Annual Benchmarking Report

Electricity transmission network service providers

November 2019

Inquiries about this publication should be addressed to:

Australian Energy Regulator
GPO Box 520
Melbourne Vic 3001

Tel: (03) 9290 1444
Fax: (03) 9290 1457

Email: AERInquiry@aer.gov.au

Summary

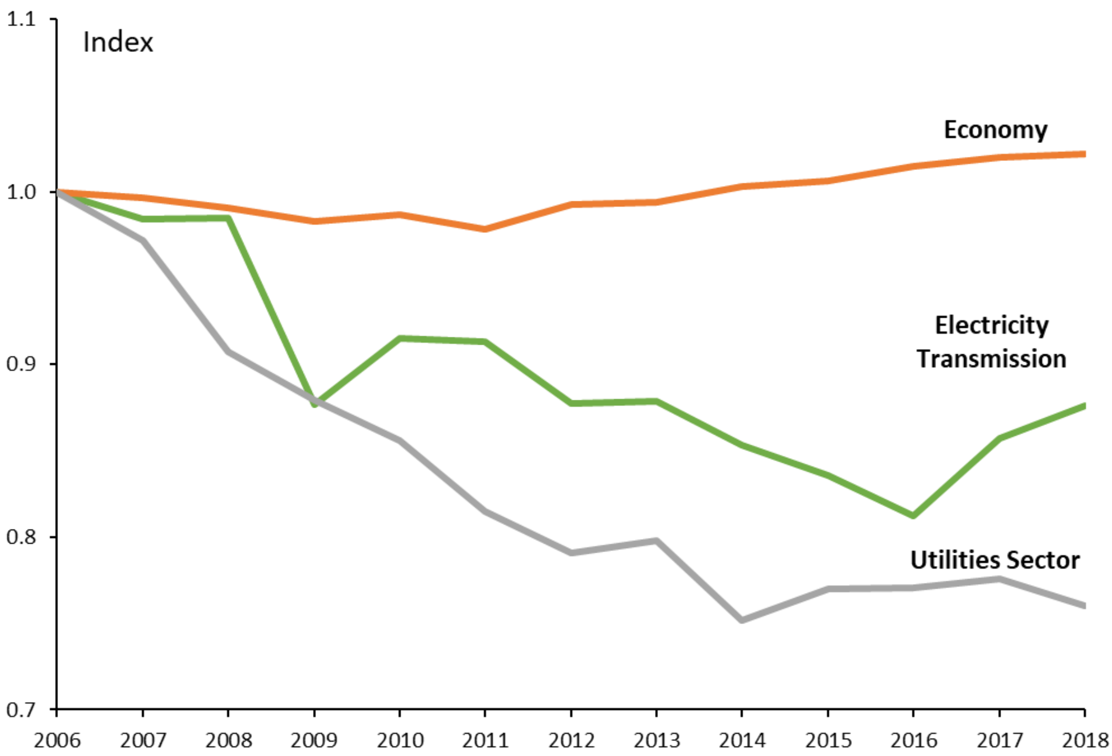
We report annually on the productivity growth and efficiency of transmission network service providers in the National Electricity Market (NEM). These service providers operate high voltage transmission lines which transport electricity from generators to distribution networks in urban and regional areas. Transmission network costs typically account for between 4 and 12 per cent 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.

Transmission network productivity has improved for second consecutive year

Electricity transmission productivity grew by 2.2 per cent over 2017–18, as measured by total factor productivity. While this growth is lower than that achieved over 2016–17 (5.3 per cent), it is still higher than productivity growth rates for the overall economy and the utilities sector (covering electricity, gas, water and waste services). The overall improvement in productivity has restored transmission productivity to its 2012 levels.

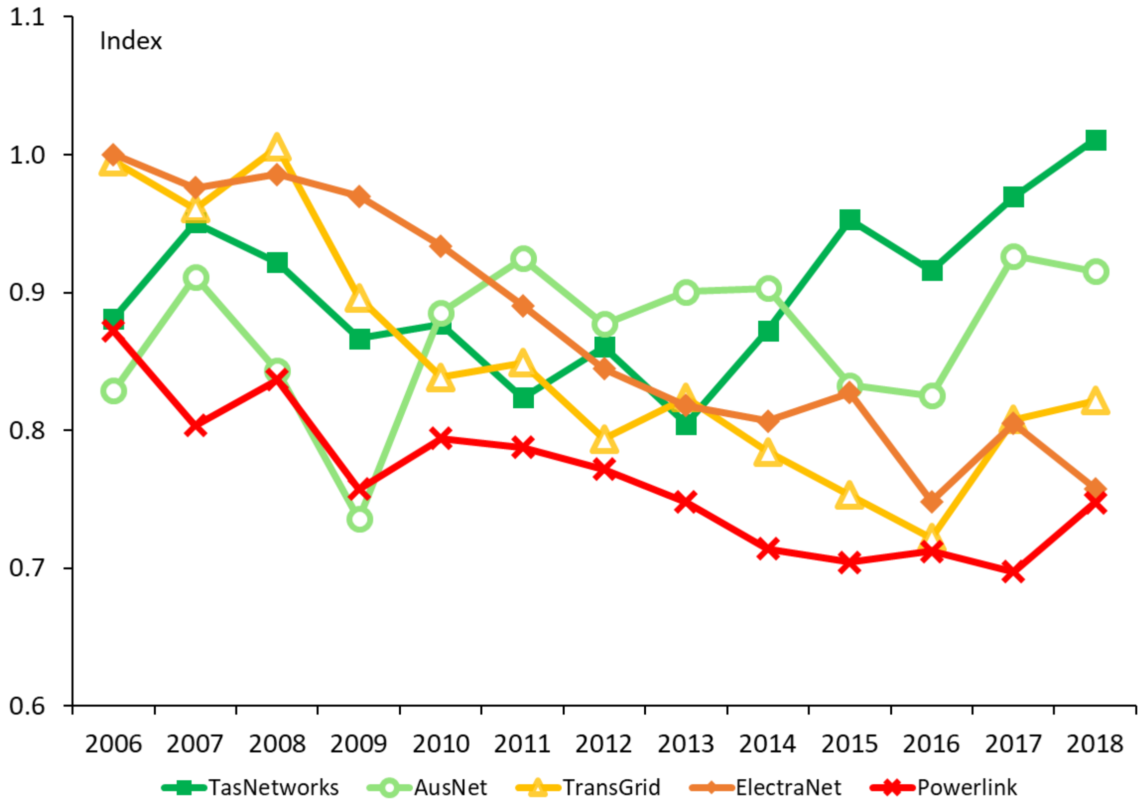
Electricity transmission, utility sector, and economy productivity, 2006-18



Three of the five transmission networks improved their productivity over 2018

There are five transmission networks in the NEM, with one in each state. The transmission networks in Tasmania (TasNetworks) and Victoria (AusNet Services) have been the most productive in the NEM since 2012. In 2017-18, TasNetworks, as well as the transmission networks in NSW (TransGrid) and Queensland (Powerlink) recorded an increased in productivity.

Electricity transmission productivity levels by state, 2006–2018



Reductions in operating expenditure drove productivity growth

The primary reason for productivity growth amongst transmission networks was reductions in operating expenditure. This in isolation contributed to a 3.4 per cent increase in productivity levels. This was partially offset by reductions in energy throughput, alongside some significant increases in overhead powerlines, which decreased productivity growth.

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 sixth 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 widely by governments and businesses around the world to measure how efficient firms are at producing outputs over time, and compared with their peers.

Our benchmarking report presents results from two types of 'top-down' benchmarking techniques.[3] Each technique uses a different method for relating outputs to inputs to measure and compare TNSP efficiency:[4]

- **Productivity index numbers (PIN)**. These techniques use a mathematical index to determine the relationship between outputs and inputs, enabling comparison of productivity performance over time and between networks.
- **Partial performance indicators (PPIs)**. These techniques are partial efficiency measures that relate one input to one output.

The primary benchmarking techniques we use in this report to measure the relative productivity of each TNSP in the NEM are multilateral total factor productivity (MTFP) and multilateral partial factor productivity (MPFP). The relative productivity of the TNSPs reflects their efficiency. MPFP examines the productivity of either opex or capital in isolation.

Being tops down measures, each benchmarking technique cannot readily incorporate every possible exogenous factor that may affect a TNSPs' costs. Therefore, the

---

1 NER cl. 6A.31(a) & (c).

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

3 Top down techniques measure a network's overall efficiency, taking 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.

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

performance measures are reflective of, but do not precisely represent, the underlying efficiency of TNSPs.

What is multilateral total factor productivity?

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

The inputs we measure for TNSPs are:

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

The outputs we measure for TNSPs are:

- Customer numbers. The number of end-user customers is a significant driver of the services a TNSP must provide.
- Circuit line length. Line length reflects the distances over which TNSPs transport electricity.
- Ratcheted maximum demand. 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 (MWh). Energy throughput is a measure of the amount of electricity that TNSPs deliver to their customers.
- Reliability (Energy not supplied). Reliability measures the extent to which networks are able to maintain a continuous supply of electricity.

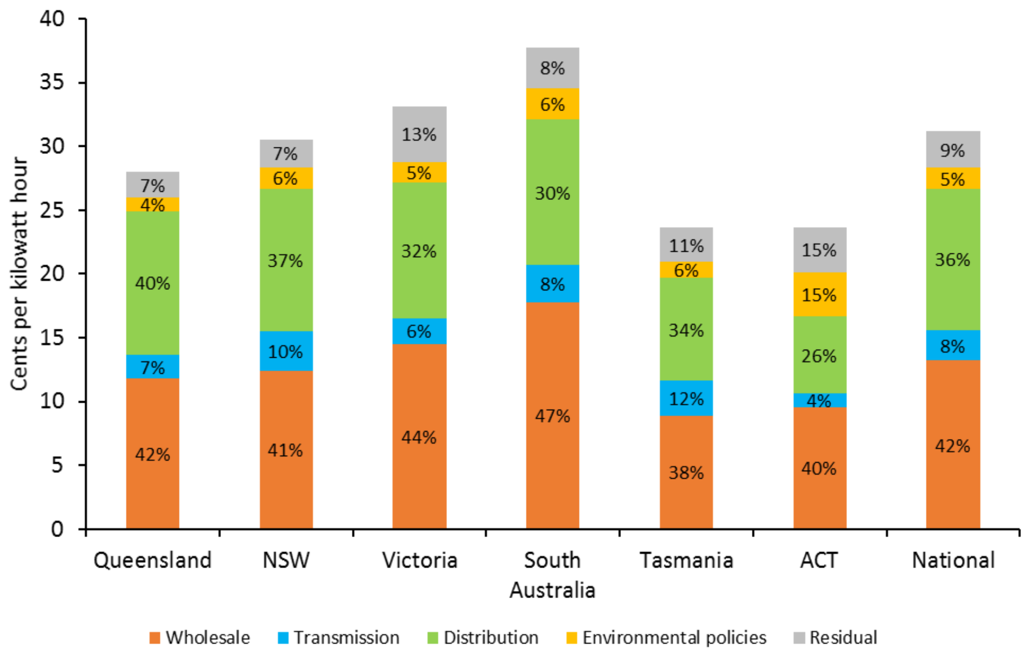
Appendix A provides reference material about the development and application of our economic benchmarking techniques. Appendix **Error! Reference source not found.** provides more information about the specific models we use and the data required.

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.

Consumers pay for electricity network costs through their retail electricity bills. Transmission network costs typically account for between four to twelve per cent of what consumers pay for their electricity while distribution costs account for 30 to 40 per cent (with the remainder covering the costs of generating, and retailing electricity, as well as various environmental policies). Figure 2.1 provides an overview of the typical electricity retail bill.[5]

Figure 2.1 Network costs as a proportion of retail electricity bills



Source: AEMC, AER analysis.

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 though a periodic regulatory process (known as revenue determinations or resets) which

5 AEMC, *2017 Residential Electricity Price Trends data*, 18 December 2017.

typically occurs every five years. The electricity network provides the AER with a revenue proposal outlining its forecast expenditures or costs over the 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.[6] 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 operating expenditure allowances of network service providers (NSPs) that are not necessarily efficient and higher charges for consumers.[7]

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 operating expenditure (opex) allowances for network businesses. The new rules also required the AER to publish the benchmarking results in an annual benchmarking report.[8]

2.1 The uses of economic benchmarking

The AER uses economic benchmarking in various ways when assessing and amending network expenditure proposals.[9] 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 expenditures 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. As we have done in this year's report, this can help us understand why network productivity is increasing or decreasing and where best to target our expenditure reviews.[10]

---

6 See: 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 (AEMC Rule Determination), p. vii.

7 AEMC, final rule determination 2012, p. viii.

8 NER, cl. 6A.31(a) & (c).

9 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.

10 AER, *Explanatory Statement - Expenditure Forecast Assessment Guideline,* November 2013: https://www.aer.gov.au/system/files/Expenditure%20Forecast%20Assessment%20Guideline%20-%20Explanatory%20Statement%20-%20FINAL.pdf, p. 78-79.

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

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

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, MTFP 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.

Further, 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. Compared to electricity distribution networks there have not been many top-down benchmarking studies of transmission networks and, consequently, MTFP analysis for transmission networks is still in a relatively early stage of development. 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 extensively with industry participants to refine our transmission benchmarking as part of our ongoing development work program.[11] We have also collected data on all major inputs and outputs for transmission businesses, and we consider the dataset used is robust.

[11] In 2017, we reviewed the output specifications of our transmission benchmarking models. Among the issues we considered was the measure 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

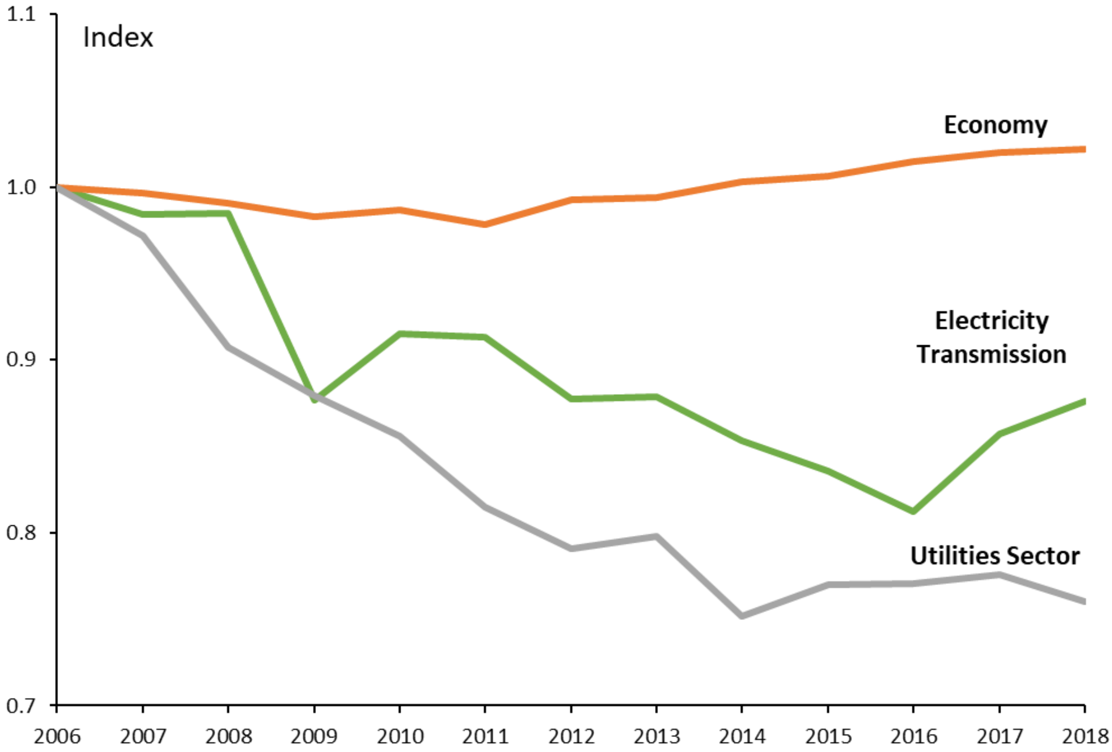
- Electricity transmission productivity, as measured by total factor productivity (TFP), increased by 2.2 per cent over 2018 following a 5.3 per cent increase in 2017. This is the first time industry TFP has increased in consecutive years since 2006. Reductions in opex drove productivity growth in the latest year.
- Productivity growth in the electricity transmission industry has exceeded that in the overall Australian economy and the utilities sector (electricity, gas, water and waste services).

This chapter presents TFP results for the electricity transmission industry over the 2006–18 period, and for the twelve month reporting period ending in 2018. TFP relates total inputs to total outputs and provides a measure of overall productivity growth for a single entity, such as an individual TNSP, or the transmission industry. This chapter also decomposes the change in TFP into its constituent input and output drivers to show their contribution to the industry-wide productivity change in 2018.[12]

Total factor productivity for the electricity transmission industry increased by 2.2 per cent in 2018. Figure 3.1 shows that year-on-year productivity of the electricity transmission industry has increased over two consecutive years for the first time since 2006 (i.e., 2017 and 2018). It has outgrown the overall economy and the utilities sector (electricity, gas, water and waste services) productivity in 2010, 2011, 2017 and 2018.

12 Appendix A includes a link to the methodology that allows us to decompose a given productivity change into its input and output components.

Figure 3.1 Electricity transmission industry, utilities sector, and economy productivity indices, 2006–2018



Source: Economic Insights; Australian Bureau of Statistics.

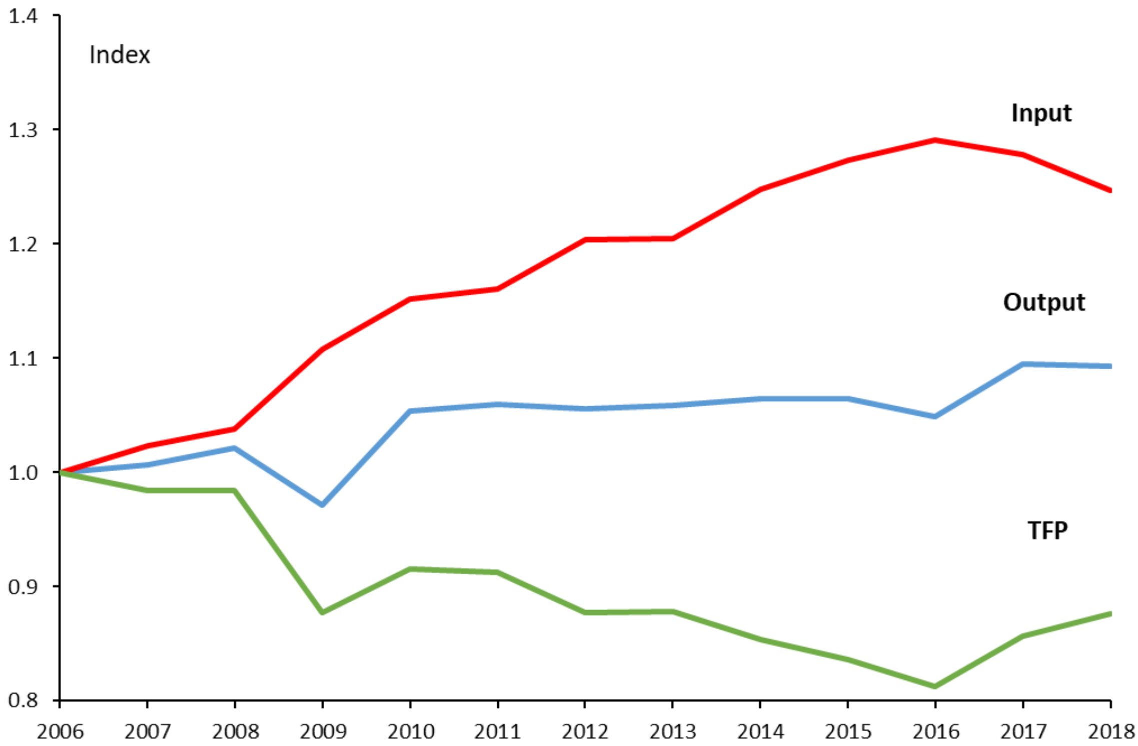
Note: The productivity of the Australian economy and the utility industry is from the ABS indices within 5260.0.55.002 Estimates of Industry Multifactor Productivity, Australia, Table 1: Gross value added based multifactor productivity indexes (a). We have rebased the ABS indices to one in 2006.

The increase in electricity transmission productivity in 2018 was driven by a 2.5 per cent decline in total inputs (Figure 3.2). In comparison, inputs grew faster than outputs over the 2006–18 period, resulting in a fall in long-term TFP by 1.3 per cent per annum.[13] The factors contributing to the input and output changes over the full 2006–18 period are reported in Appendix B.2.

The reduction in TNSP industry input use in 2018 more than offset a small reduction in industry output that year.

[13] This is based on the line of best fit.

Figure 3.2 Electricity transmission input, output and productivity indexes, 2006 to 2018

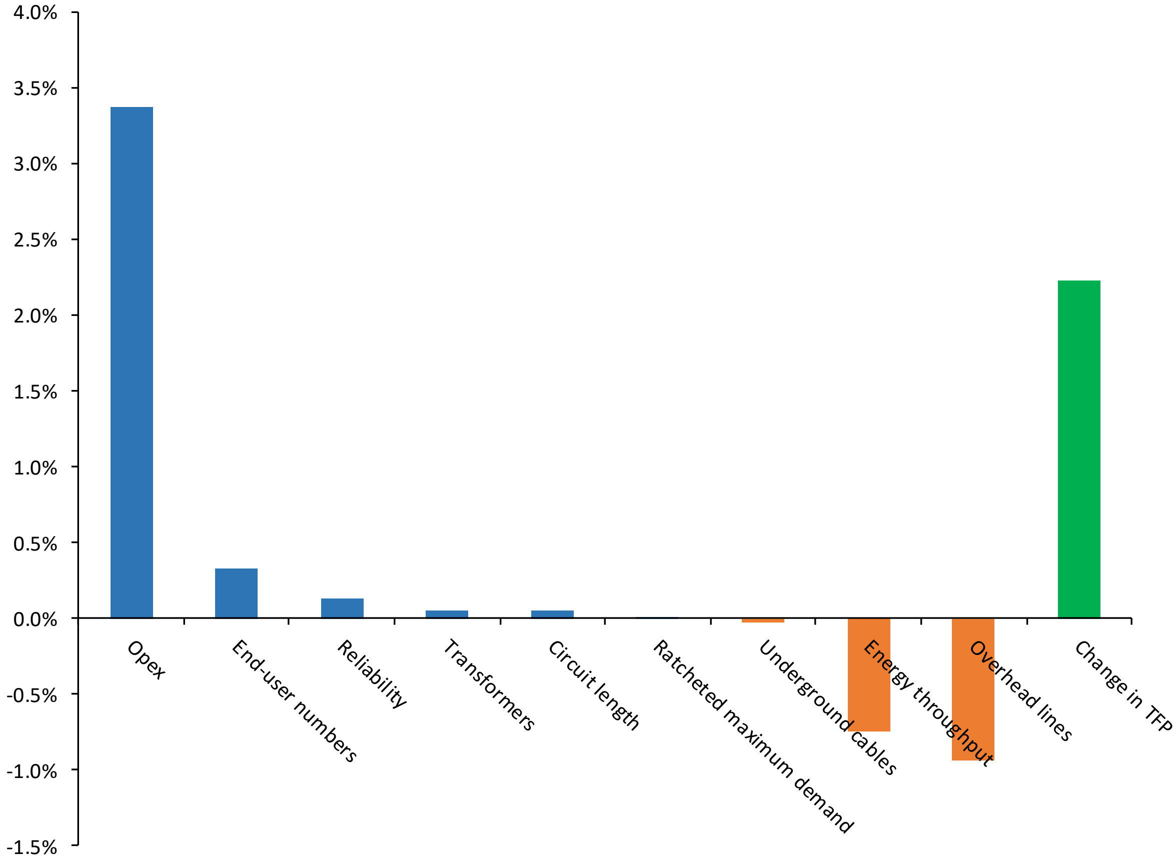


Source: Economic Insights.

Input and output contributions to changes in 2018 TFP

Figure 7 shows the percentage point contributions of each output and each input to the annual rate of TFP change over 2017–18. The contributions appear from the most positive on the left to the most negative on the right. If all the positive and negative contributions in Figure 3.3 are added together, they sum to the TFP change given by the green bar on the right of the figure.

Figure 3.3 Electricity transmission output and input percentage point contributions to annual TFP change, 2017–18



Source: Economic Insights.

Reductions in opex provided the highest positive contribution (3.37 ppts) to TFP change over 2017–18.[14] Growth in end–user numbers and improved reliability also made modest positive contributions, 0.33 ppts and 0.13 ppts respectively. However, these contributions were partly offset by the impact of declining energy throughput (–0.75 ppts) and an increase in the use of overhead lines (–0.94 ppts).

Individual TNSP contributions to productivity growth

Table 3.1 presents a decomposition of each TNSP's productivity growth over 2018, which collectively drives industry input and output changes. We chose to focus on four components: opex, reliability, energy throughput and overhead lines. This is due to the materiality of their contributions to industry TFP over 2018.

---

[14] This contrasts with the period 2016–17 where improvements in reliability made the highest contribution to TPF growth. For more details, see: AER, Annual Benchmarking Report – Electricity transmission network service providers, November 2018, p. 9.

Table 3.1 Input and output contributions to individual TFP growth rates, by TNSP, 2018

	2018					
	Annual change in TFP (%)	Reliability contribution (ppts)	Overhead lines contribution (ppts)	Energy throughput contribution (ppts)	Opex contribution (ppts)	End-user contribution (ppts)
Industry	**2.2**	**0.1**	**-0.9**	**-0.7**	**3.4**	**0.3**
AusNet (Vic)	0.0	-0.1	-0.1	-2.4	2.0	0.3
ElectraNet (SA)	-6.0	0.3	-0.5	-5.5	-0.6	0.4
PowerLink (QLD)	7.2	-0.1	-0.1	0.3	6.0	0.4
TasNetworks (Tas)	3.2	0.8	0.1	0.0	2.5	0.0
TransGrid (NSW)	1.2	0.2	-2.2	0.2	3.1	0.3

Source: Economic Insights, AER analysis.

Powerlink, TransGrid, TasNetworks and and AusNet reported relatively higher reductions in opex over 2018, which materially contributed to their TFP (6.0 ppts, 3.1 ppts, 2.5 ppts and 2.0 ppts, respectively). For AusNet, however, the contribution of opex reduction to its TPF was entirely offset by that of declining energy throughput (–2.4 ppts).

ElectraNet's productivity deteriorated over 2018 by –6 per cent. This outcome was driven by a fall in energy throughput.

All TNSPs, except ElectraNet achieved higher TFP growth in 2018 compared to the average annual industry-wide TFP decline of 1.3 per cent over 2006–18. The full set of input and output contributions to TFP over the 2006–18 and 2017–18 period can be found in the Economics Insights report online.[15]

[15] Economic Insights, *Economic Benchmarking Results for the Australian Energy Regulator's 2019 TNSP Annual Benchmarking Report*.

4 Relative efficiency of individual transmission networks

Key points

- TasNetworks and AusNet continued to be the highest ranking TNSPs on MTFP levels over 2018. TransGrid remained in the mid-range while Powerlink continued to be ranked lowest on MTFP levels in 2018 although it significantly reduced the gap relative to the fourth-placed TRG.
- TasNetworks, TransGrid and Powerlink all recorded an increase in multilateral total factor productivity (MTFP) over 2018. Powerlink recorded the biggest increase of 6 per cent. ElectraNet and AusNet saw a decline in MTFP of 6 per cent and 1.2 per cent, respectively

This chapter presents the results of benchmarking techniques we use to measure and compare productivity of individual TNSPs over the 2006–18 period, and for the 12-month reporting period of 2018. One of these techniques is multilateral total factor productivity, which relates total inputs to total outputs and provides a measure of overall network efficiency relative to other networks. It is the primary indicator we use in this report to measure and compare the relative efficiency of TNSPs. We rank each TNSP's relative performance in 2017–18 using MTFP scores.

We also use supporting benchmarking techniques to assist in interpreting the MTFP results. These techniques include:

- Multilateral partial factor productivity (MPFP), which is a 'partial' benchmarking approach that uses the same output specification as MTFP and provides more detail on the contribution of opex and the individual components of capital to changes in productivity. However, they do not account for synergies between capital and opex like the MTFP model.
- Partial performance indicators (PPIs), which provide a general indication of comparative performance in delivering one type of output.

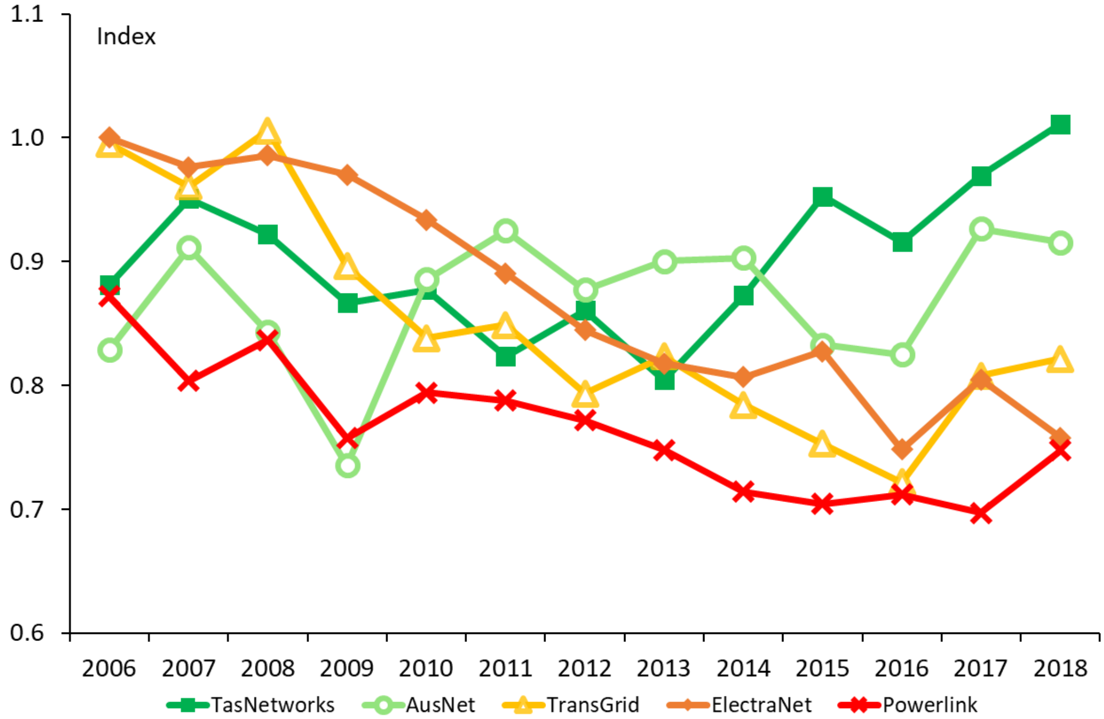
4.1 MTFP results by TNSP

Figure 4.1 presents electricity transmission productivity by TNSP as measured by MTFP over the period 2006 to 2018.[16] ElectraNet and AusNet's productivity decreased over the year by 6 per cent and 1 per cent, respectively.

---

16 2006 is set as the base (i.e., index = 1.00).

Figure 4.1 Electricity transmission MTFP indexes by TNSP, 2006–2018



Source: Economic Insights.

Table 4.1 sets out the relative ranking of each TNSP according to 2017 and 2018 MTFP scores. TNSPs' rankings have remained unchanged in 2018 despite movement in individual productivity scores.

Table 4.1 TNSP MTFP scores, rankings and changes, 2017 and 2018

TNSP	Rank (2018)	Rank (2017)	MTFP Score (2018)	MTFP Score (2017)	% change between 2017–18
TasNetworks	1	1	1.01	0.97	+4%
AusNet Services	2	2	0.92	0.93	-1%
TransGrid	3	3	0.82	0.81	+2%
ElectraNet	4	4	0.76	0.81	-6%
Powerlink	5	5	0.75	0.70	+7%

Source: Economic Insights

ElectraNet, TransGrid and Powerlink's MTFP scores have trended down over the longer 2006–18 period, being 24 per cent, 17 per cent and 14 per cent lower, respectively, in 2018 than in 2006. As a result, despite recording the highest score at the start of the period TransGrid and ElectraNet were ranked third and fourth in 2018, respectively. By contrast, AusNet' and TasNetworks' MTFP scores trended upwards over the period and were 10 per cent and 15 per cent higher, respectively, in 2018 compared to 2006, making them the two most productive TNSPs by MTFP score since 2015. We note that both AusNet and TasNetworks are integrated with distribution network businesses.

TasNetworks, Powerlink and Transgrid all increased their MTFP levels in 2018 while those of AusNet and ElectraNet both fell.

The rankings in Table 4.1 are only indicative of relative performance.[17]

4.2 Supporting benchmarking techniques

This section reports the results of capital and operating expenditure multilateral partial factor productivity as well a range of PPIs.

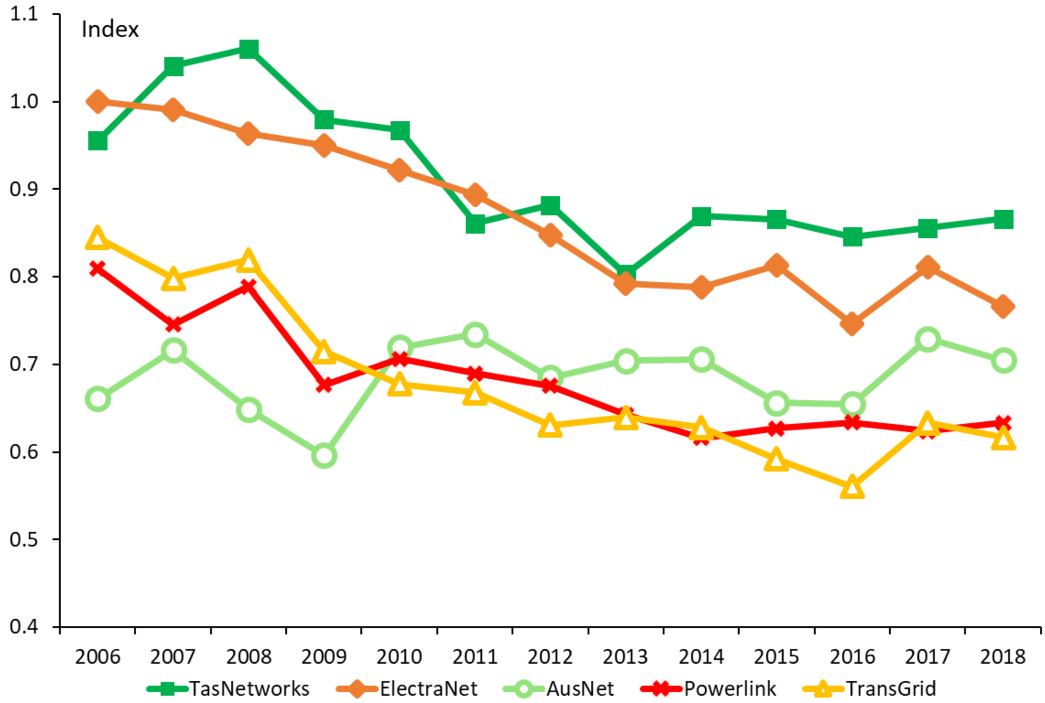
Capital multilateral partial factor productivity

Capital MPFP considers the productivity of the TNSP's use of overhead lines, underground cables and transformers. Figure 4.2 presents the capital MPFP indexes for all TNSPs.[18]

[17] The comparison of productivity levels between TNSPs should be treated with caution because the benchmarking of transmission networks is relatively new, and because our models do not directly incorporate all relevant operating environment factors.

[18] 2006 is set as the base (i.e., index = 1.00).

Figure 4.2 Capital MPFP index, 2006–18



Source: Economic Insights.

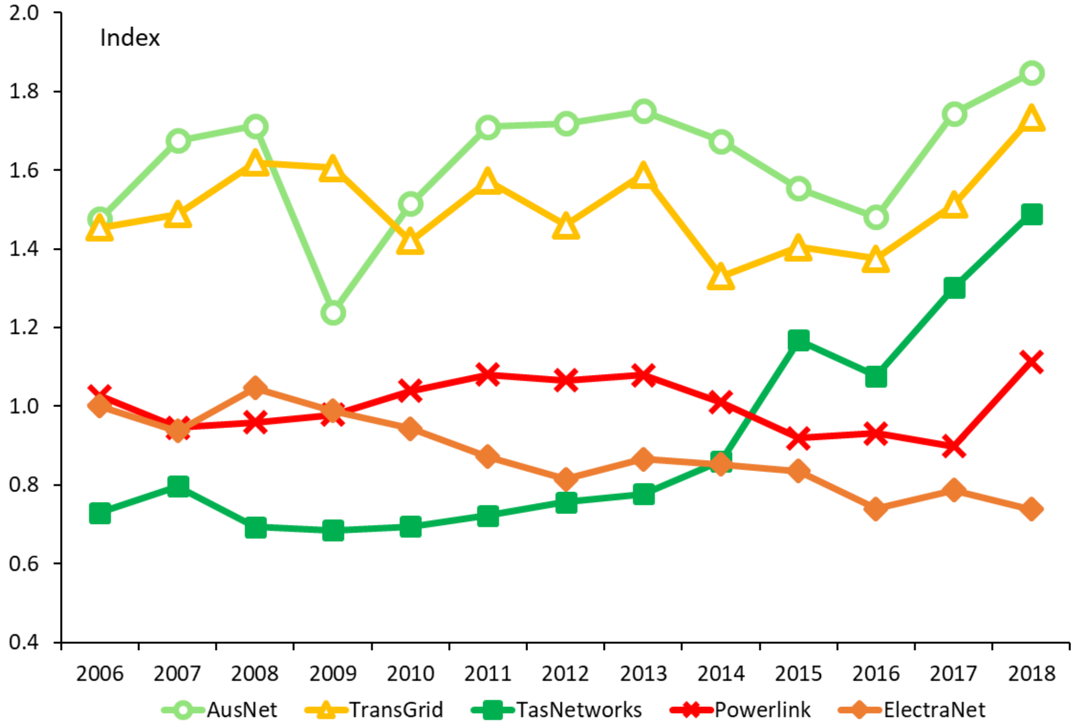
Despite some volatility, each TNSP's capital productivity has generally declined since 2006. The exception is AusNet, which achieved slightly higher capital productivity in 2018 than in 2006. Capital productivity for Powerlink and TasNetworks slightly improved over 2018 while that of TransGrid, AusNet and ElectraNet declined.

Opex multilateral partial factor productivity

Figure 4.3 presents the opex MPFP indexes for all TNSPs.[19]

[19] 2006 is set as the base (i.e., index = 1.00).

Figure 4.3 Opex MPFP index, 2006–18



Source: Economic Insights.

Figure 4.3 shows that opex MPFP improved substantially in 2018 for four TNSPs: Powerlink, TransGrid, TasNetworks and AusNet (21 per cent, 14 per cent, 13 per cent and 6 per cent, respectively). This is consistent with MTFP results where reductions in opex led an increase in 2018 productivity. TasNetworks' 2018 opex productivity level is 104 per cent above its 2006 level. Similarly, opex productivity for AusNet and TransGrid in 2018 is substantially above its 2006 level (25 per cent and 19 per cent, respectively). Powerlink, having improved opex productivity over 2007- 2011 and 2018, is now 8.6 per cent above its 2006 level in 2018.

ElectraNet is the only TNSP that recorded a decline in opex MPFP in 2018 (–6.3 per cent). Its opex MPFP has declined over the 2006-18 period at an average annual rate of 2.5 per cent to be 26 per cent below its 2006 level in 2018.

AusNet and TransGrid have had the highest opex MPFP levels over the 2006–18 period. TasNetworks has improved its opex MPFP performance significantly since 2014 to now lie in third place.

Partial performance indicators

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 benchmarking techniques, such as MTFP.

The inputs we use are the TNSPs' total cost, made up of opex and asset costs. Asset cost is the sum of annual depreciation and return on investment on the TNSP's regulatory asset base.[20] 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.

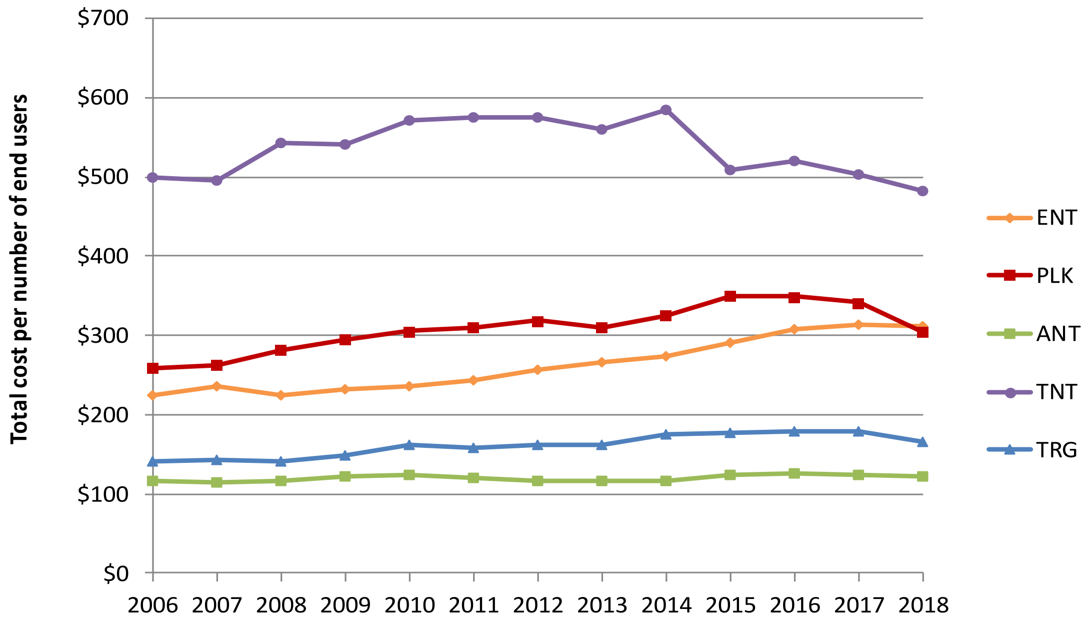
The outputs we use are number of end users, circuit line length, maximum demand served and energy transported. We examine each of these outputs below.

Total cost per end user

The total cost per end user is presented in Figure 4.3. AusNet maintained the lowest cost per end user in 2018. Conversely, TasNetworks continued to have the highest cost per end user of all the transmission networks at over four times that of AusNet Services. Except for TasNetworks, total costs per end user have grown for all TNSPs over the past 13 years, with the strongest growth by ElectraNet of 39 per cent and Powerlink of 18 per cent. This is primarily due to TNSPs' regulatory asset base (RAB) and opex increasing faster than the increase in end users. Over 2017–18, TasNetworks, Powerlink and TransGrid decreased their total cost per end user, while ElectraNet and AusNet's stayed relatively constant.

[20] To calculate asset costs relevant to PPIs, MTFP and Capital MPFP, where possible we have applied annual rate of return values calculated in accordance with the AER's approach to setting rate of return in the most recent determination. See AER, *Final Decision TasNetworks Transmission and Distribution Determination*, *Overview*, July 2016, pp. 30–32. These include a market risk premium of 6.1 per cent, and a risk free rate based on the simple average of the daily 10-year for a CGS (over the risk free rate averaging period) for each year in the benchmarking report). For this benchmarking report, we choose to continue to use the approach in previous benchmarking reports that use the Bloomberg BBB fair value curve (365 day averaging period) to calculate the debt risk premium. The AER's present approach is set out in the 2018 Rate of Return Guideline. However, historical data going back to 2006 is not available for the RBA curve.

Figure 4.4 Total cost per end user ($2018), 2006–2018

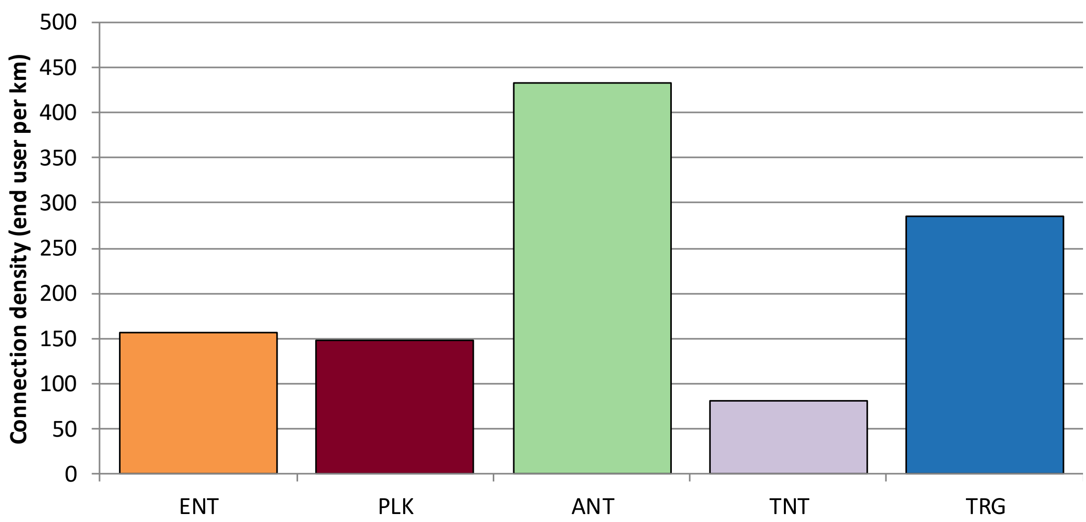


Source: AER analysis, Economic Benchmarking RINs

We note the total cost per end user measure potentially favours 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 2014–18 is presented in Figure 4.5.

Figure 4.5 shows that AusNet Services has the highest average connection density, followed by TransGrid, ElectraNet, Powerlink and TasNetworks respectively. This is consistent with the cost per end-user rankings in Figure 4.4.

Figure 4.5 Connection density (end user per circuit km, 2014–18 average)



Source: AER analysis, Economic Benchmarking RINs.

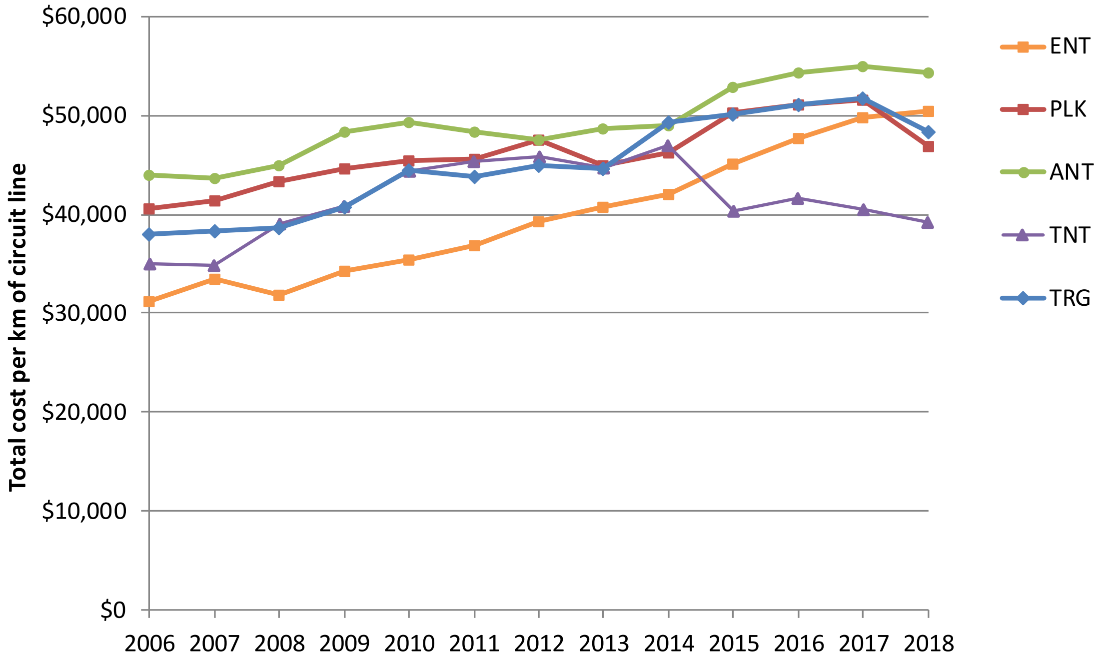
Total cost per km of transmission circuit length

From Figure 4.6 we see TasNetworks has the lowest cost per kilometre of circuit length in 2018, while AusNet has the highest cost per kilometre of circuit length.

All TNSPs experienced relatively strong growth in total costs per kilometre of transmission circuit length between 2006 and 2018. This is due to increases in the RAB and opex exceeding the growth in transmission circuit length. The largest increase in cost per kilometre of circuit length was by Electranet (62 per cent), followed by Transgrid (27 per cent). The lowest growth was by TasNetworks, but it was still a substantial 12 per cent.

The difference in costs between the TNSPs with the highest and lowest cost per km narrowed over the intervening years, from a peak of $14 017 in 2009, to a low of $6,874 in 2014. However, following a sharp decline in costs by TasNetworks in 2014–15 and a levelling off since 2015 when the costs of all other networks continued to increase, the gap in total cost per kilometre of transmission circuit length has again widened to $14 485 in 2018.

Figure 4.6 Total cost per km of transmission circuit length ($2018), 2006 to 2018



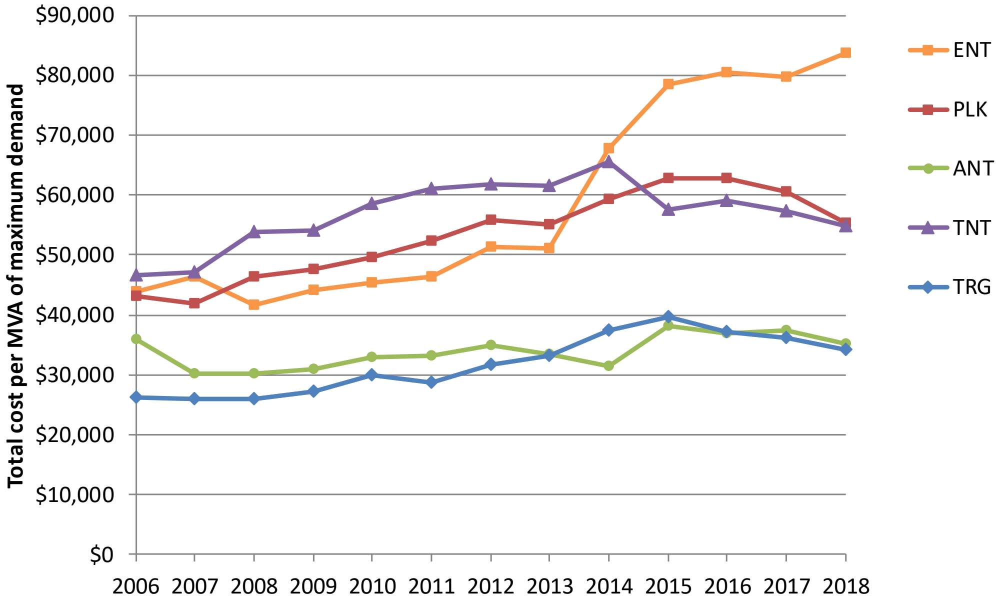
Source: AER analysis, Economic Benchmarking RINs.

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

Figure 4.7 shows TNSPs' total costs per MVA of non-coincident maximum demand. ElectraNet had the highest cost per MWA of maximum demand in 2018. This follows very strong cost growth between 2013 and 2015 because of a substantial drop in maximum demand with no offsetting decrease in TNSPs' total costs. ElectraNet's costs in 2018, at around $83 719 per MVA of maximum demand, are more than double that of better performing TNSPs, TransGrid ($34 175/MVA) and AusNet Services ($35,076/ MVA).

Generally, there has been moderate growth in total costs per MVA of maximum demand between 2006 and 2018, with TasNetworks up 17 per cent to $54 733/MVA, Powerlink up 28 per cent to $55 200/MVA and TransGrid up 31 per cent to $34 175. ElectraNet was the exception, due to the surge in 2014 and 2015, with an increase of 91 per cent.[21] On the other hand, AusNet Services had a small decline in total cost per MVA maximum demand over the period (–2 per cent).

Figure 4.7 Total cost per MVA of maximum demand served ($2018), 2006–2018



Source: AER analysis, Economic Benchmarking RINs.

Total cost per MWh of energy transported

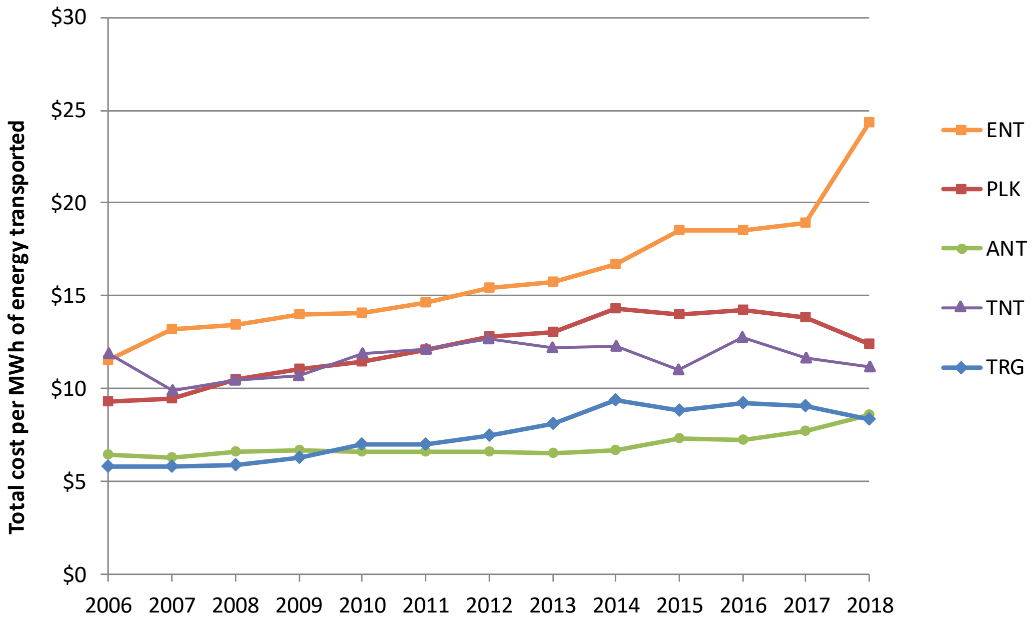
Error! Reference source not found. shows total cost per MWh of energy transported. ElectraNet recorded the highest cost per MWh of energy transported relative to the other TNSPs, at over $24/MWh in 2018, in part due to its large reduction in MWh transported that year. AusNet Services and TransGrid are again the best performers on this measure, at around one third of the total cost per MWh of ElectraNet, at $8.5/MWh and $8.3/MWh respectively.

---

[21] ElectraNet's maximum demand dropped substantially in 2014 and 2015 while TC continued to rise over the longer period.

Costs per MWh of energy transported increased for most TNSPs over the period from 2006 to 2014. AusNet has experienced a small increase in total cost per MWh of energy transported from 2014 to 18, but this is relatively small compared to ElectraNet's increase over the same period.

Figure 4.8 Total cost per MWh of energy transported ($2018), 2006–2018



Source: AER analysis, Economic Benchmarking RINs.

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
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).
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 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.
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 2019 TNSP Benchmarking Report,* September 2019
- 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*, 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*, 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 determine the relationship between outputs and 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 is 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. 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 customer numbers, 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 2018, along with the Basis of Preparation provided by each TNSP, are published on our website.[22]

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 current AEMO value of customer reliability (VCRs) capped at a maximum absolute value of 5.5 per cent of gross 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

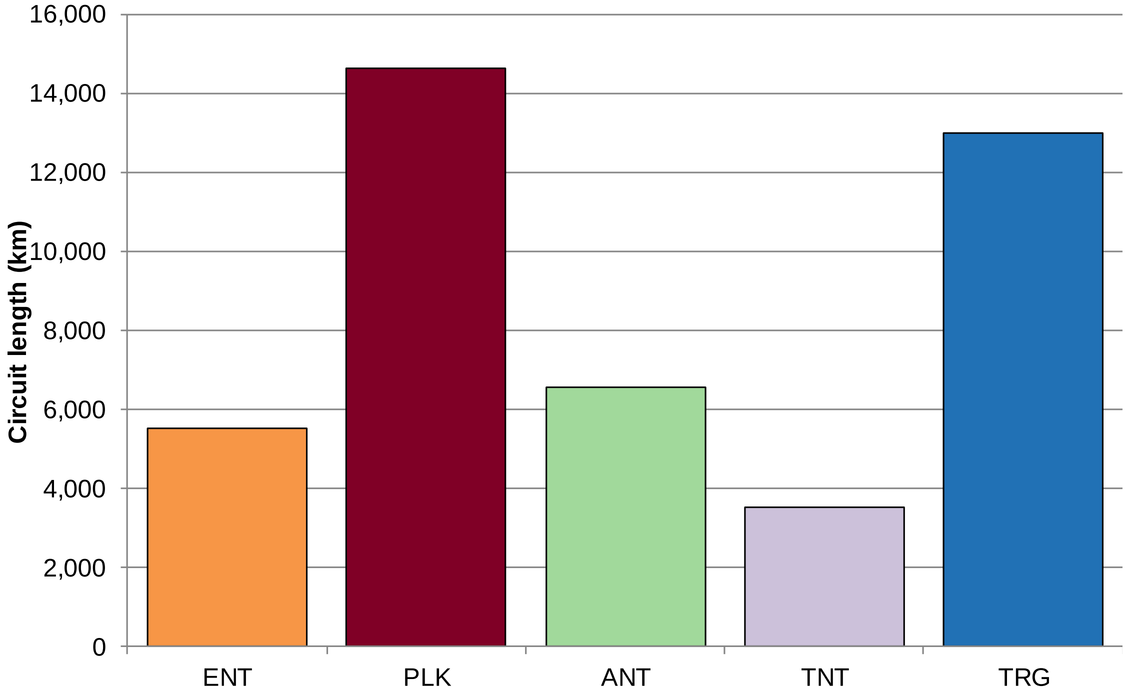
Circuit length reflects the distances over which TNSPs deliver electricity to downstream users from generators, which are typically over thousands of kilometres. We measure line length in terms of circuit line length. This is the length in kilometres of lines, measured as the length of each circuit span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

---

22 This dataset is available at: https://www.aer.gov.au/node/483.

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, on average, over the five years from 2014 to 2018.

Figure B.1 Five year average circuit length by TNSP (2014 to 2018)

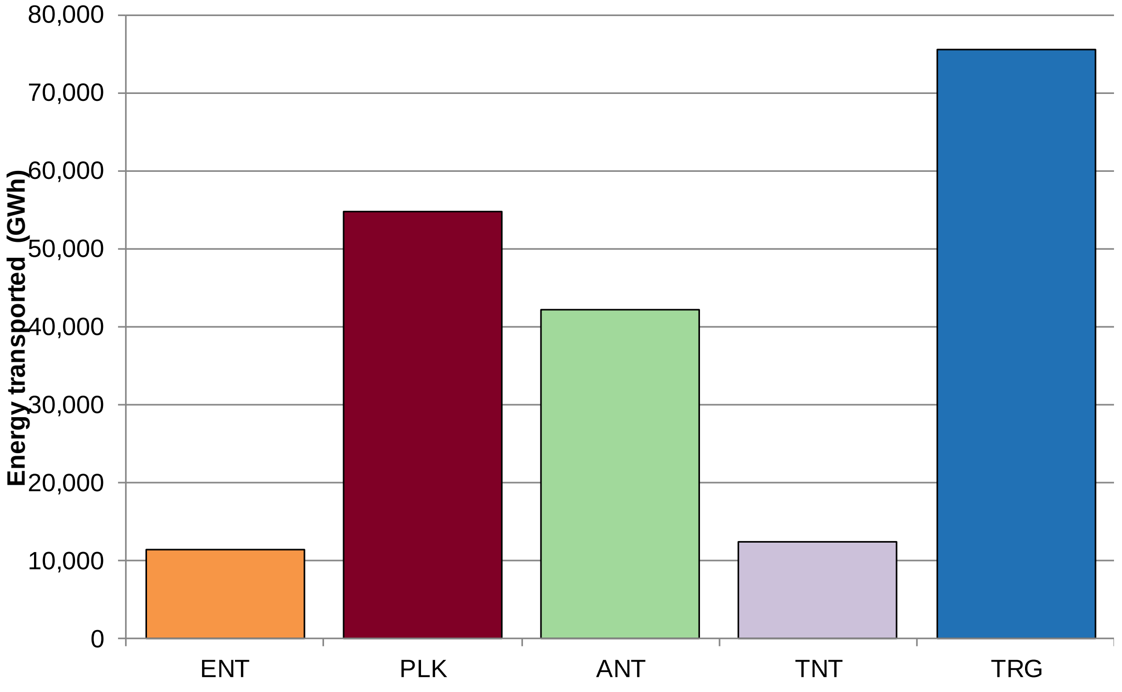


Source: Economic Benchmarking RINs.

Energy transported

Energy transported is the total volume of electricity throughput 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 2018.

Figure B.2 Energy transported in 2018 (GWh)



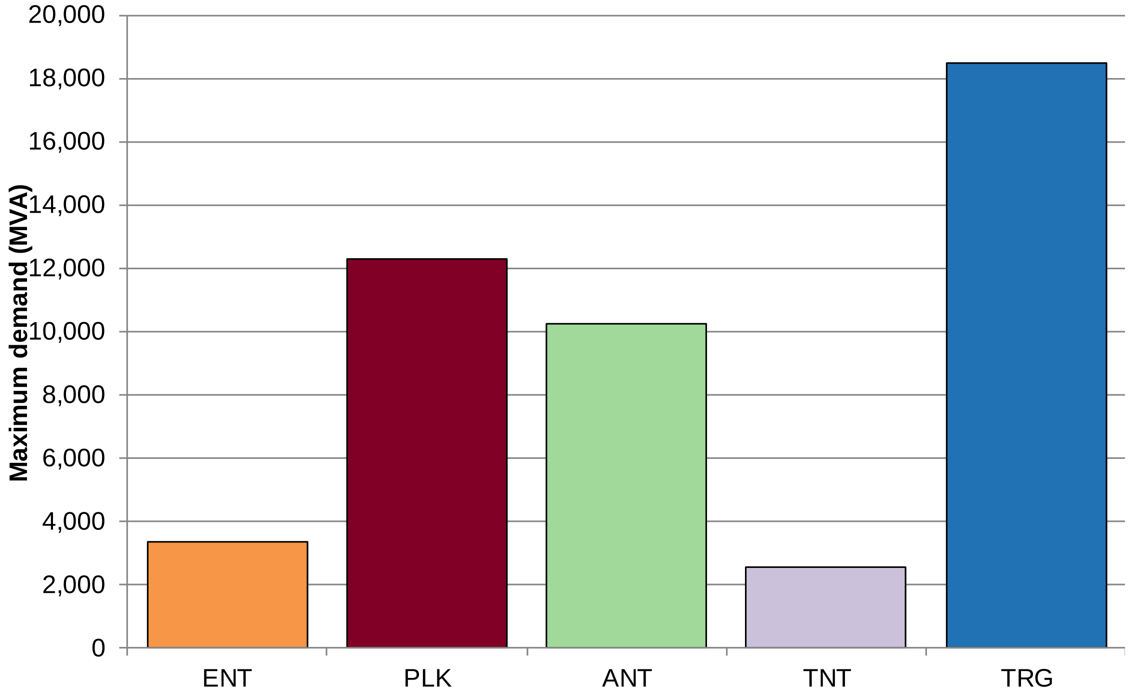
Source: Economic Benchmarking RINs.

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. 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 2018.

Figure B.3 Maximum demand in 2018 (MVA)



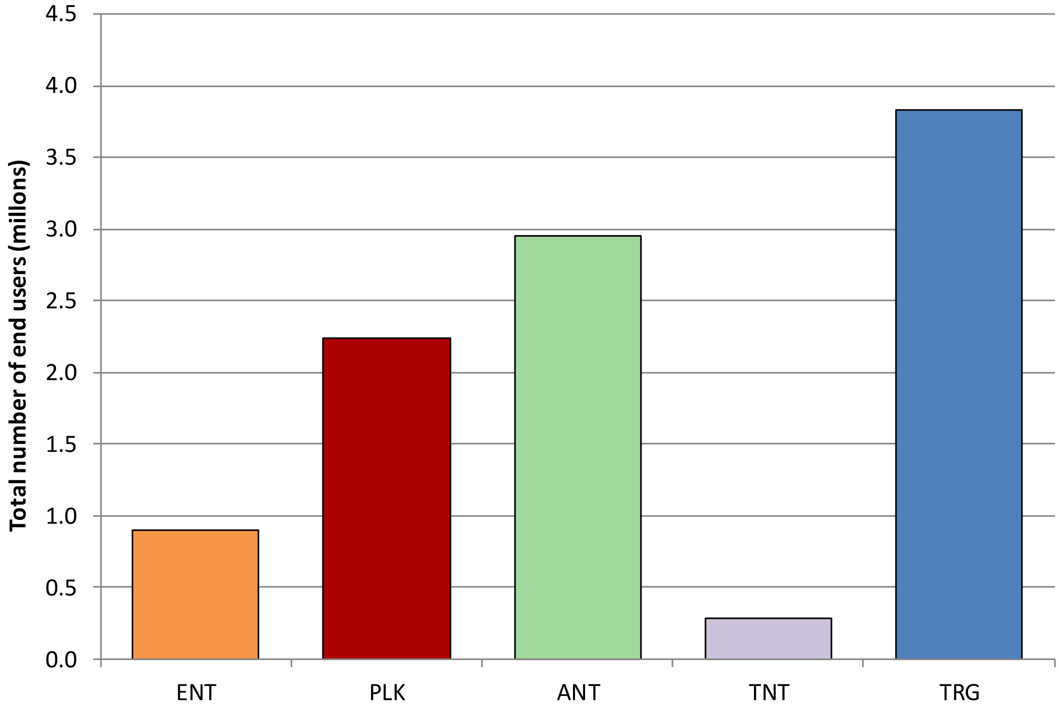
Source: Economic Benchmarking RINs.

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. **Error! Reference source not found.**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 3.8 million end users in NSW, followed by Victoria, with AusNet Services servicing over 2.9 million end users. Tasmania has the smallest network, with TasNetworks servicing around 288,000 end users in 2018.

Figure B.4 End user numbers for 2018 (millions)



Source: Economic Benchmarking RINs.

Total outputs

Table B.1 presents the average network outputs from 2014 to 2018 for TNSPs, with the exception of reliability.

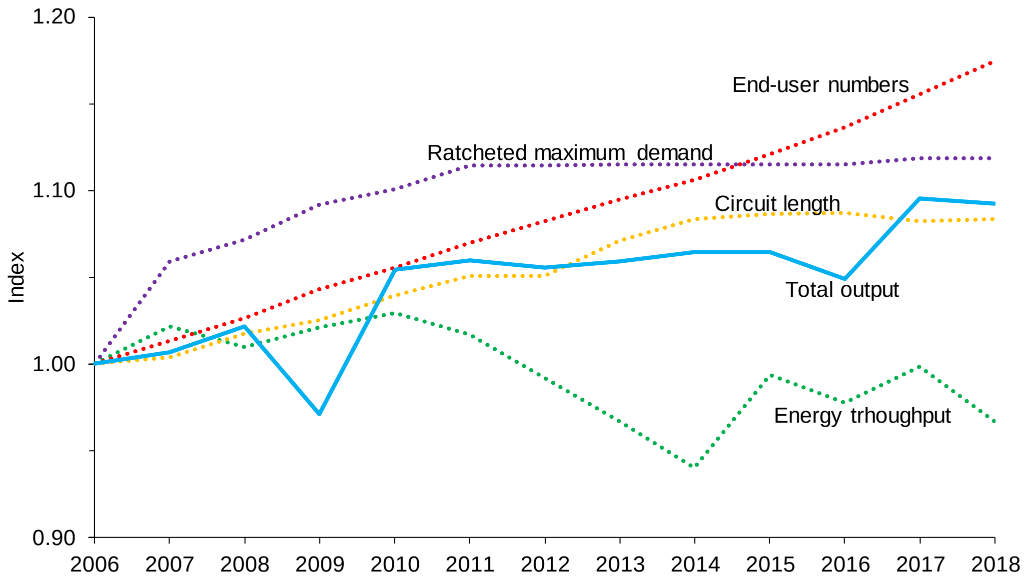
Table B.1 TNSP outputs 2014–2018 average

	Circuit line length (km)	Energy transported (GWh)	Maximum demand (MVA)	Number of end users
ElectraNet	5,523	13,526,032	3,330	867,410
Powerlink	14,669	52,535,338	12,010	2,162,489
AusNet Services	6,578	46,786,576	9,788	2,849,457
TasNetworks	3,548	12,597,030	2,518	284,944
TransGrid	13,032	73,020,000	17,740	3,725,991

Source: Economic Benchmarking RINs.

Figure B.5 presents indexes of the key industry outputs over the 2006–18 period.

Figure B.5 Components of total output 2006–2018



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:

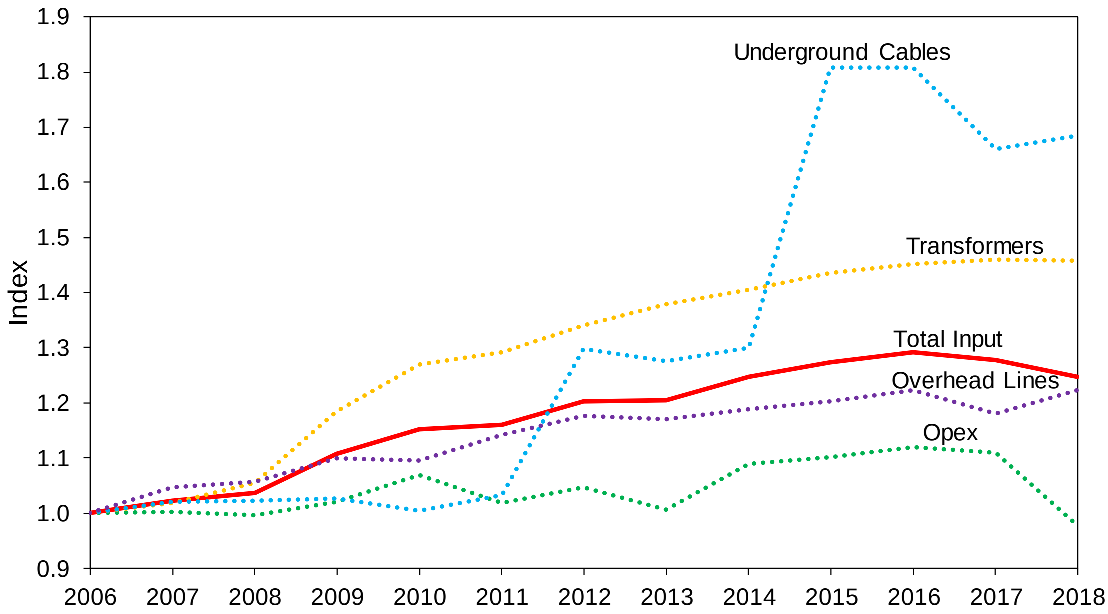
- Operating expenditure (opex). This is the expenditure TNSPs spend on operating and maintaining their assets. We use the observed opex spent on prescribed services. Nominal opex is deflated by an index of labour and other relevant prices to obtain a measure of the quantity of opex inputs.
- Capital stock (assets). TNSPs use physical assets to provide services and invest 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.[23]
    - 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 2006–18 period.

---

23 Economic Insights, *Memorandum TNSP MTFP Results*, July 2014, p. 5.

Figure B.6 Factors contributing to total inputs, 2006–2018



Source: Economic Insights.

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 2014–18 ($'000, 2018)

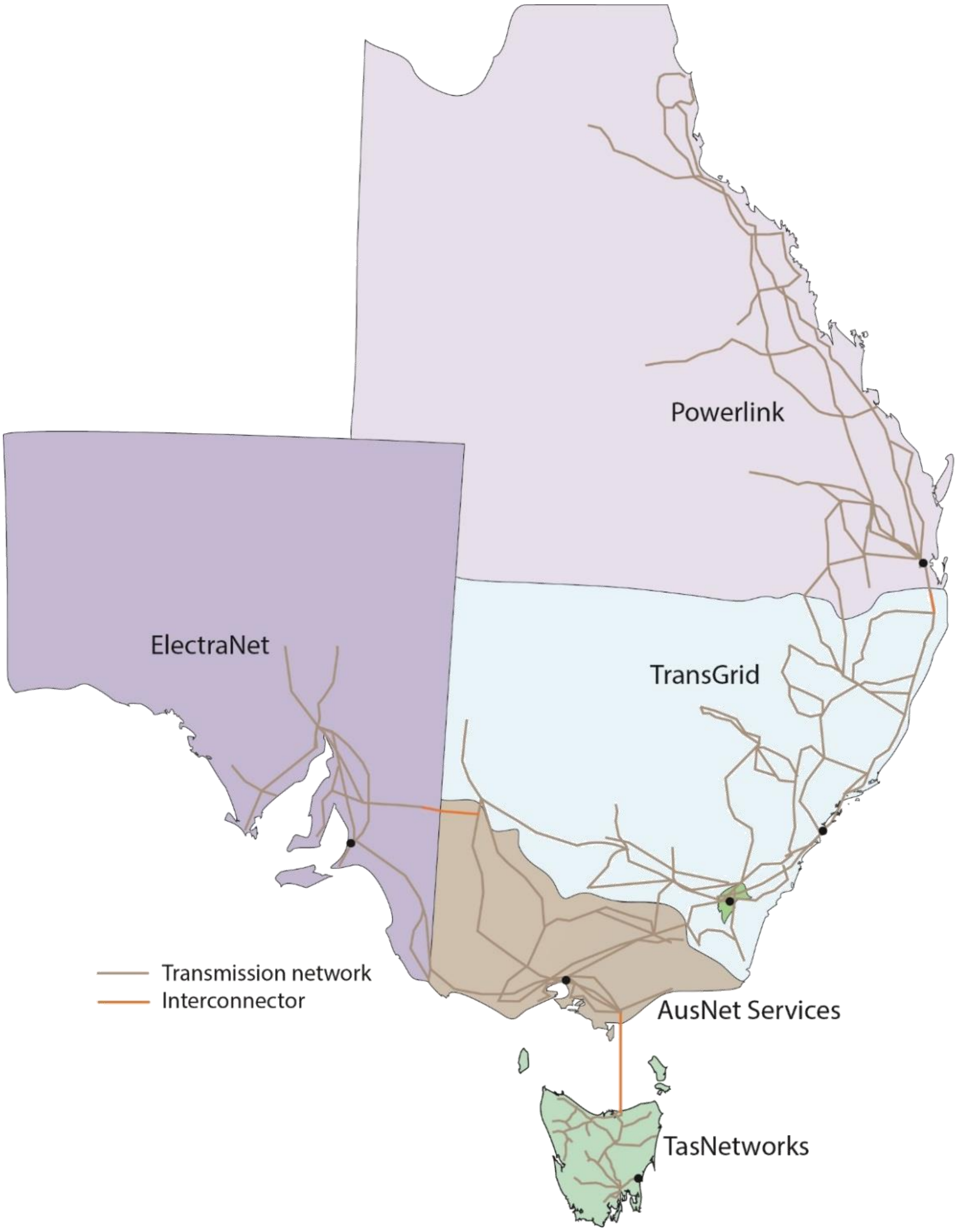
	Opex	Capex	RAB	Depreciation	Asset cost
ElectraNet	88,660	178,002	2,189,943	97,705	171,129
Powerlink	215,594	267,692	6,886,384	275,509	506,395
AusNet Services	90,235	157,731	2,955,061	160,093	259,170
TasNetworks	37,821	65,384	1,436,904	62,032	110,208
TransGrid	176,550	327,608	6,235,431	267,785	476,846

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



D Submissions

We sought comment from TNSPs on the benchmarking results presented in this report and received a submission from Powelink, which commented on a number of presentational issues.

This submission is available on the AER’s 2019 benchmarking website.