisons at the aggregate expenditure level difficult.

However, we consider the benchmarking analysis presented in this report is reasoned and comprehensive. We have consulted with industry participants to refine our transmission benchmarking as part of our ongoing development work program and, as outlined in section 1.2, will continue to do so.[28] We have also collected data on all major inputs and outputs for TNSPs, and we consider that the dataset used is robust.

[27] Economic Insights, *Economic Benchmarking Results for the Australian Energy Regulator's 2021 TNSP Annual Benchmarking Report*, November 2021, p. 3.

[28] In 2017, we reviewed the output specifications of our transmission benchmarking models. Among the issues we considered were the measure of customer connections and the weighting of network reliability. A more detailed description of the updated TNSP benchmarking specifications, stakeholder comments and our rationale for the changes can be found here.

3 The productivity of the electricity transmission industry as a whole

Key points

- Electricity transmission productivity as measured by TFP increased by 1.7% over 2020.
- An improvement in network reliability, combined with a reduction in opex and overhead line capacity, were the main drivers of the productivity increase over 2020.
- The increase in electricity transmission productivity over 2020 contrasts with declining productivity in the overall Australian economy and the utilities sector, which declined over the same period by 1.0 and 4.0%, respectively.
- Transmission industry TFP has decreased over the period 2006–20, with the long term decline in capital partial factor productivity (PFP) largely driving this result.
- An improvement in transmission productivity since 2016 can be linked to reductions in opex as reflected by improved opex PFP, stabilisation of capital inputs (that is, less growth in capital assets compared to earlier years) and capital PFP.

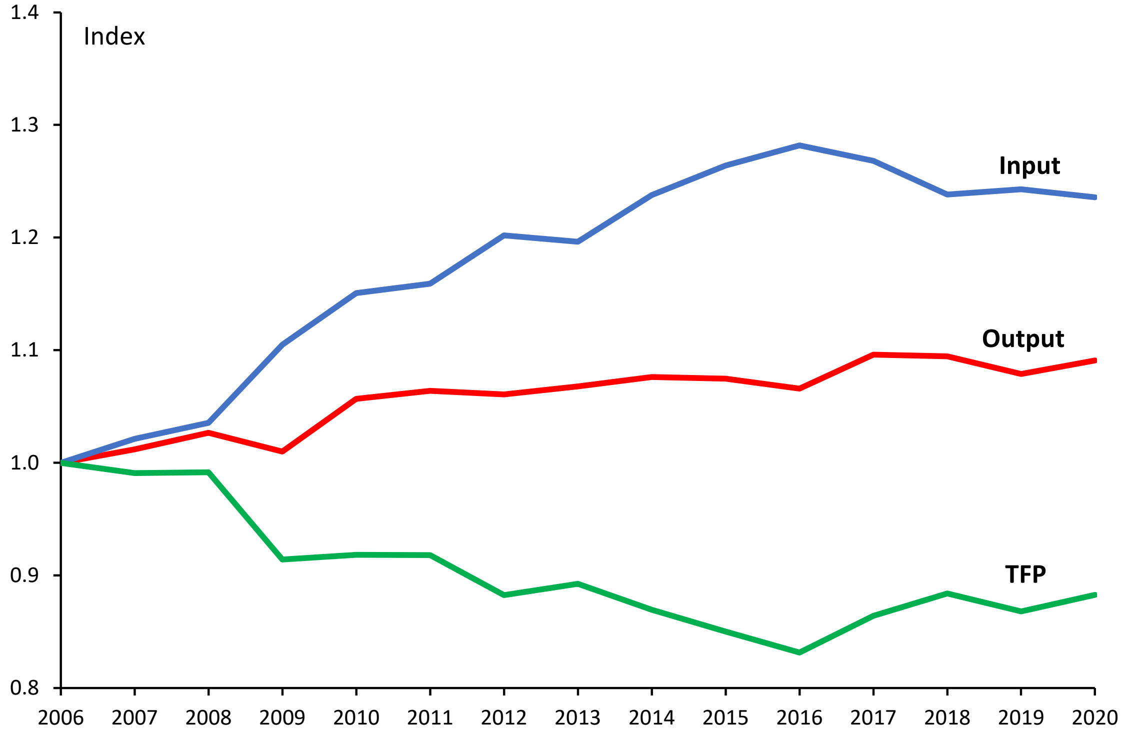
We present below TFP results for the electricity transmission industry over the 2006–20 period and for the 12-month period of regulatory year 2020. We also set out the input and output drivers, and their contribution to the industry-wide productivity change in 2020, as well as the major input and output contributions to the change in productivity at the TNSP level.

3.1 Transmission industry productivity over time

Figure 5 presents TFP for the electricity transmission industry over the period 2006–20. Over this 15 year period, input use grew faster (1.5% per year on average) than outputs (0.6% per year on average). This resulted in a decline in long-term TFP by 0.9% per annum on average.[29] There was an improvement in transmission industry productivity for two consecutive years (2017 and 2018), followed by a decline in 2019, and then a 1.7% increase in 2020 which restored electricity transmission productivity to slightly below its 2018 level.

[29] This is based on logarithmic endpoint-to-endpoint growth, using logarithmic difference method to calculate the annual average rate of growth. We have followed the Economic Insights report to report log-difference annual growth rates by periodical percentage change in productivity indexes. As for individual inputs and outputs, as well as partial performance indicators, we have referred to the percentage change calculation for both annual and periodical rate of change.

Figure 5 Transmission industry input, output and TFP indices, 2006–20



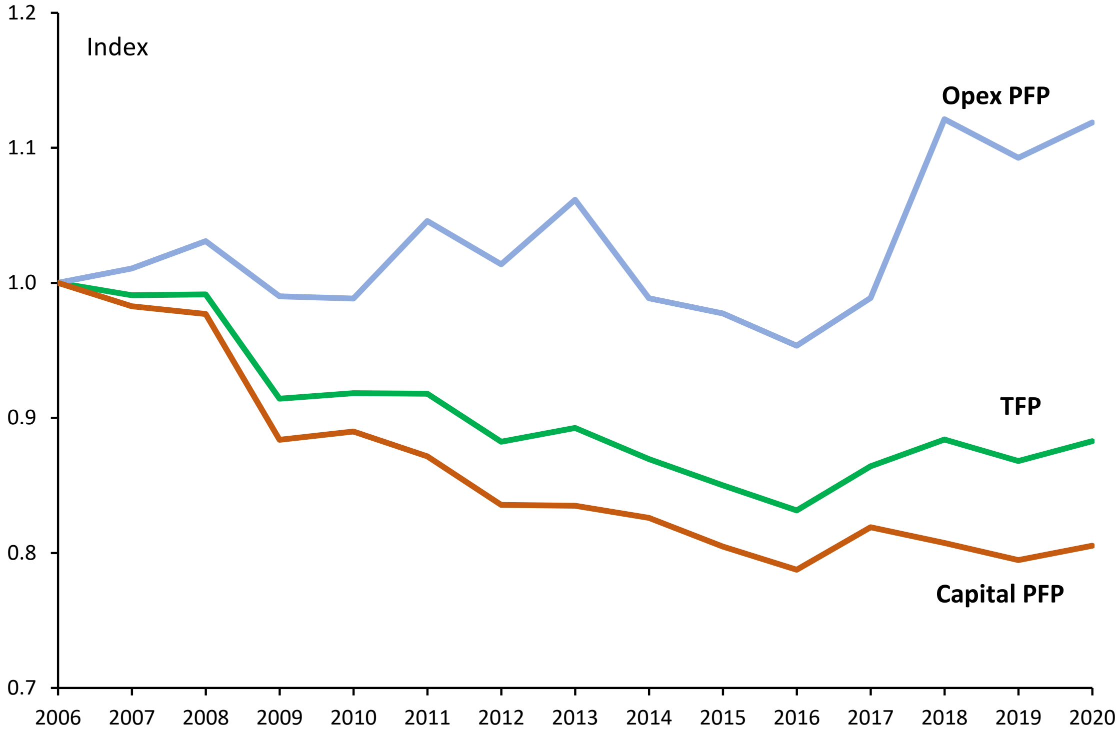
Source: Economic Insights.

Figure 6 shows that the long-term decline in capital PFP is largely driving this long-term reduction in transmission network productivity. Over the last 15 years (2006–20), capital PFP declined at average annual rate of 1.5% compared to opex PFP that grew at average annual rate of 0.8%. The improvement in transmission productivity from 2016 can be primarily linked to the increase in opex PFP, although stabilisation of capital PFP also contributed to the improvement (that is less growth in capital assets compared to earlier years). Figure 6 shows that opex PFP increased significantly over 2017 and 2018 and capital PFP fluctuated but increased in 2017 and 2020. In 2020, opex PFP grew by 2.4% and capital PFP by 1.3% to contribute to the 1.7% growth in TFP.

Figure 7 compares the TFP of the electricity transmission industry over time relative to estimates of the overall Australian economy and utilities sector[30] productivity. Over the past 15 years, declining productivity in the electricity transmission industry was broadly consistent with the utilities sector, although the average annual rate of decline of -0.9% was not as low as in the utilities sector which experienced average annual growth of -2.4%. In contrast, the Australian market economy's productivity grew slightly over the 2006–20 period with an average annual growth of 0.1%.

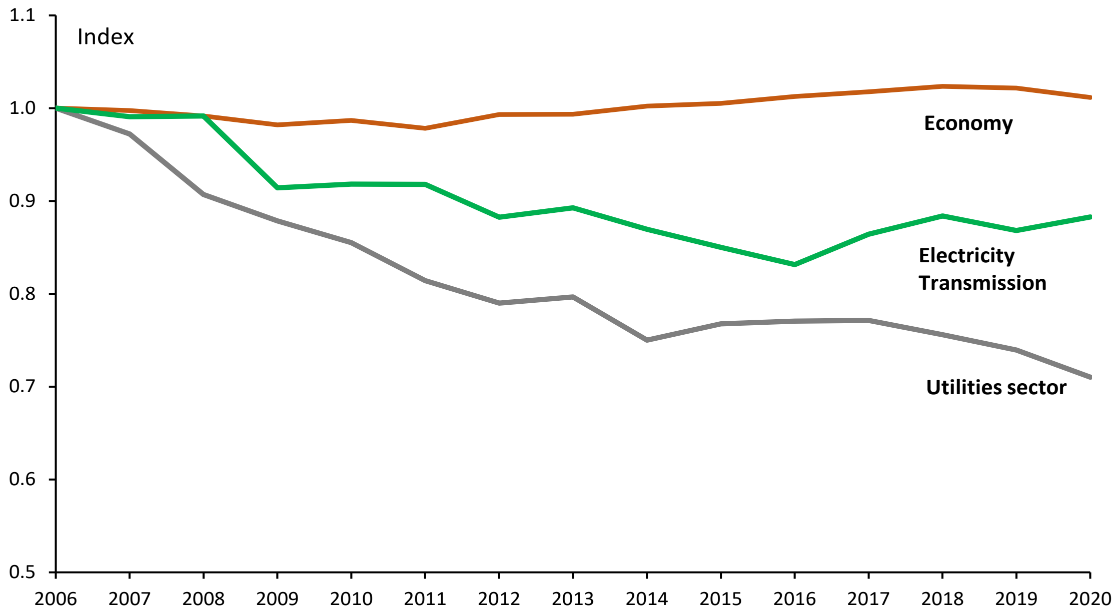
30 Electricity, gas, water and waste services (EGWWS).

Figure 6 Transmission industry opex PFP and capex PFP, 2006–20



Source: Economic Insights.

Figure 7 Electricity transmission industry, utilities sector, and economy productivity indexes, 2006–20



Source: Economic Insights; Australian Bureau of Statistics

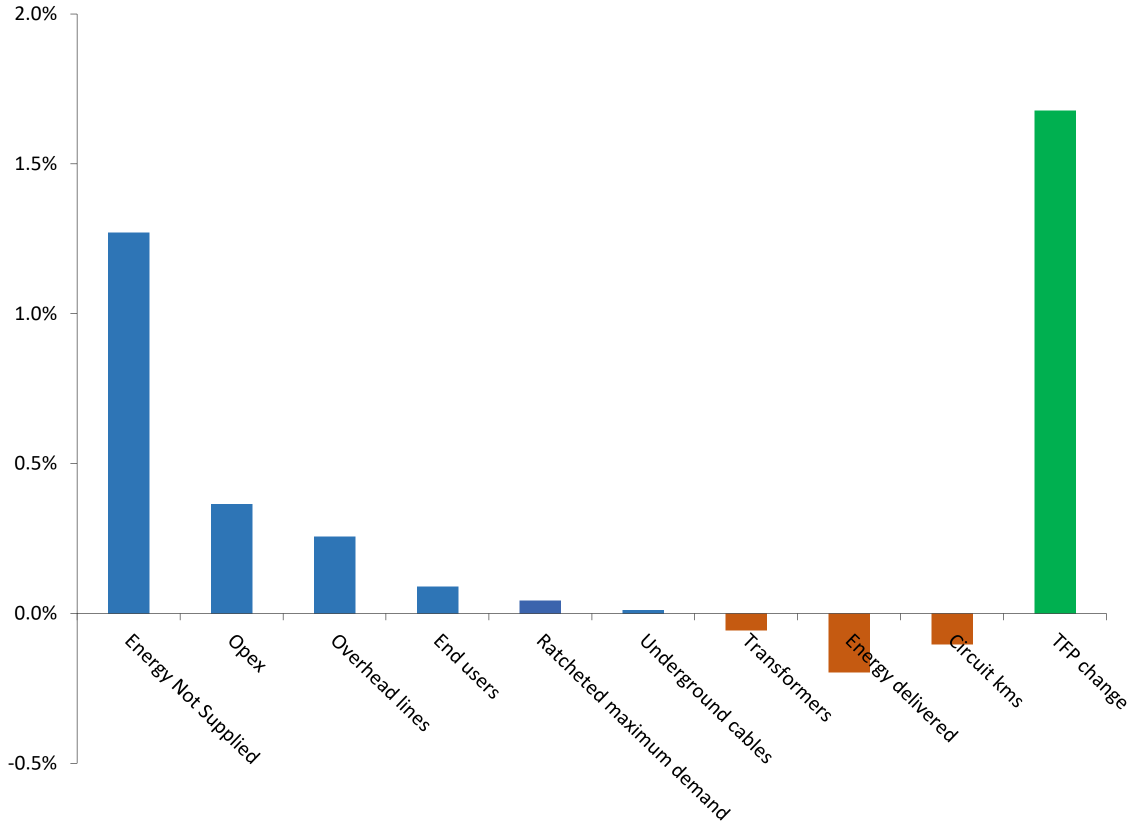
Note: The productivity of the Australian market economy and the utility industry is from the ABS indices within 5260.0.55.002 Estimates of Industry Multifactor Productivity, Australia, Table 1: Gross value added based multifactor productivity indexes (a). We have rebased the ABS indices to one in 2006.

3.2 Transmission industry productivity over 2020

Transmission industry productivity measured by TFP increased by 1.7% over 2020.

Figure 8 shows the drivers of change in electricity transmission productivity over 2020 by showing the contributions of each output and each input to the change in TFP. The contributions appear 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 8 are added together, they sum to the TFP change given by the green bar on the right of the figure.

Figure 8 Transmission industry output and input percentage point contributions to average annual TFP change, 2020



Source: Economic Insights.

Figure 8 shows that the primary driver of increased productivity for the transmission industry in 2020 was improved network reliability (i.e. lower energy not supplied). This in isolation contributed a 1.3 percentage point increase to the growth rate of TFP. Energy not supplied enters the total output index as a negative output such that a reduction in energy not supplied represents an improvement in reliability and a higher level of service for end users. Conversely, an increase in energy not supplied reduces total output as end users are inconvenienced more by not having supply over a wider area and/or for a longer period. In 2020, reliability improved as there was a reduction in energy not supplied. The drivers of this change in reliability at a TNSP level are discussed below and largely reflect the improved reliability performance of two TNSPs, AusNet and ElectraNet.

In addition to improved network reliability, a reduction in opex and overhead lines capacity also drove the transmission productivity increase in 2020, contributing 0.4 and 0.3 percentage points, respectively. Their impact was partially offset by reductions in energy delivered and a decrease in circuit length, which contributed -0.2 and -0.1 percentage points respectively, to transmission industry productivity change.

3.2.1 Individual TNSP contributions to productivity growth over 2020

Table 1 presents a decomposition of each TNSP's TFP growth over 2020, which collectively drove industry input and output changes. We have focused on energy not supplied, opex, overhead lines, energy throughput, and circuit length contributions given their materiality in driving TFP growth over 2020.

Table 1 Selected input and output contributions to TFP growth rates by TNSP, 2020

	Annual change in TFP (%)	Energy not supplied (ppts)	Opex (ppts)	Overhead lines (ppts)	Throughput (ppts)	Circuit length (ppts)
Transmission industry	1.7	1.3	0.4	0.3	-0.2	-0.1
AusNet	6.9	4.0	2.5	-0.3	0.0	0.8
ElectraNet	2.6	3.2	-1.6	0.4	0.1	0.1
Powerlink	0.6	-0.7	0.2	1.1	-0.2	0.0
TasNetworks	-0.1	-0.3	4.0	-0.2	-0.6	-3.0
TransGrid	-1.6	-0.9	-0.5	0.0	-0.3	0.0

Source: Economic Insights

The productivity of three TNSPs as measured by TFP growth improved over 2020 (AusNet, ElectraNet and Powerlink) while that of two TNSPs (TasNetworks and TransGrid) declined.

The productivity of AusNet, ElectraNet, and Powerlink grew over 2020 by 6.9%, 2.6% and 0.6%, respectively. AusNet reported a significant improvement in reliability with energy not supplied decreasing in 2020 by 87% relative to its level in 2019. It did not have a significant single outage event in 2020 as occurred in 2019. As a result, energy not served made the largest positive contribution to AusNet's TFP change at 4.0 percentage points. This was followed by a reduction in opex and a reduction in circuit length that contributed 2.5 percentage points and 0.8 percentage points, respectively. AusNet reported a reduction in nominal opex of 8% over 2020,[31] driven by a range of factors, including saving and efficiencies in maintenance, not increasing self-insurance provisions and other cost reductions. AusNet also reported a reduction in underground cables.[32]

Improved reliability (reduced energy not supplied) also made the largest positive contribution of 3.2 percentage points to ElectraNet's TFP change in 2020. This was driven by a relatively milder weather in 2020, with less storm and lightning events especially around the months of

[31] AusNet's real opex as used in the benchmarking decreased by 11.0% in 2020.

[32] AusNet, *Email to the AER – Additional question - AER 2021 annual benchmarking report - follow up questions,* 7 May 2021.

November and December. As a result, the number of connection point (end users) supply interruptions were comparatively less.[33] The positive contribution of improved reliability was partly offset by an increase in opex, which had a negative contribution, -1.6 percentage points. ElectraNet reported a 7% increase in nominal opex over 2020,[34] driven by a range of factors, including the timing of a multi-year regional maintenance cycle and the tightening of the insurance market.[35]

Improved overhead line (capacity) utilisation was the primary driver of Powerlink's productivity growth over 2020.[36] It contributed 1.1 percentage points in isolation, but this was partly offset by reduced reliability (an increase in energy not served) that contributed -0.7 percentage points. Powerlink reported perfect reliability over 2019 but energy not supplied increased to 4.58 MWh in 2020.[37] Powerlink also reported a reduction in the rating of some overhead circuit for compliance purpose after identifying a number of spans on several 275kV circuits where mandatory minimum ground clearances were not met at the rated circuit capacity.[38]

TasNetwork's productivity declined very slightly by 0.1% over 2020. A reduction in opex had the largest positive contribution (4.0 percentage points) to its productivity over 2020. But this was entirely offset by the combined negative contribution due to lower circuit length (-3.0 percentage points), lower energy throughput (-0.6 percentage points), reduced reliability (-0.3 percentage points) and an increase in the capacity of overhead lines (-0.2 percentage points). TasNetworks reported that COVID 19 impacted some maintenance activities in 2020, leading to a reduction in opex.[39] It also reported that the reduction in circuit length was driven by the removal from service of the Waddamana to Bridgewater 110kV overhead transmission line.[40]

TransGrid's productivity declined over 2020 by 1.6%. The increase in energy not supplied, or reduced reliability, was the largest negative contribution (-0.9 percentage points) to the TransGrid's productivity decline, followed by the effect of increased opex that contributed -0.5 percentage points. TransGrid reported a single reliability incident had driven its worsening reliability, where rodent interference on a protection relay at one section of the

[33] ElectraNet, *Email to the AER – AER 2021 annual benchmarking report - follow up questions on ElectraNet's 2019-20 EB RIN data,* 30 April 2021.

[34] ElectraNet's real opex as used in the benchmarking increased by 4.6% in 2020.

[35] ElectraNet, *Email to the AER – AER 2021 annual benchmarking report - follow up questions on ElectraNet's 2019-20 EB RIN data,* 30 April 2021.

[36] The capacity of overhead lines, one of the inputs, has decreased, which results in improved utilisation.

[37] AER, *Annual Benchmarking Report Electricity transmission network service providers*, November 2020, p. 18; Powerlink, *Email to the AER – Powerlink's response to the AER's Questions of 9 April 2021*, received on 22 June 2021.

[38] Powerlink, *Email to the AER – Powerlink's response to the AER's Questions of 9 April 2021*, received on 22 June 2021.

[39] TasNetworks, *Email to AER - AER 2021 annual benchmarking report - follow up questions on TasNetworks' 2019-20 EB RIN data*, received on 30 May 2021.

[40] TasNetworks, *Email to AER - AER 2021 annual benchmarking report - follow up questions on TasNetworks' 2019-20 EB RIN data*, received on 30 May 2021.

network resulted in an incorrect protection operation causing a loss of supply to a couple of sections of the network.[41]

Four TNSPs (AusNet, ElectraNet, Powerlink and TasNetworks) achieved productivity change over 2020 at a rate that is greater than the average annual over the 2006-20 period (-0.9%). The full set of input and output contributions to TFP over the 2006–20 and 2019–20 periods can be found in the Economics Insights' report.[42]

[41] TransGrid, *Email to the AER – Additional question - AER 2021 annual benchmarking report - follow up questions on TransGrid's 2019-20 EB RIN data,* 22 June 2021.

[42] Economic Insights, *Economic Benchmarking Results for the Australian Energy Regulator's 2021 TNSP Annual Benchmarking Report,* November 2021, pp. 7–17.

4 Relative efficiency of individual transmission networks

Key points

- TasNetworks continued to be the highest ranking TNSP as measured by MTFP over 2020 despite a decline in productivity over the last two years. TasNetworks has remained the top ranked TNSP since 2012, but we note that our transmission benchmarking does not account for all possible differences in operating environment factors.
- Three TNSPs (AusNet, ElectraNet and Powerlink) improved their productivity over 2020. In particular, AusNet's productivity increased significantly over 2020, following a decline over 2019.
- While TransGrid's productivity decreased slightly over 2020, it is significantly higher than its 2016 level.
- The productivity of ElectraNet, Powerlink and TransGrid has deteriorated over the 2006–20 period.

Below we present the economic benchmarking results that we use to measure and compare productivity of individual TNSPs over the period 2006–20 and for the 2020 regulatory year. We also provide our key observations on the reasons for changes in 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 efficiency relative to other networks. MTFP is the headline technique we use to measure and compare the relative productivity of individual TNSPs. This is supported by the corresponding partial productivity measures of opex and capital inputs.
- 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 chapter, particularly the MTFP results, are only indicative of the TNSPs' relative performance. While the analysis accounts for some factors that are beyond a TNSP's control, such as network density and some system structure factors, additional operating environment factors can affect a TNSP's costs and benchmarking performance. At this stage, as noted in section 2.2, our transmission benchmarking analysis does not incorporate additional operating environment factors beyond the network density differences, which are incorporated via the output specification.

4.1 MTFP productivity results for TNSPs

Figure 9 presents the relative productivity levels of TNSPs as measured by MTFP over the 2006–20 period.[43] It shows a general clustering of four TNSPs below TasNetworks, who has been the outlier since around 2013 and 2014.

Figure 9 also shows that three TNSPs recorded increases in productivity in 2020 (AusNet, ElectraNet, and Powerlink). TransGrid recorded the highest decline in productivity over the same period (-1.2%), primarily driven by deteriorating reliability due a single incident as noted in section 3.2. TasNetworks also experienced a slight decline in productivity over 2020 (-0.2%) but was still the highest ranking TNSP as measured by MTFP (see Table 1). Figure 9 also shows a clustering of four TNSPs at the bottom half of the chart, with different results to TasNetworks. In that regard we note that our transmission benchmarking does not account for all possible differences in operating environment factors.

TasNetworks' productivity over 2020 is higher than at the start of the period in 2006, despite it declining since 2018. TasNetworks' productivity declined from 2006 to 2013 before trending up from 2014. The positive trend from 2015 likely reflects efficiencies resulting from the merger of Tasmanian distribution and transmission networks.[44] TasNetworks has remained the most productive TNSP since 2012. It is followed by ElectraNet and in a reasonably tight cluster, the other TNSPs.

The productivity of ElectraNet, TransGrid and Powerlink as measured by MTFP has generally fallen over the 15-year period examined in Figure 9 and is lower in 2020 than it was in 2006. This is despite the productivity increases these three businesses achieved in recent years.

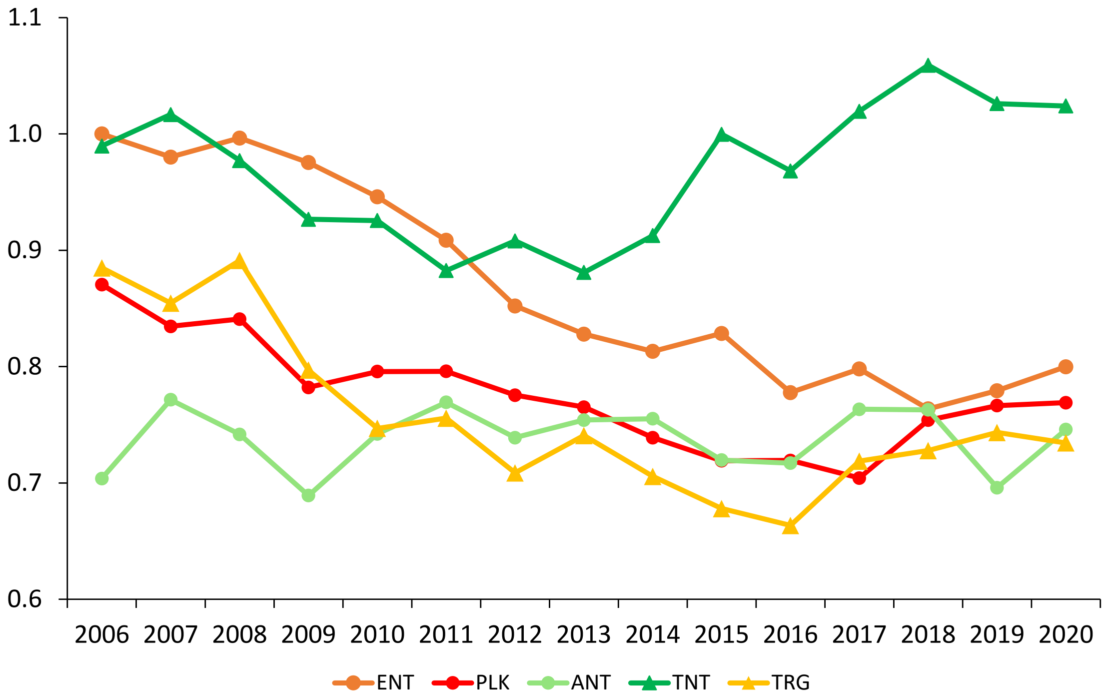
TransGrid's productivity improved over the period 2017 to 2019, before declining slightly in 2020, while Powerlink's productivity has improved over the last three consecutive years (2018, 2019 and 2020). ElectraNet's productivity has improved over the last two years (2019 and 2020).

AusNet's productivity as measured by MTFP is 6.0% higher in 2020 than it was in 2006. Its MTFP performance improved in 2020 following a significant decline in 2019 (which as noted in section 3.2 above was due to a single network outage event). Over the period 2012 to 2018 AusNet's productivity was relatively stable and slightly increased.

[43] 2006 is set as the base (i.e. index = 1.00).

[44] TasNetworks was formed on 1 July 2014 from a merger between Aurora and Transend.

Figure 9 Electricity transmission MTFP indexes by TNSP, 2006–20



Source: Economic Insights.

Table 2 presents the MTFP rankings for individual TNSPs in 2020, the change in rankings between 2019 and 2020, and the annual growth in productivity (as reflected by the change in their MTFP productivity scores) between 2019 and 2020.[45] It shows that TasNetworks and ElectraNet maintained their first and second rankings, Powerlink remained stable while AusNet improved by one place to be fourth and TransGrid's ranking moved to fifth.

Table 2 TNSP MTFP scores, rankings and changes, 2019 and 2020

	Rank (2020)	Rank (2019)	MTFP Score (2020)	MTFP Score (2019)	% change between 2019 and 2020
TasNetworks	1	1	1.02	1.03	-0.2%
ElectraNet	2	2	0.80	0.78	2.6%
Powerlink	3	3	0.77	0.77	0.3%
AusNet	4↑	5	0.75	0.70	6.9%
TransGrid	5↓	4	0.73	0.74	-1.2%

Source: Economic Insights.

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

[45] The rankings in this table are indicative only because, as outlined earlier, there may be other operating environment variables not captured in the MTFP model.

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

These partial productivity measures assist in interpreting the MTFP results by examining the contribution of opex and capital assets to overall productivity. They use the same output specification as MTFP but provide more detail on the contribution of the individual components of capital and opex to changes in productivity. However, they do not account for synergies between capital and opex like the MTFP model. As noted in section 1.3, these partial measures provide a way of gaining insight into the factors driving MTFP trends.

Figure 10 and Figure 11 present capital MPFP and opex MPFP results respectively for all TNSPs over the 2006–20 period.[46] AusNet achieved positive growth over 2020 in both capital MPFP and opex MPFP (4.6% and 16.1%). This is consistent with its 6.9% growth in MTFP over 2020. In contrast, while ElectraNet and Powerlink achieved a positive growth in capital MPFP (4.5% and 0.5% respectively), their opex MPFP declined over 2020 (-1.2% and -0.2% respectively). TasNetworks also achieved a mixed outcome, with a positive growth in opex MPFP (11.4%) and a decline in capital MPFP over 2020 (-4.1%). TransGrid is the only TNSP that had a negative growth in both opex MPFP and capital MPFP in the year (-3.4% and -1.1%).

Figure 10 shows that capital productivity has generally declined for since 2006 for all TNSPs (18 to 26% between 2006 and 2020) except for AusNet where it has remained broadly stable, falling only by 0.5%. However, the rate of decline has decreased over the more recent period 2012 to 2020.

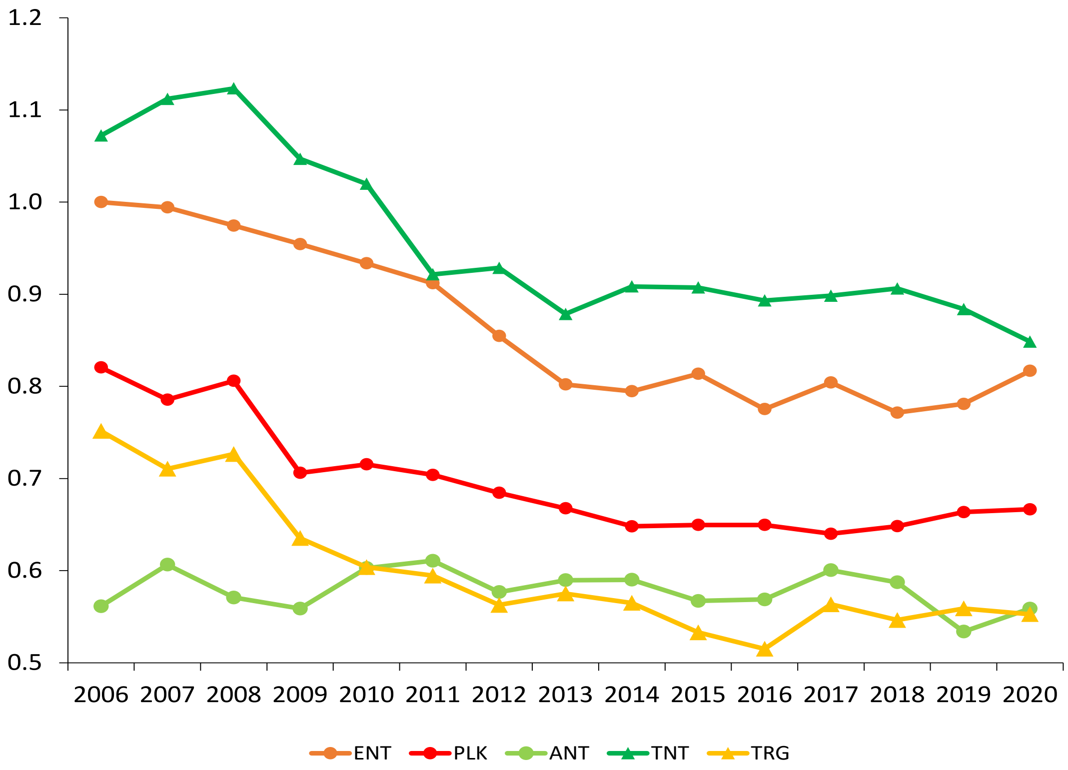
The slow and consistent decline in capital MPFP over time for those TNSPs other than AusNet is due to network capacity growing more than outputs as measured by customers, demand, line length and energy consumption. This continues to be a cause for concern.[47] TasNetworks has remained the highest ranked 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 network with voltage class at 132kV and above, but the majority of TasNetworks Transmission's network is of 110kV and 220kV.

Figure 11 shows that in terms of opex MPFP over the 15-year period to 2020 AusNet and TransGrid remained relatively higher performers and Powerlink and ElectraNet relatively lower performers. Despite recording the lowest opex MPFP at the start of the period, TasNetworks joined the higher performing TNSPs in 2015, with opex MPFP in 2020 higher than the 2006 level by 102.0%.

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

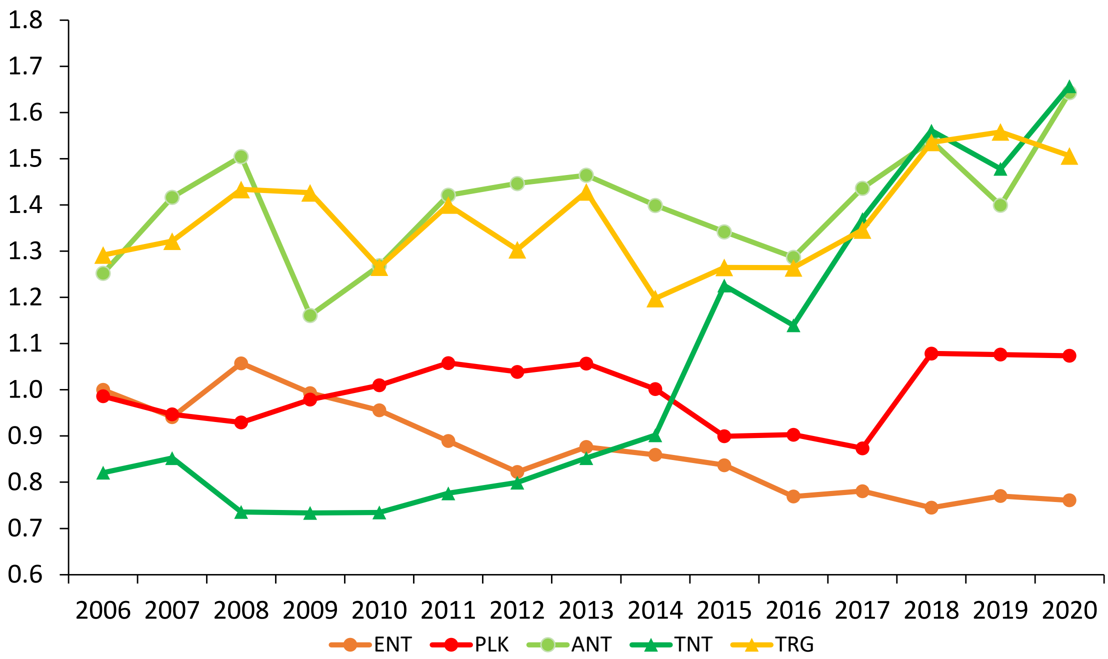
[47] However, as stated in section 2.2, the MTFP and MPFP models used in this analysis do not capture all OEFs.

Figure 10 Capital MPFP index, 2006–20



Source: Economic Insights.

Figure 11 Opex MPFP index, 2006–20



Source: Economic Insights.

4.2 Partial performance indicator results of TNSPs

PPIs provide a simple representation of the input costs used to produce particular outputs. 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 interrelationships between outputs into account. Therefore, PPIs are most useful when used in conjunction with other top-down benchmarking techniques, such as MTFP.

The inputs we use are the TNSPs' total costs, made up of opex and asset costs. Asset cost is the sum of annual depreciation and return on the TNSP's regulatory asset base, and benchmark tax liability under the building block model approach.[48] This measure has the advantage of reflecting the total cost of assets for which customers are billed on an annual basis, using the average return on capital over the period. This accounts for variations in the return on capital across TNSPs and over time.

The outputs we use are 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.

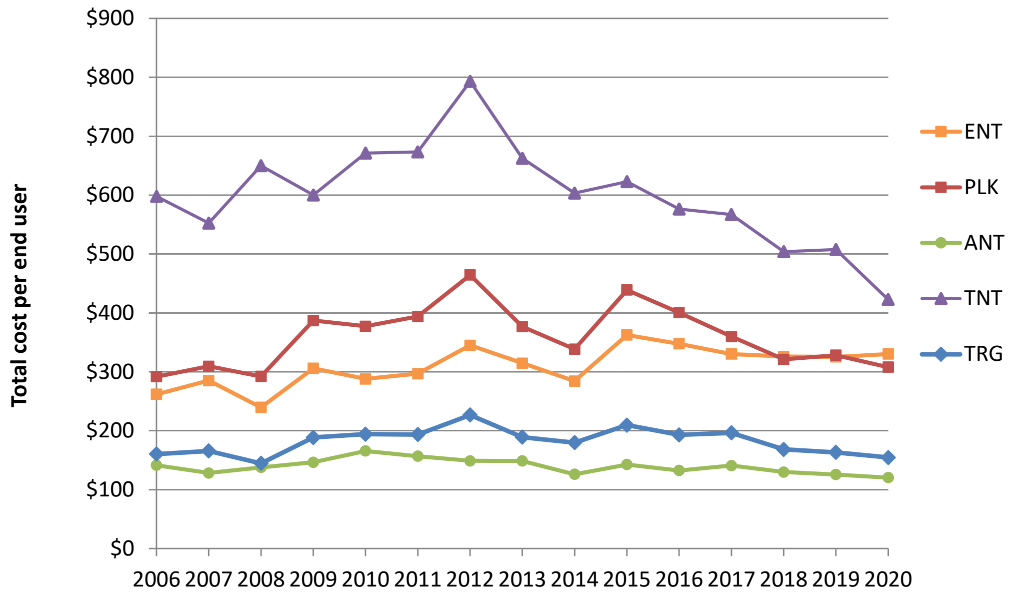
4.2.1 Total cost per end user

We present the total cost per end user in Figure 12. AusNet maintained the lowest total costs per end user in 2020. Conversely, TasNetworks continued to have the highest total costs per end user of all TNSPs, although it reduced significantly in 2020. ElectraNet is the only TNSP in 2020 that reported an increase in total cost per end user (1.5%). All the other TNSPs recorded a decline and TasNetworks had the largest decrease in 2020 (-16.7%).

Total costs per end user for AusNet, TasNetworks and TransGrid are lower in 2020 than they were in 2006 -14.8%, -29.3% and -3.6%, respectively). The opposite is true for ElectraNet and Powerlink where total costs per end user are higher in 2020 than they were in 2006 (26.1% and 5.5%, respectively). This may be due to these TNSPs' costs (mainly its asset costs reflecting the growth in TNSP's regulatory asset bases) increasing faster than the increase in end users.

[48] We have applied to the PPI calculations the same annual user cost of capital approach we applied to MTFP and MPFP analysis. As noted earlier, we have updated the calculation of the annual user cost of capital in 2020 to reflect the AER's Rate of Return Instrument 2018. In previous years the annual user cost of capital calculations broadly reflected the 2013 rate of return guideline. See: https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/rate-of-return-instrument-2018/final-decision.

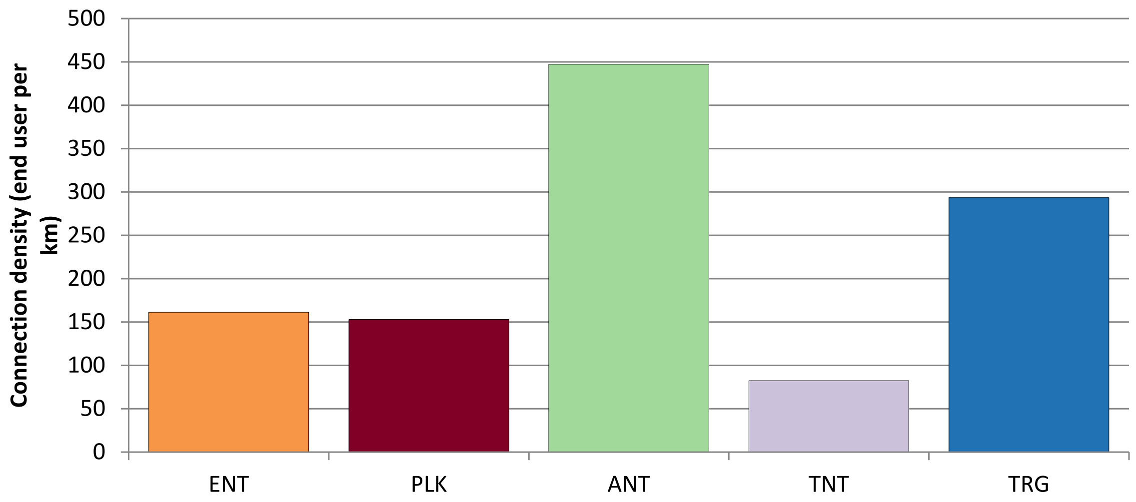
Figure 12 TNSP cost per end user



Source: Economic Benchmarking RINs; AER analysis.

We note the total cost per end user measure 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 connection point. The average connection density of TNSPs over 2016–20 is presented in Figure 13. This shows that AusNet has the highest average connection density, followed by TransGrid, ElectraNet, Powerlink and TasNetworks respectively. This is broadly consistent with the cost per end user rankings in Figure 12.

Figure 13 TNSP connection density (end user per circuit km, 2016–20 average)



Source: Economic Benchmarking RINs; AER analysis.

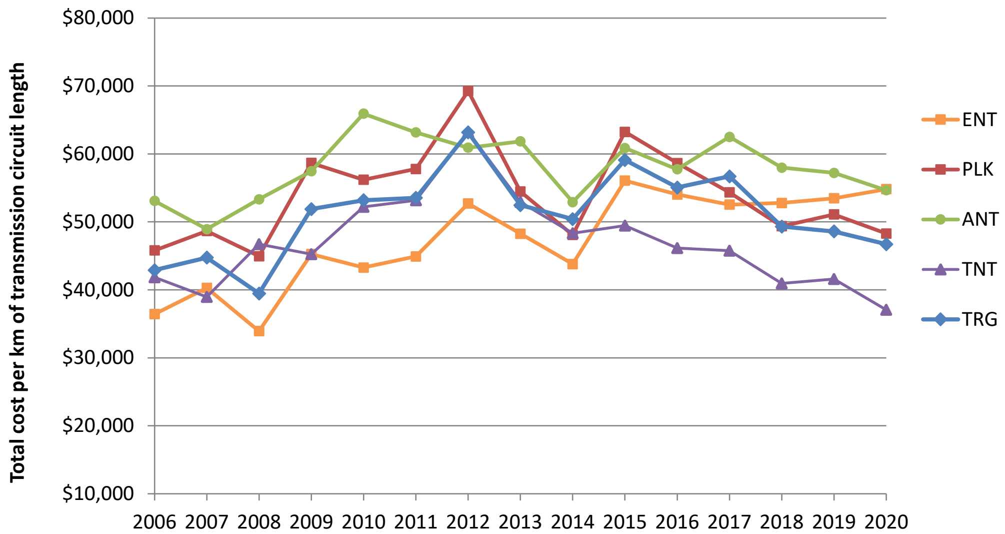
4.2.2 Total cost per km of transmission circuit length

In Figure 14 we can see that TasNetworks had the lowest cost per kilometre of circuit length in 2020, while ElectraNet had the highest cost per kilometre of circuit length (slightly above AusNet).

All TNSPs, except TasNetworks, experienced some growth in total costs per kilometre of transmission circuit length between 2006 and 2020. This is due to increases in annual user cost exceeding the growth in transmission circuit length. The largest increase in cost per kilometre of circuit length over this period was by ElectraNet (50.2%), followed by TransGrid (8.9%) and Powerlink (5.4%). TasNetworks' cost per kilometre of circuit length in 2020 was 11.4% lower than its 2006 level.

In recent years, the difference in cost per km of transmission circuit length between the highest and lowest ranking TNSPs has widened. The gap in total cost per kilometre of transmission circuit length between TNSPs has increased since 2014 as a result of a sharp decline in costs by TasNetworks. For the other TNSPs, there was a step up in 2015 followed by a steady decline, such that in 2020 Powerlink and TransGrid's total cost per kilometre of transmission circuit length is at or below its 2014 level. In 2020, the difference between ElectraNet (highest cost per km of transmission circuit length) and TasNetworks (lowest cost per km of transmission circuit length) was $17 631 ($2020) whereas in 2014 the difference between AusNet (highest cost per km of transmission circuit length) and ElectraNet (lowest cost per km of transmission circuit length) was $9 103 ($2020).

Figure 14 TNSP total cost per km of transmission circuit length ($2020), 2006–20



Source: Economic Benchmarking RINs; AER analysis.

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

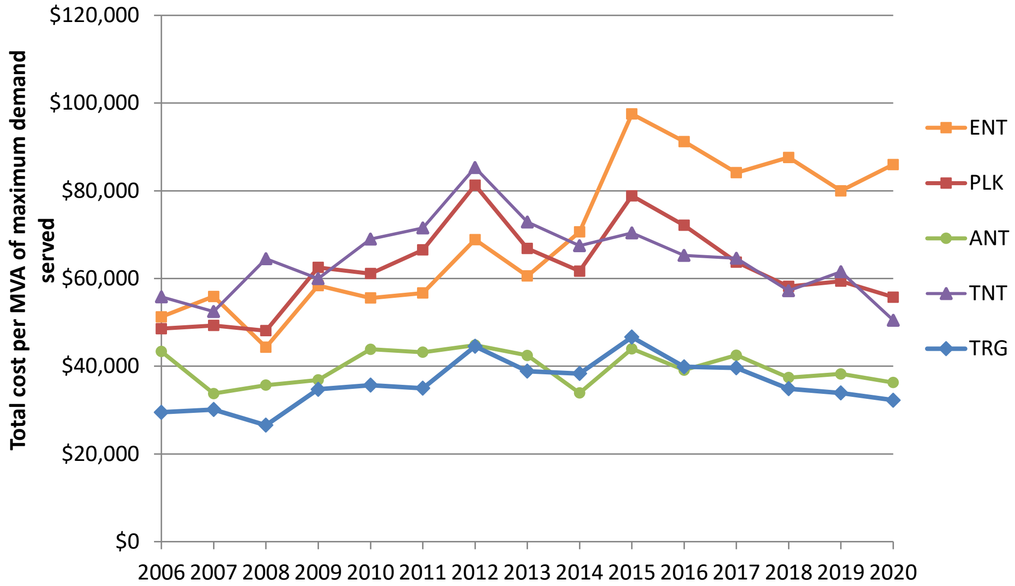
Figure 15 shows TNSPs' total costs per MVA of non-coincident maximum demand.

ElectraNet reported the highest cost per MVA of maximum demand in 2020. This follows large growth between 2013 and 2015 because of a substantial drop in maximum demand without an offsetting decrease in its total costs. ElectraNet's costs per MVA of maximum demand increased in the latest 12-month period by 7.5% (from $79 983/MVA ($2020) in

2019 to $85 974/MVA ($2020) in 2020), partially offsetting a fall in 2019. Its costs per MVA in 2020 are approximately two and a half times greater than the two best performing networks, TransGrid ($32 264/MVA, ($2020)) and AusNet ($36 284/MVA, ($2020)).

Since 2006 three TNSPs have reported growth in total costs per MVA of maximum demand (ElectraNet, Powerlink and TransGrid). ElectraNet's total costs per MVA of maximum demand, largely due to the surge between 2013 and 2015, increased by 67.7% between 2006 and 2020. On the other hand, TransGrid and Powerlink have experienced a relatively smaller increase in total cost per MVA of maximum demand over the 2006–20 period (9.4% and 14.8% respectively) with all TNSPs except for ElectraNet showing steady reductions in recent years. Over the 2006–20 period, AusNet's costs have decreased by 16.3% to $36 284/MVA ($2020) and those of TasNetworks have decreased by 9.5% to $50 494 ($2020).

Figure 15 TNSP total cost per MVA of maximum demand served ($2020), 2006–20



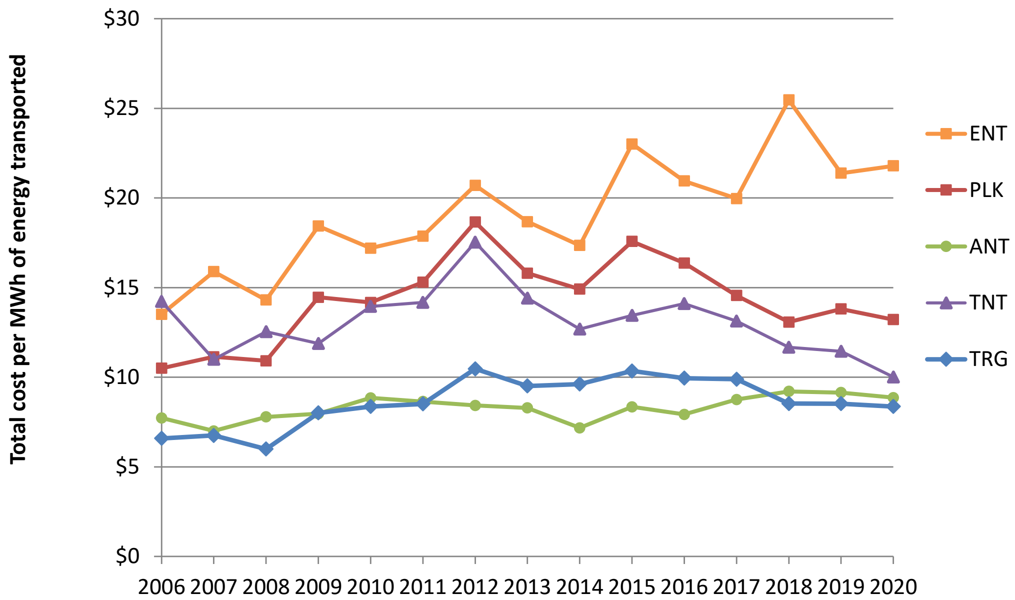
Source: Economic Benchmarking RINs; AER analysis.

4.2.4 Total cost per MWh of energy transported

As can be seen in Figure 16, ElectraNet recorded the highest cost per MWh of energy transported in 2020 at $21.8/MWh. In 2020, TransGrid and AusNet were the best performers on this measure, with approximately 40% of the total cost per MWh of ElectraNet, at $8.4/MWh and $8.9/MWh respectively.

Costs per MWh of energy transported have risen over the 2006–20 period for most TNSPs, with the exception being TasNetworks. ElectraNet's costs per MWh of energy transported have risen by 61.3% over the 2006–20 period, whereas TransGrid, Powerlink and AusNet's costs have increased by 27.0%, 25.9% and 14.7% respectively. TasNetworks, on the other hand, experienced a decrease of 29.7% in costs per MWh of energy transported over the same period. This has resulted in an increase in the gap between TNSPs since around 2014 and 2015.

Figure 16 TNSP total cost per MWh of energy transported ($2020), 2006–20



Source: Economic Benchmarking RINs, AER analysis.

4.3 Explaining differences between the MTFP and PPI results

An issue raised by AusNet in reviewing a draft of this year's report was the differences in the MTFP and PPI benchmarking results.[49] It noted that in three out of the four PPIs, AusNet has either the lowest or second-lowest costs, but this is in contrast to the MTFP results where it ranks fourth. For example, it noted that despite being the top two performers on following PPIs measures, AusNet and TransGrid are measured as the two least productive TNSPs in the NEM in terms of MTFP:

- Total cost per end user (Figure 12)
- Total cost per Mega Volt Amp (MVA) (Figure 15)
- Total cost per MWh of energy transported (Figure 16)

AusNet added that, despite having the lowest regulatory asset base (RAB) per end-use customer, AusNet and TransGrid are measured as having the lowest capital MTFP under the current benchmarking model.

AusNet sought a conceptual explanation of these differences.

We note that we use the top-down economic benchmarking for different purposes from the PPI analysis. The MTFP / MPFP benchmarking approach examines the efficiency in the use of inputs to produce total outputs where the TNSPs are multiple-input users and multiple-output producers. In contrast, the PPI analysis considers the efficiency of the input costs (i.e.

[49] AusNet Services, Submission to the AER's 2021 draft Annual Benchmarking Report, 20 October 2020, pp. 2–4.

total cost, opex and capital cost) used to deliver a particular output. We have used MTFP analysis as our primary tool to examine the overall efficiency and productivity of TNSPs while using the MPFP and PPIs analysis as supporting tools to reveal sources of inefficiencies.

The MPFP and PPIs 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. 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:

- Using MTFP / MPFP, five outputs are measured and aggregated by output weighting based on cost share. As MTFP / MPFP measures a weighted average output quantity, it 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. While AusNet is measured as having relatively low cost in terms of end user, maximum demand and energy transported PPI, it is found to incur the highest cost in terms of circuit length. When considering all the outputs together, AusNet's relative position changes depending on the weighting allocated to circuit length relative to other outputs. Under the corrected output weights, as updated in the 2020 Annual Benchmarking Report, the weight applied to circuit length is 52.8% of gross revenue. Ausnet considers this weight is too high and that it has an outsized impact on the results.[50] This issue of output weights will be subject to an independent review as outlined in section 1.2.1.
- Under the MTFP / MPFP analysis four inputs (i.e., opex, overhead lines, underground cables, transformers) are measured in terms of physical quantity. In contrast, the PPIs analysis considers input costs (instead of quantities), and measures the opex and annual user cost of capital in real dollar value. The cost measure differs from the input quantity measure, particularly in relation to capital.[51] As the annual user cost of capital is measured as the sum of return on capital and depreciation, for TNSPs with the same physical quantity of capital inputs in place, their annual user cost of capital can differ substantially due to differences in asset valuation and prices actually paid, investment cycles and asset lives.

For the above reasons, we do not expect the MTFP / MPFP and PPIs analyses to present the same or similar results. The use of the PPIs analysis is to provide further insights into the efficiency performance of TNSPs.

We also note that our Annual Benchmarking Reports present cost-based PPIs analysis rather than RAB-based PPI analysis. As with the annual user cost of capital measure, RAB

[50] Using the output quantity index from the MTFP analysis, AusNet's total cost per unit of total output is below the average for the other four TNSPs.

[51] We consider that opex input prices and opportunity costs of capital can be expected to be similar between TNSPs.

values can differ substantially across TNSPs due to differences in asset valuation and prices, as well as asset age and lives.

Shortened forms

Shortened form	Description
AEMC	Australian Energy Market Commission
AER	Australian Energy Regulator
ANT	AusNet Services (transmission)
Capex	Capital expenditure
ENT	ElectraNet
MW	Megawatt
MWA	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
Efficiency	A Transmission Network Service Provider's (TNSP) 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).
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). In this year's annual benchmarking report, we also apply the method to time-series TFP analysis at the industry level and for individual TNSP to better capture large energy not served changes.
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 TNSP's 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.
Ratcheted maximum demand	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 over time or growth rates to be compared across networks. This method was used in previous annual benchmarking reports (up to 2019) to examine productivity change over time at the TNSP level and the industry level.
VCR	Value of Customer Reliability. VCR represents a customer's willingness to pay for the reliable supply of electricity.

A References and further reading

This benchmarking report is informed by several sources.

Economic Insights publications

The following publications explain in detail how Economic Insights 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
- 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
- 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 at: https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/annual-benchmarking-report-2017/initiation.

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.

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: https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements.

B Benchmarking models and data

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

B.1 Benchmarking techniques

This report presents results from two types of 'top-down' benchmarking techniques:

- Productivity index numbers. These techniques use a mathematical index to measure the relationship between outputs relative to inputs:
  - TFP relates total inputs to total outputs and provides a measure of overall productivity growth for a single entity (a network or the whole industry). It allows total productivity growth rates to be compared for different periods of time for the one entity. It also allows total factor productivity growth rates to be compared across networks but does not allow productivity levels to be compared across networks. It can be used to decompose productivity change into its constituent input and output parts.
  - MTFP relates total inputs to total outputs and provides a measure of overall network efficiency relative to other networks. It thus allows total productivity levels to be compared between networks and over time when it is applied to combined time-series and cross-section (or 'panel') data.
  - MPFP is a partial efficiency measure which uses the same output specification as MTFP but separately examines the productivity of opex and capital against total output. It allows partial productivity levels to be compared between networks.
- PPIs. These techniques, also partial efficiency measures, relate one input to one output (contrasting with the above techniques that relate one or all inputs to total outputs). PPIs measure the average amount of an input (such as total cost) used to produce one unit of a given output (such as total end users, megawatts of maximum electricity demand or kilometres of circuit line length).

B.2 Benchmarking data

The inputs and outputs used in the benchmarking techniques for this report are described below. 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 economic benchmarking regulatory information notices (EB RINs). The EB RINs require all TNSPs to provide a consistent set of data which is verified by the TNSP's 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 2020, along with the Basis of Preparation provided by each TNSP, are published on our website.[52]

An overview of the inputs and outputs are in box 1 below.

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 2020 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).

B.2.1 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.

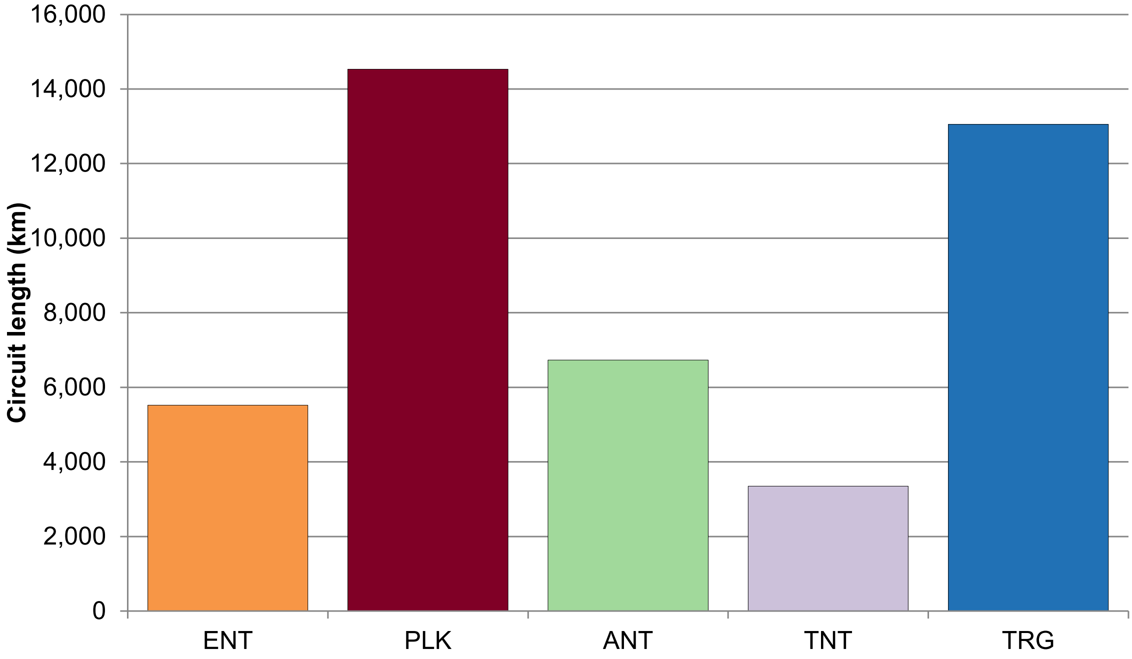
Circuit length

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.

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

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 who 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 2020.

Figure B.1 Circuit length by TNSP in 2020 (km)

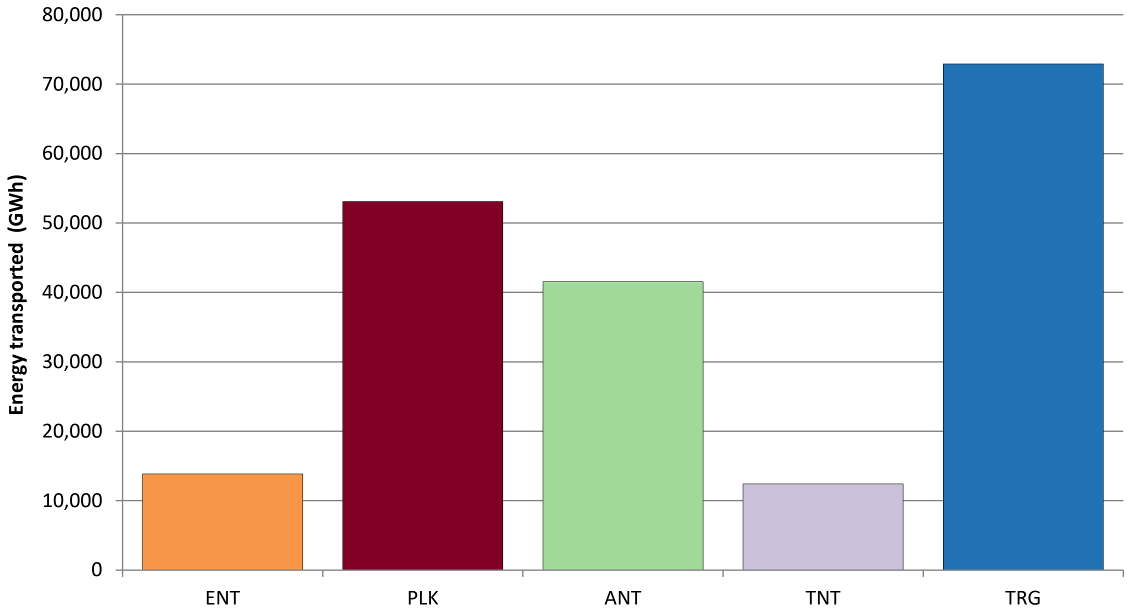


Source: Economic Benchmarking RINs.

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 2020.

Figure B.2 Energy transported in 2020 (GWh)



Source: Economic Benchmarking RINs

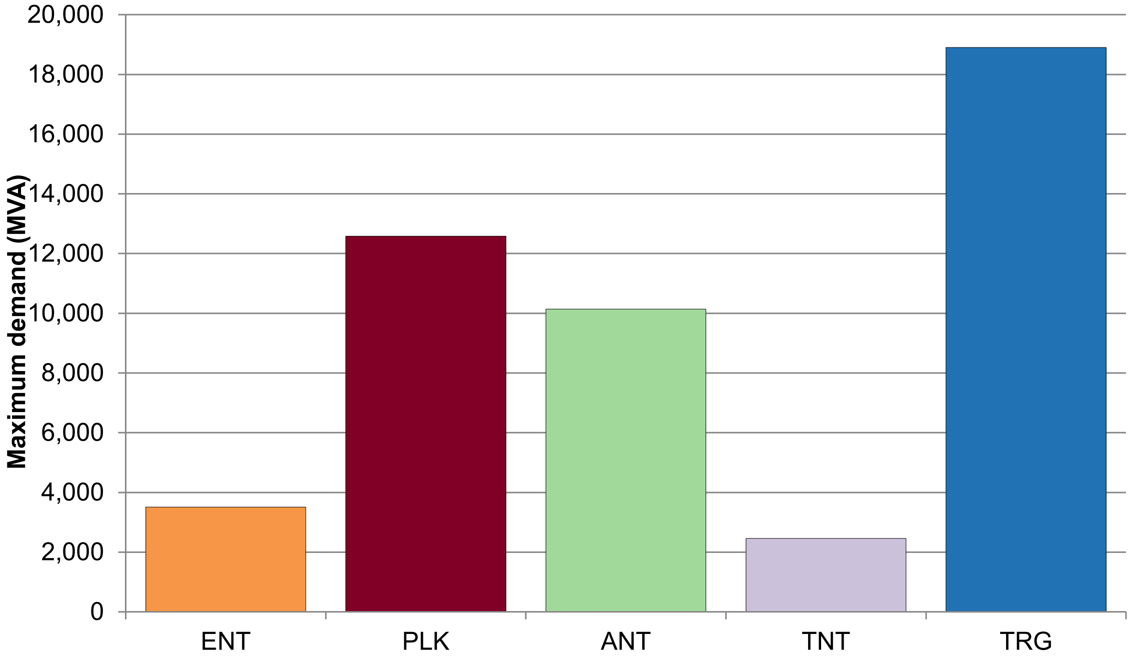
Maximum demand

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. Ratcheted maximum demand is the highest value of peak demand observed in the benchmarking period up to the year in question for each TNSP.[53] 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 2020.

[53] For example, in 2020 ElectraNet's maximum demand is 3 512 MVA, while its ratcheted maximum demand occurred in 2013 and was 4 403 MVA.

Figure B.3 Maximum demand in 2020 (MVA)



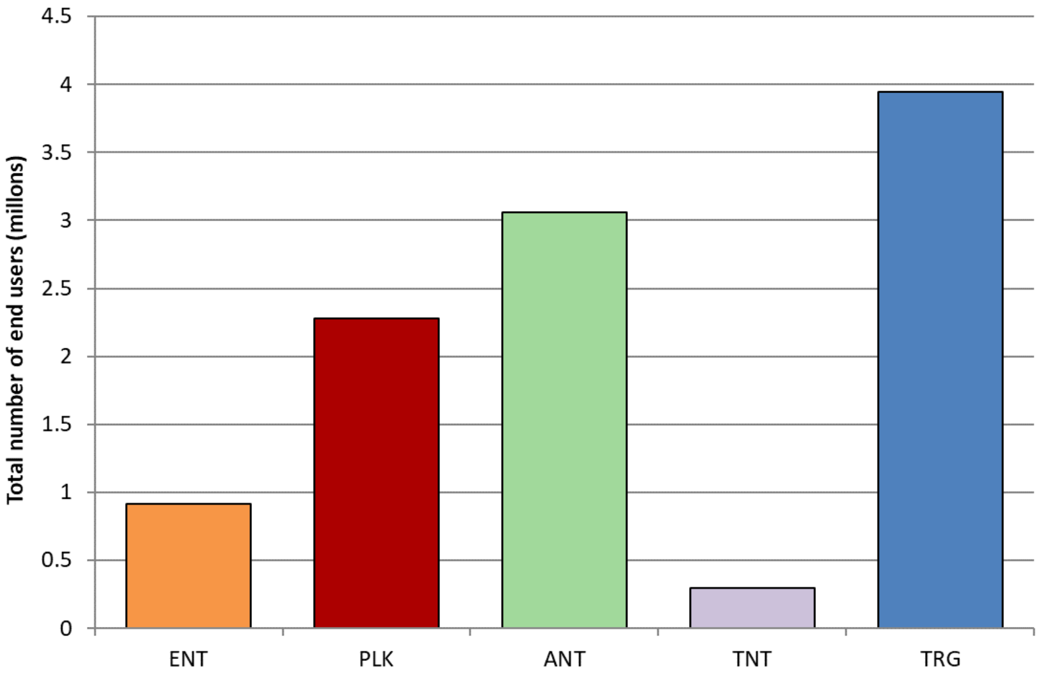
Source: Economic Benchmarking RINs.

End user numbers

The end user number output measures the number of customers TNSPs are required to provide a service for. 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.

As expected, the size of the network aligns with the population in each state. NSW is the largest network, with TransGrid providing services for over 3.9 million end users in NSW, followed by Victoria, with AusNet servicing over 3.0 million end users. Tasmania has the smallest network, with TasNetworks servicing around 294,000 end users in 2020.

Figure B.4 End user numbers for 2020 (millions)



Source: Economic Benchmarking RINs.

Total outputs

Table B.1 presents the average network outputs from 2016 to 2020 for TNSPs, with the exception of reliability.

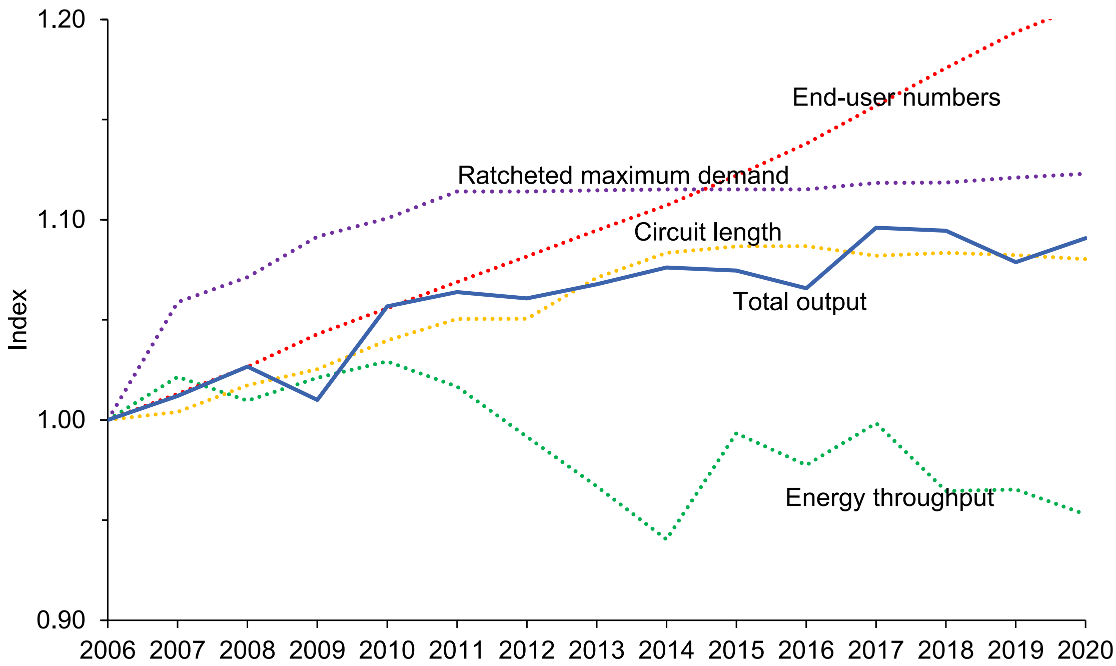
Table B.1 TNSP outputs 2016–2020 average

	Circuit line length (km)	Energy transported (MWh)	Maximum demand (MVA)	Number of end users
ElectraNet	5,520	13,572,212	3,449	890,429
Powerlink	14,574	53,763,442	12,357	2,225,859
AusNet	6,620	43,873,476	9,927	2,961,335
TasNetworks	3,514	12,362,611	2,487	289,062
TransGrid	13,062	74,040,000	18,560	3,832,959

Source: Economic Benchmarking RINs.

Figure B.5 presents indexes of the key industry outputs over the 2006–20 period (with the exception of reliability) along with the total output index.

Figure B.5 Components of total output 2006–20



Source: Economic Insights

B.2.2 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 MTFP technique are:

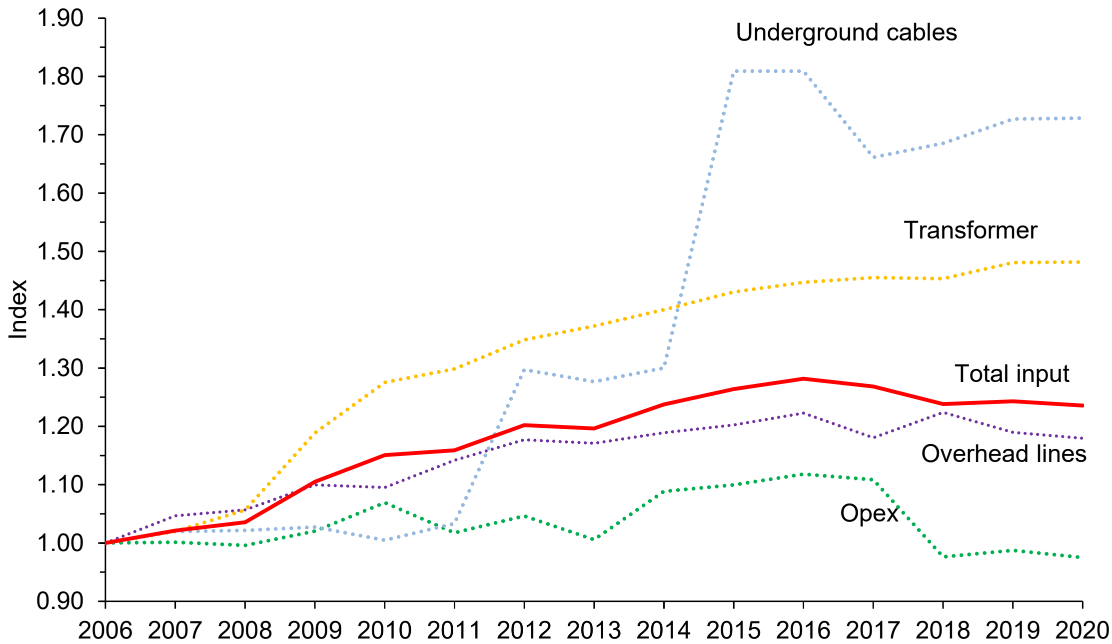
- Operating expenditure (opex). This is the expenditure TNSPs spend on operating and maintaining their assets. We use the observed opex spent on prescribed transmission services. Nominal opex is deflated by an index of labour and other relevant prices to obtain a measure of the quantity of opex inputs.
- 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 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.[54]

[54] Economic Insights, *Memorandum – TNSP MTFP Results*, 31 July 2014, p. 5.

– 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 2006–20 period.

Figure B.6 Factors contributing to total inputs, 2006–20



Source: Economic Benchmarking RINs.

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

Table B.2 Average annual costs for network inputs for 2016–20 ($'000, 2020)

	Opex	Capex	RAB	Depreciation
ElectraNet	96,300	155,973	2,372,910	111,866
Powerlink	216,235	147,967	6,874,962	292,837
AusNet	89,514	151,200	3,078,139	176,739
TasNetworks	32,903	46,442	1,443,912	62,549
TransGrid	169,369	235,047	6,424,143	279,645

Source: Economic Benchmarking RINs.

C Map of the National Electricity Market

This benchmarking report examines the efficiency 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 C.1 illustrates the network areas for which the TNSPs are responsible.

Figure C.1 Electricity transmission networks within the NEM