Annual Benchmarking Report

Electricity transmission network service providers

November 2015

AUSTRALIAN ENERGY REGULATOR

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Shortened forms

Shortened term	Full title
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
ANT	AusNet Services (transmission)
capex	Capital expenditure
ENT	ElectraNet
MTFP	Multilateral total factor productivity
NEL	National Electricity Law
NEM	National Electricity Market
NER	National Electricity Rules
opex	Operating expenditure
PLK	Powerlink
PPI	Partial performance indicator
RAB	Regulatory asset base
TNI	Transmission node identifiers
TNT	TasNetworks (transmission)
TNSP	Transmission network service provider
TRG	TransGrid

Glossary

Term	Description
Allocative efficiency	Allocative efficiency is achieved where resources used to produce a set of goods or services are allocated to their highest value uses (i.e., those that provide the greatest benefit relative to costs). In other words, goods and services are produced in the combination that consumers value the most. To achieve this, prices of the goods and services must reflect the productively efficient costs of providing those goods and services.
Dynamic efficiency	Dynamic efficiency reflects the need for industries to make timely changes to technology and products in response to changes in consumer tastes and in productive opportunity. Dynamic efficiency is achieved when a business is productively and allocatively efficient over time.
Inputs	Inputs are the resources TNSPs use to provide services.
MPFP	Multilateral partial factor productivity. MPFP is a PIN technique that measures the relationship between total output and one input.
MTFP	Multilateral total factor productivity. MTFP is a PIN technique that measures the relationship between total output and total input.
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. OEFs 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 DNSPs provide.
PIN	Productivity index number. PIN techniques determine the relationship between inputs and outputs using an index.
PPI	Partial performance indicator. PPIs are simple techniques that measure the relationship between one input and one output.
Productive efficiency	Productive efficiency is achieved when a business produces its goods and/or services at the least possible cost. To achieve this, the business must be technically efficient (produce the most output possible from the combination of inputs used) while also selecting the lowest cost combination of inputs given prevailing input prices.
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.

Contents

Overview

The AER regulates all electricity networks in the National Electricity Market (NEM). We set prices so that energy consumers pay no more than necessary for the safe and reliable delivery of electricity services. Benchmarking underpins this by enabling us, at an overall level, to identify the relative efficiency of electricity networks, and to track changes in efficiency over time.

This is the second annual benchmarking report. The benchmarking models presented in this report are the culmination of a substantial work program that commenced in 2012 after changes to the electricity rules removed impediments to the use of benchmarking in making regulatory determinations. For this program, we worked with leading economic experts and consulted extensively with the transmission network service providers (TNSPs) and electricity consumers to establish benchmarking data requirements, model specifications and a guideline setting out how benchmarking would be used in determinations. This has included adjusting the data in response to submissions to make it more consistent.

We consider that our benchmarking models are the most robust measures of overall efficiency available. At the same time, however, we recognise that there is no perfect benchmarking model, and have been cautious in our initial application of these results in recent determinations. Benchmarking is a critical exercise in assessing the efficiency of expenditure in regulatory proposals and we will continue to invest in refining our benchmarking techniques into the future.

This report uses a different format to our 2014 report, with less emphasis on technical detail. We have focused on an economic benchmarking technique—multilateral total factor productivity (MTFP)—as the primary technique to compare relative efficiency. MTFP is a sophisticated 'top down' technique that enables us to measure each TNSP's overall efficiency at providing electricity services.[1] In addition to MTFP, we present partial performance indicators (PPIs) and partial factor productivity measures.

Key messages

Productivity across the industry has been declining over the past several years. This can be seen in Figure 1 , which shows the combined industry inputs have, in most years, increased at a greater rate than outputs since 2008.

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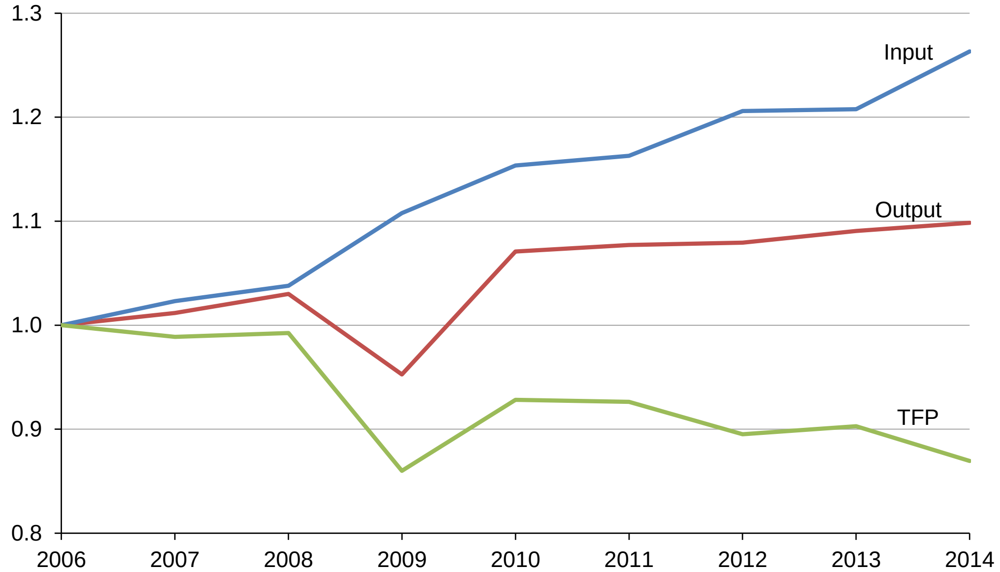
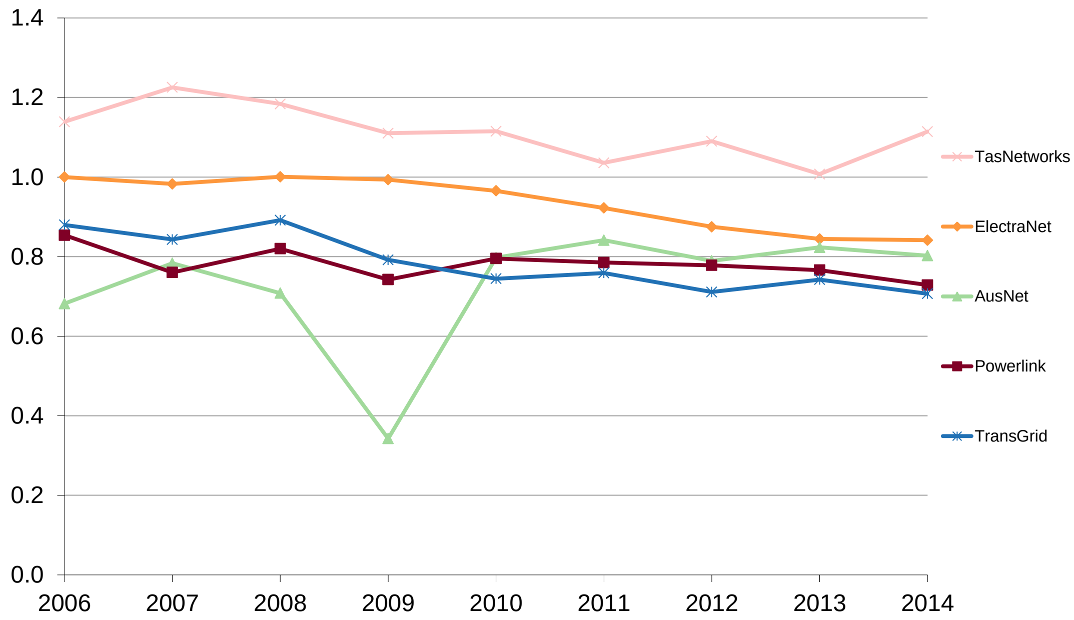
[1] This does not include interconnector networks and the distribution network service providers that operate subtransmission assets.

Figure 1 MTFP input, output and TFP indices for all TNSPs, 2006–14



This can also be seen in Figure 2, which shows the MTFP score for most TNSPs has been declining over the observation period.

Figure 2 Multilateral total factor productivity by TNSP for 2006–14



Note: In 2009 AusNet Services had large customer interruptions which is why AusNet performs poorly in this year.

The general decline in productivity is largely due to the use of resources to maintain, replace and augment the networks by TNSPs has been increasing at a rate greater than that of the demand for electricity network services. Notably, the productivity of most TNSPs converged in 2013, after a period of steady decline by ElectraNet.

Despite the general decline in productivity for most TNSPs over the observation period, in the 12 months between 2013 and 2014, the productivity of TasNetworks has improved significantly. TasNetworks' performance in 2014 exceeds that of all the other TNSPs in the NEM, as it has throughout the observation period. However, in 2014, due to the recent convergence in the performance of the other four TNSPs, the gap in performance between TasNetworks and its peers is larger than in previous years..

1 Introduction

This annual benchmarking report informs consumers about the relative efficiency of network service providers. It is prepared to facilitate greater consumer engagement and participation in network revenue decisions.

1.1 Who the report compares

The electricity industry in Australia is divided into four distinct parts, with a specific role for each stage of the supply chain—generation, transmission, distribution and retail.

Electricity generators are located usually near fuel sources, and often long distances from most electricity customers. The supply chain, therefore, requires networks to transport power from generators to customers:

- High voltage transmission lines transport electricity from generators to distribution networks in metropolitan and regional areas
- Distribution networks convert electricity from the high voltage transmission network into medium and low voltages and transport electricity from points along the transmission lines to residential and business customers.

This report focusses on the transmission sector. Five TNSPs (not including interconnectors) operate in the NEM. Appendix D presents a map of the NEM showing the service area for each TNSP.

Despite the existence of some differences between the operating environments of the TNSPs, they all supply electricity using the same technology and assets. This means they are natural comparators for benchmarking. Appendix A contains (among other things) references for further reading on benchmarking electricity networks overseas.

1.2 What the report measures

The core function of a TNSP is to provide consumers with access to electricity. This function must be undertaken in accordance with certain performance requirements, usually to achieve desired policy objectives including minimum service standards for delivering electricity safely and reliably.

The objective of this report is to benchmark the TNSPs to determine who provides electricity services, in accordance with requirements, most efficiently. Several approaches to benchmarking exist, which may be broadly classified into 'top down' and 'bottom up' techniques. Top down techniques measure a business's efficiency overall, which means they take into account efficiency trade-offs between components that make up the total.

Bottom up techniques, in contrast, separately examine the components that make up the total, often at a granular level. Components are then built up to form the total. In most cases, bottom up techniques are not effective at examining efficiency trade-offs between all of the different components of a TNSP's operations.[2] They are also resource intensive. Most regulators overseas use top down economic benchmarking techniques rather than bottom up techniques.[3]

This report presents top down benchmarking techniques, using an inputs and outputs framework. Inputs are the resources a TNSP uses to provide services (such as capital and labour) and outputs are measures that represent those services (such as the number of customers and how much electricity they need). The fewer inputs a TNSPs uses to provide outputs, the lower the cost of providing transmission services and, hence, the lower the price consumers pay for the services. The benchmarking techniques in this report examine the combination of inputs the TNSPs use to deliver their outputs.

Using the combination of resources to deliver outputs for the least possible cost is known as 'productive efficiency'. Productive efficiency is one of the three components of economic efficiency (productive, allocative and dynamic efficiency[4]) which is achieved when inputs are optimally selected and used in order to deliver outputs that align with customer preferences.

This report examines the TNSPs' productive efficiency in providing core network services. Measuring productive efficiency over time also provides an insight into the TNSPs' dynamic efficiency.

1.3 Reasons for measuring comparative performance

Comparative information on the performance of electricity TNSPs contributes to the wellbeing of all electricity consumers by encouraging improvements in the services they provide, particularly their cost effectiveness. This is important in an industry where the service providers are natural monopolies because they may not face the same pressures to operate efficiently as service providers in a competitive market. Consumers have limited means of gathering information about TNSP performance and very little opportunity to choose their TNSP or express their preferences by accessing services elsewhere.

Key reasons for reporting comparative performance information across jurisdictions are to:

- provide meaningful information to consumers and other stakeholders
- encourage participation and engagement in the AER's regulatory processes

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2 This is particularly the case with opex. However, it is should be recognised that for capex, in some cases, a bottom up assessment is useful in circumstances where a discrete number of projects to be undertaken can be clearly identified.

3 Bottom up techniques are not commonly used. One example, however, is in Spain where the regulator constructs a network reference model. This model designs large scale electricity distribution networks optimally, considering all technical features imposed on the actual distribution networks. The WIK Consult report referenced in Appendix A provides more detail on the Spanish bottom up model.

4 Refer to glossary for definitions.

- identify high performing TNSPs
- enable TNSPs to learn from peers that are delivering their services more efficiently
- generate additional incentives for TNSPs to improve their efficiency.

In addition to being useful for stakeholders, the comparative performance information in this report is relevant to our transmission determinations. For example, we use opex MPFP in assessing the forecast rate of change for opex.

2 Approach

This report uses top down benchmarking techniques to measure each TNSP's efficiency in delivering network services to consumers. In essence, we rank the TNSPs according to their relative efficiency of providing services in accordance with service standard obligations. We present three different types of techniques to do this, drawing on data provided by the TNSPs.

2.1 Inputs and outputs

Inputs are the resources a TNSP uses to provide services. The two inputs we focus on are opex and capital stock (assets). TNSPs spend opex to operate and maintain their assets. TNSPs invest in capital to replace or upgrade their assets and to expand their network for growth in customers or to increase the amount of electricity they can deliver.

Outputs are measures that represent the services the TNSPs provide. TNSPs provide customers with access to a safe and reliable supply of electricity, so the outputs we use in this report are circuit line length, maximum demand, energy throughput, voltage of entry and exit points and reliability. We consider these measures capture the total output faced by TNSPs effectively because:

- TNSPs transport electricity over long distances from generators to distribution networks and high voltage customers
- the network must be capable of delivering energy to customers when they need it, including at times when demand is at its greatest (maximum demand)
- TNSPs must provide their services in accordance with reliability standards and aim to minimise interruptions to electricity supply.

TNSPs also provide certain other services related to voltage stability and system security. However, the provision of these services does not differ significantly between TNSPs so we do not consider them as part of our benchmarking analysis.

Since TNSPs use multiple inputs to provide multiple outputs to customers, it is necessary to aggregate them to produce an efficiency measure. Appendix A contains references for further reading on how Economic Insights, our benchmarking expert, chose the inputs and outputs and produced the aggregate efficiency measure. Appendix B provides detail about the inputs and outputs used in this report.

2.2 Techniques

There are different types of top town benchmarking techniques. We present two types in this report:

- productivity index number (PIN) techniques
- partial performance indicators (PPIs).

These techniques each use different mathematical or econometric methods for relating outputs to inputs. Appendix A contains references to further reading on the PIN techniques used in this report.

2.2.1 Productivity index number techniques

PIN techniques use an index to determine the relationship between outputs and inputs. They measure productivity by constructing a ratio of inputs used for total output delivered. The PIN analysis used in this report is multilateral total factor productivity (MTFP). MTFP relates total inputs to total outputs.

The 'multilateral' method enables comparison of productivity levels and productivity trends. MTFP is the primary technique we use to compare relative efficiency in this report. We present the MTFP results in section 3.

2.2.2 Partial performance indicators

PPIs are simple techniques that relate one input to one output (contrasting with the above economic benchmarking techniques that relate inputs to multiple outputs). In this report, we consider the ratios of the transmission networks' total cost against their outputs of voltage weighted entry and exit points, circuit line length and maximum demand served. Section 4.2 contains the PPI results.

2.3 Data

All techniques in this report use data provided by the TNSPs in response to our economic benchmarking regulatory information notices (EB RINs). The EB RINs require all TNSPs to provide consistent data and is verified by the TNSP's chief executive officer and independently audited. This data has been subject to rigorous testing and validation by both Economic Insights and us.

2.4 Differences in operating environments

When benchmarking, it is important to recognise that TNSPs operate in different environments. Certain factors arising from a DNSP's operating environment are beyond its control. These factors, which we call 'operating environment factors' (OEFs) may influence a TNSP's costs and, therefore, its benchmarking performance.

The economic benchmarking techniques presented in this report capture key OEFs. For example MTFP takes into account a TNSP's assets and its connection, maximum demand and energy throughput densities. However, not all OEFs can be captured in the models. In our recent distribution determinations for the NSW, ACT and QLD DNSPs, we conducted a separate assessment of OEFs and made ex post adjustments to account for them. However, it would not be practical to make ex post adjustments to account for the differences between all operating environments relative to each other for the purposes of this report.

3 Multilateral total factor productivity results

This section presents the benchmarking results for MTFP, the primary technique used to measure overall relative efficiency. Results are presented over a nine-year period, from 2006 to 2014.

The output specification used in this analysis comprises energy throughput, circuit line length, ratcheted maximum demand,[5] voltage weighted entry and exit points and reliability. Reliability is measured by customer minutes off supply. It is a negative output because a decrease in supply interruptions is equivalent to an increase in output. The input specification is both opex and capital.

Opex is the observed opex spent on prescribed services. Capital is split into overhead lines, underground cables and transformers.

Further detail about the MTFP input and output specifications can be found in the Economic Insights publications referred to in Appendix A. Figure 3 displays the output and input indices and the resultant TFP index, combined for all TNSPs.

Figure 3 MTFP input, output and TFP indices for all TNSPs, 2006–14

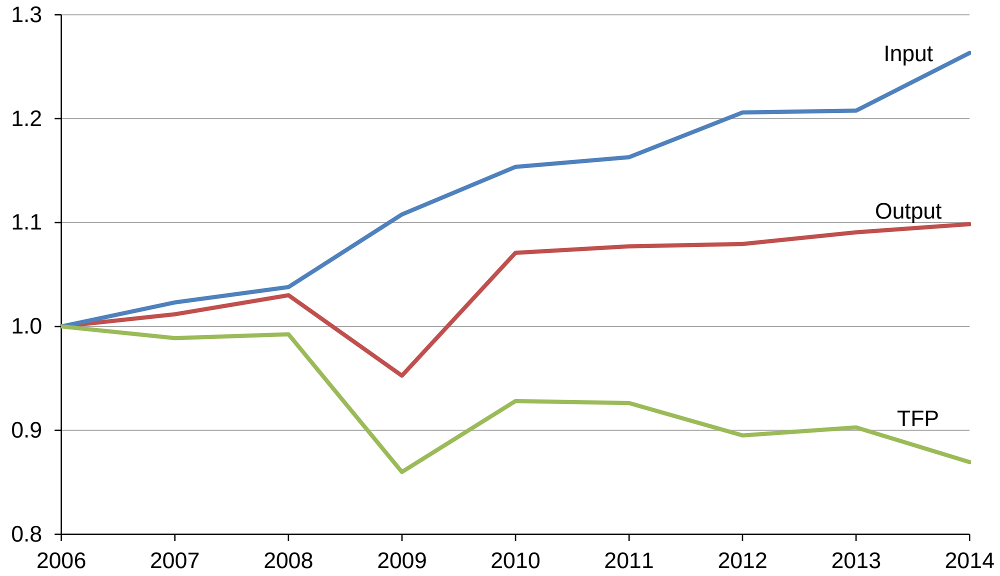


Figure 3 shows that since 2007, inputs have increased at a greater rate than outputs. In other words, TNSPs have been spending resources (opex and capital) at a greater rate than the key factors that drive the supply of electricity transmission services. This indicates productivity declining across the whole sector. With the exception of 2013,

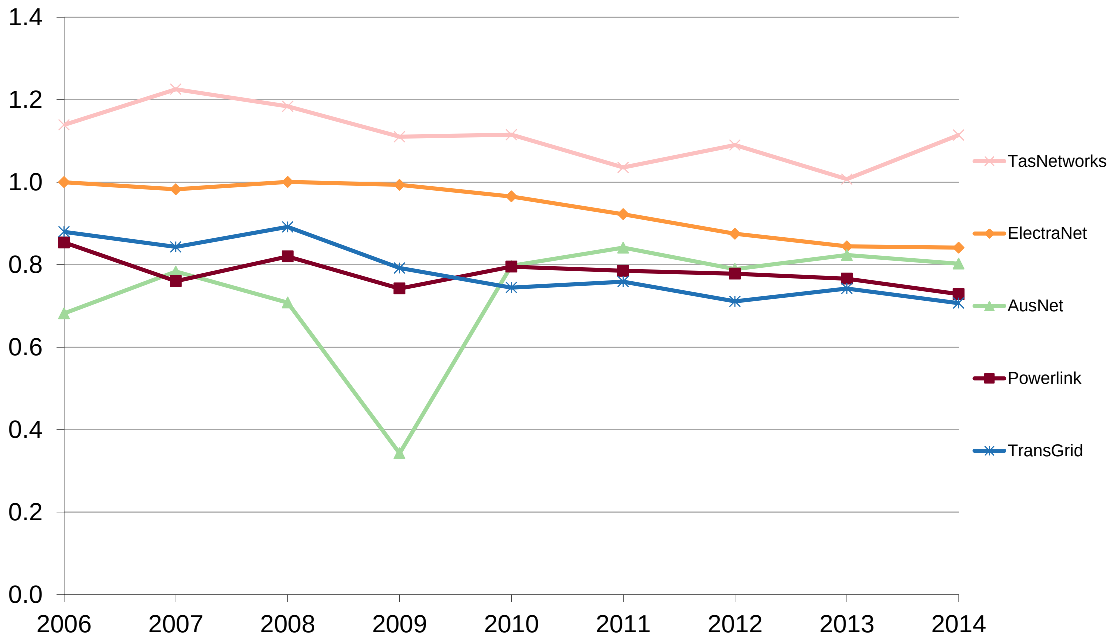
5 'Ratcheted' maximum demand is the highest value of maximum demand for each TNSP, observed in the time period up to the year in question. It recognises capacity that has been used to satisfy demand and gives the TNSP credit for this capacity in subsequent years, even though annual maximum demand may be lower in subsequent years.

which showed minimal positive productivity growth, there has been negative productivity growth each year. There are two reasons for this:

- most outputs have increased moderately or remained relatively flat in recent years
- TNSPs have been increasing the resources that they have been using to deliver their services.

Figure 4 presents the MTFP results for each TNSP. This illustrates that the productivity of most networks has declined from 2006 to 2014. AusNet Services is the only network to improve its productivity over the period. TasNetworks is the only network to improve its productivity from 2013 to 2014.

Figure 4 Multilateral total factor productivity by TNSP for 2006–14



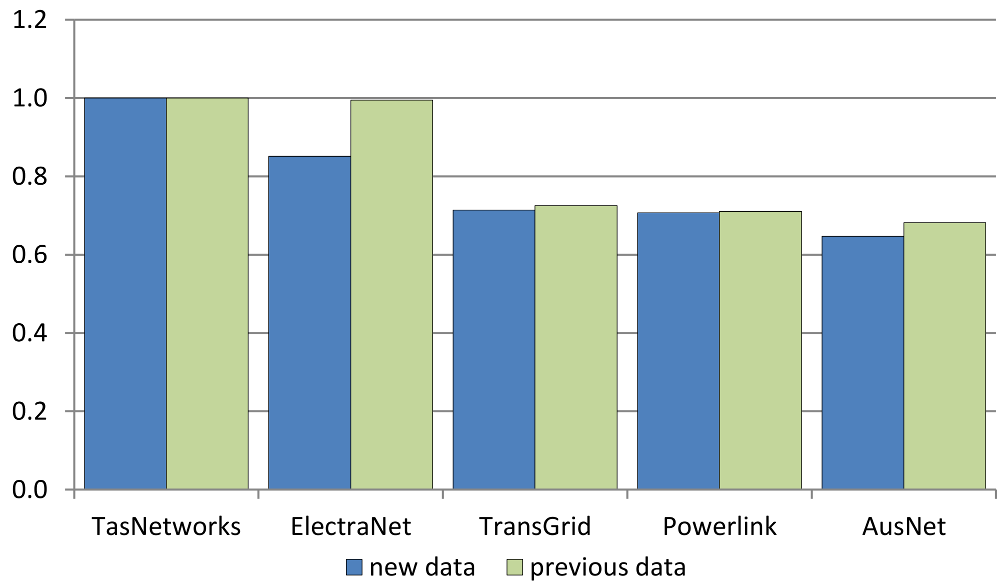
Note: In 2009 AusNet Services had large customer interruptions which is why AusNet performs poorly in this year.

In contrast to electricity distribution networks, where there has been a long history of benchmarking by international regulators, the benchmarking of transmission networks is relatively new. As a result, and because our models do not incorporate OEFs, the comparison of productivity levels between firms should be treated with caution. However, the MTFP scores indicate that TasNetworks has relatively high productivity level compared to the other TNSPs.

Further, we have made some changes to the MTFP series based on submissions made by the TNSPs that improves its comparability – particularly in regard to transformer capacity and entry and entry point data. Figure 5 compares the 2006 to

2013 average MTFP scores using the updated data and previous data. Using the new data, it can be seen that the performance of most TNSPs has remained similar. [6]

Figure 5 Average MTFP index scores for 2006–13[7]



3.1 Observations for 2013–14

A requirement of the annual benchmarking report is to present each TNSP's relative efficiency over a twelve month period. This section compares each TNSP's MTFP performance in 2014. It also compares each TNSP's average performance over the 2006–14 period because one off factors in a particular year can influence the results. It is, therefore, important to look at performance over a longer period of time.

Table 1 ranks each TNSP according to its period-average MTFP score and its 2014 score. The rankings in this table are indicative only because, as outlined in section 2.4, there may be other operating environment variables not captured in the MTFP model.

6 Specifically ElectraNet's connection point voltage decreased due to measuring the connection point voltage on the distribution side rather than the transmission side.

7 In this chart we have set TasNetworks' performance at 1 under both the new and old data. This is because we have not altered TasNetworks' data. This is necessary as ElectraNet is the base for the index. Graphing the raw scores would have shown all the networks improving rather than ElectraNet's performance falling (which is actually the case).

Table 1 TNSP MTFP rankings for 2014 and period-average

TNSP	Average Rank	2014 Rank	Average Score	2014 Score	2014 % change
TasNetworks	1	1	1.113	1.114	10.6%
ElectraNet	2	2	0.936	0.841	-0.4%
TransGrid	3	5	0.786	0.707	-4.8%
Powerlink	4	4	0.781	0.729	-4.9%
AusNet Services	5	3	0.730	0.802	-2.5%

Table 1 also shows the percentage change in score between 2013 and 2014. The last column in Table 1 shows the only TNSP who has improved its productivity between 2013 and 2014 is TasNetworks. All other TNSPs' MTFP performance declined in 2014. Both Powerlink and TransGrid had the largest declines in productivity with falls of 4.9 and 4.8 per cent respectively. AusNet Services had a decline of 2.5 per cent and ElectraNet had a marginal decline of 0.4 per cent.

4 Results from supporting techniques

For the purposes of this report, the techniques presented in this section support the MTFP results because they either measure relative efficiency of one input (MPFP) or provide a general indication of comparative performance (PPIs). They are, however, useful for assessing relative efficiency and we use all of them in our distribution determinations.

4.1 Multilateral partial factor productivity

The MPFP techniques use the same output specification (energy throughput, circuit line length, ratcheted maximum demand, voltage weighted entry and exit points and reliability) but examine the productivity of either opex or capital in isolation (rather than both). This is why they are 'partial' factor productivity metrics.

Figure 5 displays capital MPFP for all TNSPs over the 2006–14 period. The input specification is the same as the capital index in the MTFP model so it simultaneously considers the productivity of each TNSP's use of overhead lines and underground cables and transformers.

Figure 6 Capital partial factor productivity for 2006–14

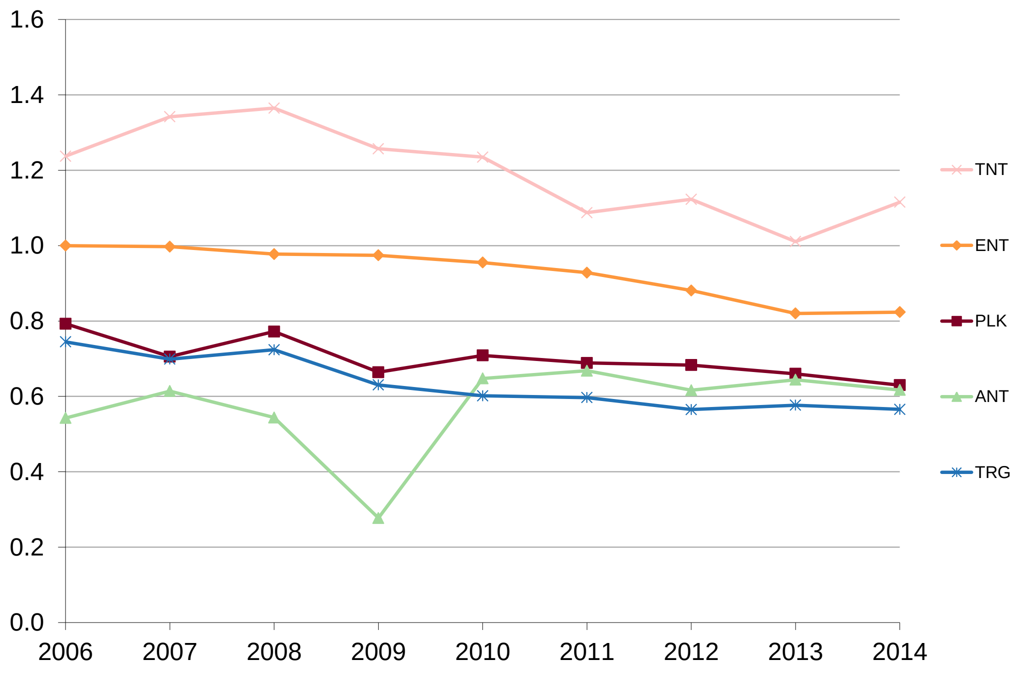
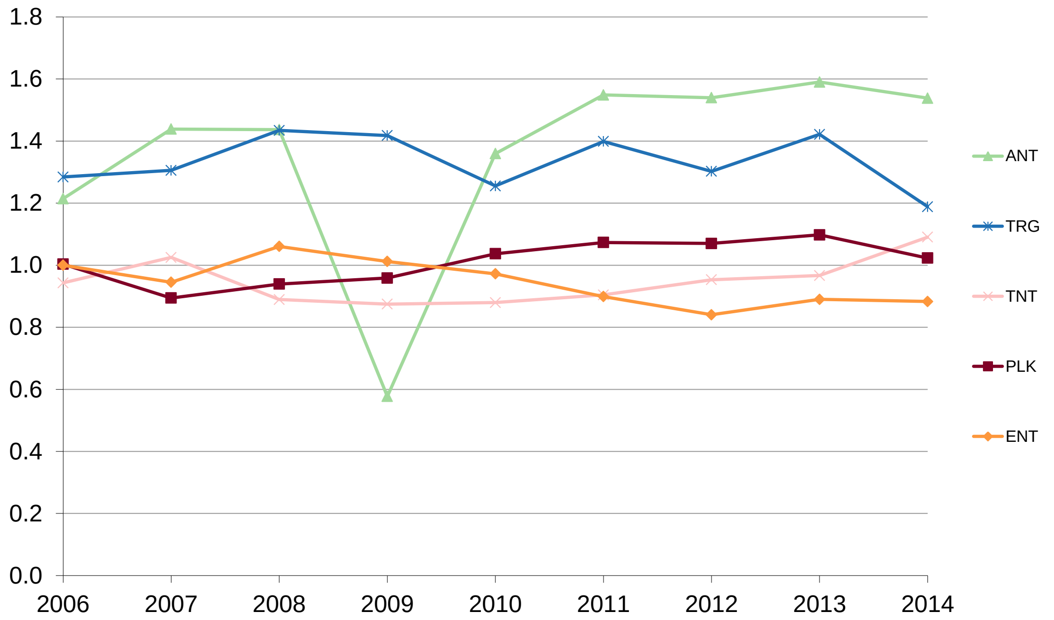


Figure 6 shows that the capital productivity for ElectraNet and TasNetworks has improved between 2013 and 2014. The capital productivity for the other TNSPs has declined moderately between 2013 and 2014.

Figure 7 displays opex MPFP for all TNSPs over the same period. There has been some variability in the opex partial productivity over the period. AusNet, Powerlink and

TasNetworks have improved their performance over the period. However, only TasNetworks has improved its opex MPFP performance in 2014.

Figure 7 Opex partial factor productivity for 2006–14



The ranking of the TNSPs changes somewhat under the two MPFP results, which reflects differing input combinations. AusNet and TasNetworks are two pertinent examples. AusNet performs poorly under the capital MPFP metric but performs well under the opex MPFP. TasNetworks is the opposite as it performs well under the capital measure and not as well under the opex measure.

4.2 Partial performance indicators

This section presents our PPI analysis. The PPIs support the MTFP results because they provide a general indication of comparative performance and are useful for assessing the relative efficiency of the TNSPs.

The inputs we use are the TNSPs' total cost, comprising opex and assets. The outputs we use are voltage weighted entry and exit points, circuit line length and maximum demand served. We examine each of these outputs below, noting that the appropriate measurement of transmission outputs is a matter of ongoing consideration.[8]

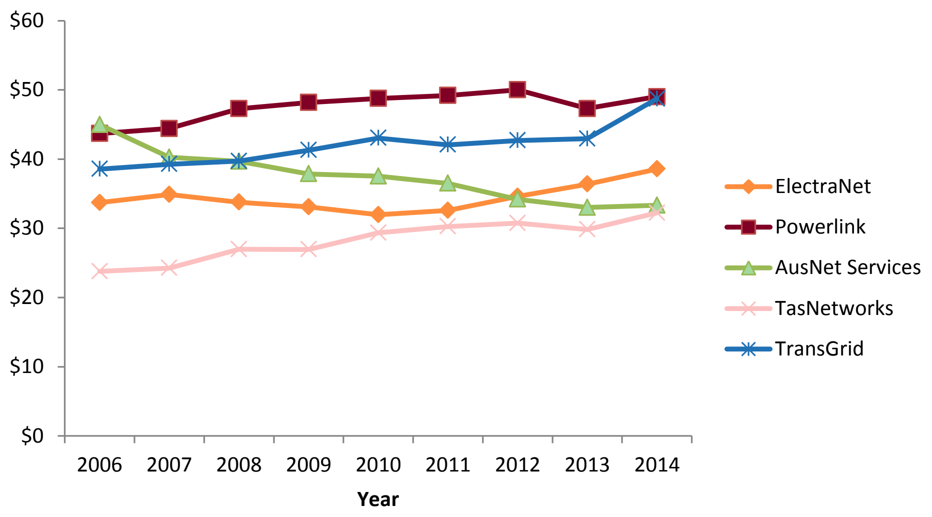
It is important to keep in mind that the Australian Energy Market Operator (AEMO) undertakes the augmentation procurement functions for AusNet Services' transmission network in Victoria. This is not the case for the other TNSPs in the NEM, who undertake these functions themselves. AusNet Services' reported total cost is therefore less than it otherwise would be if it had to capture all augmentation expenditure.

[8] This approach differs from the approach taken in our benchmarking report for electricity distributors. In our benchmarking report for the electricity distributors we chose to focus on input costs per customer.

All the PPIs in this report measure average costs over a five year period (from 2010 to 2014). We use an average to mitigate the effect of one-off changes in opex or assets in a particular year. Five years is the length of a typical regulatory period.

Figure 8 shows the total cost per kilovolt (kV) of entry and exit points.[9] In 2014, Powerlink and TransGrid continued to have the highest costs per entry and exit point voltage of all the transmission networks. TasNetworks has the lowest cost per voltage weighted connection point. We note that this measure potentially favours more dense transmission networks (where density is measured in terms of circuit km per voltage of connection points). The more dense transmission networks tend to have more entry and exit points per km and hence are required to maintain less lines per connection point. Figure 9 shows the connection density of the transmission networks.

Figure 8 Total cost per total kV of entry/exit points ($2014)



[9] As a result of changes to connection point data and removal of double counted TNIs (see section B.1.4), the results have changed somewhat since last year's report. The main change is that AusNet Services' cost per connection point has increased.

Figure 9 Connection density (kV of connection points per circuit km)

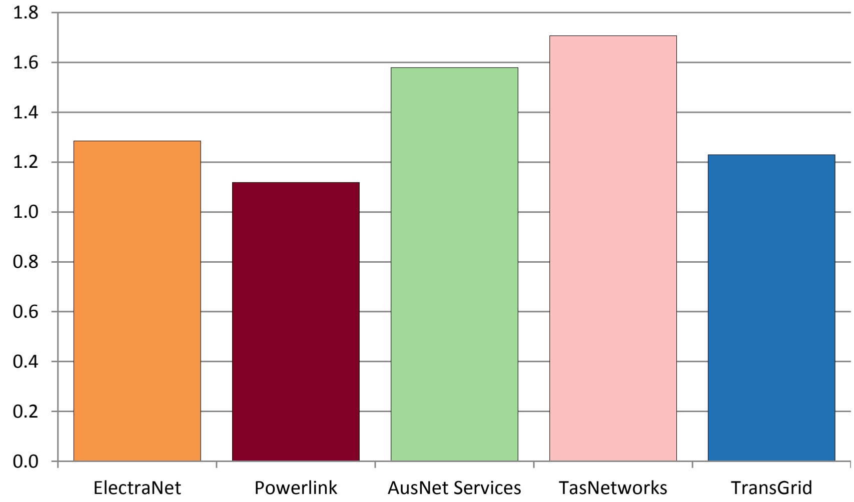


Figure 10 shows the cost per kilometre of circuit length. In 2014, most transmission networks incurred a total cost of approximately between $50,000 and $60,000 per circuit kilometre. ElectraNet has the lowest total cost in respect of this output with a total cost of $50,000 per circuit kilometre.

Figure 10 Total cost per km of transmission circuit length ($2014)

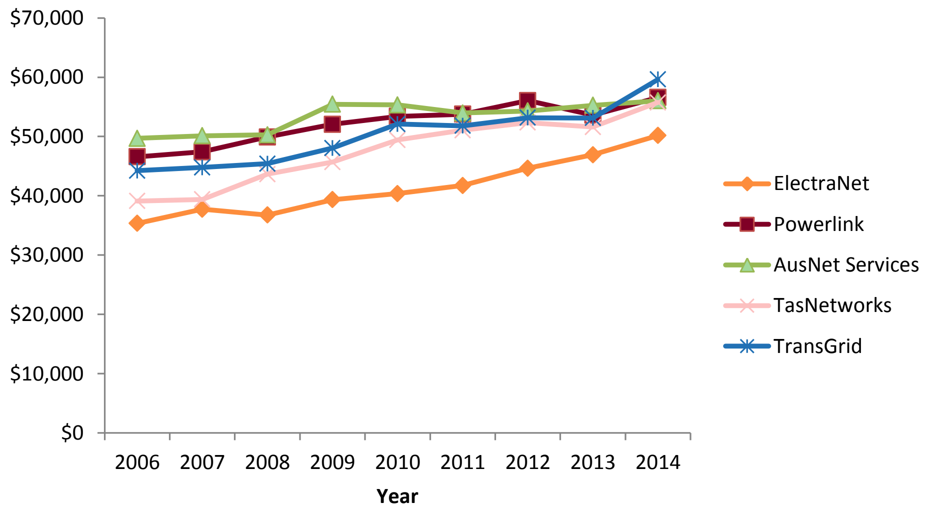
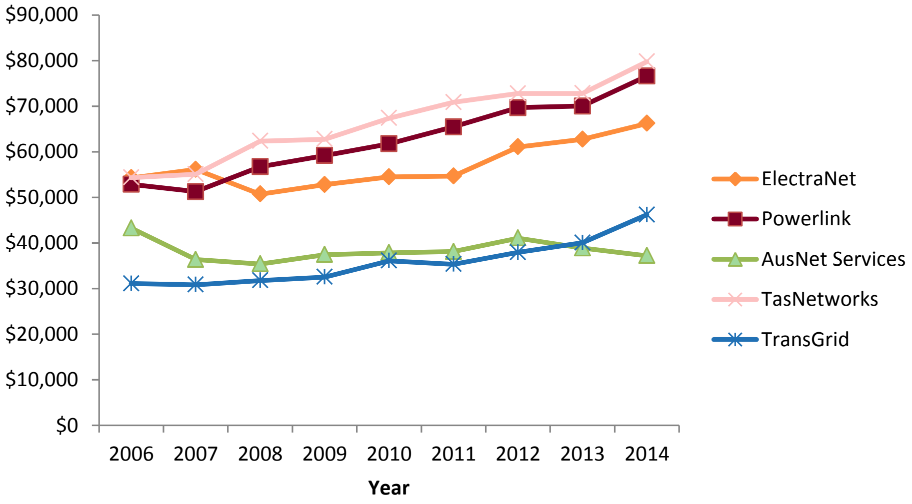


Figure 11 presents the total cost per MW of non-coincident maximum demand. The performance of TNSPs under this measure differs to the two PPI measures discussed above. Under this measure, TasNetworks has the highest total cost per MW of maximum demand. TransGrid and AusNet services have the lowest. TransGrid performs well under this measure as it has the highest maximum demand of all the networks. TasNetworks has the lowest maximum demand, which likely explains its high cost per MW of maximum demand.

Figure 11 Total cost per MW of maximum demand served ($2014)



5 Conclusions

Productivity across the industry has been declining over the past several years. Productivity is declining because the resources used to maintain, replace and augment the networks are increasing at a greater rate than the demand for electricity network services (measured in terms of maximum demand, line length, energy, and connection point kV). TasNetworks is the only network to improve its productivity in 2014 with a substantial 10.6 per cent improvement.

The supporting measures provide alternative measures of comparative performance. While, in some cases, the best and worst performers on a supporting metrics rank similarly to those on MTFP, the supporting techniques do not measure overall efficiency. PPIs examine efficiency in the use of only one output. The partial factor productivity measures only consider a single input. Therefore, the results of these measures while useful for assessing relative efficiency, will not be the same as they are for MTFP.

Appendices

A References and further reading

This benchmarking report is informed by several sources. These include ACCC/AER research and expert advice provided by Economic Insights. We retained Economic Insights to assist us with the economic benchmarking relied on in this report and in recent transmission determinations. References to relevant transmission determinations are also included below.

Economic Insights publications

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

- Economic Insights, *Memorandum – TNSP MTFP Results*, November 2015
- 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).

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 (link).

AER transmission determinations

In each of the following determinations, the AER applied economic benchmarking to determine efficient total forecast opex.

- AER, Draft decision, *TransGrid transmission determination 2015–16 to 2017–18 Attachment 7: Operating expenditure*, November 2014 (link).
- AER, *Final decision TransGrid transmission determination 2015−16 to 2017−18 Attachment 7 – Operating expenditure*, April 2015 (link).
- AER, *Draft decision TasNetworks transmission determination 2015–16 to 2018–19 Attachment 7: Operating expenditure*, November 2014 (link)

B Inputs and outputs

This appendix contains further information on the outputs and inputs used in the benchmarking techniques. The November 2014 Economic Insights report referenced in Appendix A explains the input and output specifications used in this report.

B.1 Outputs

The techniques in the report measure output using line length, energy transported, maximum demand, voltage of entry and exit points and reliability.

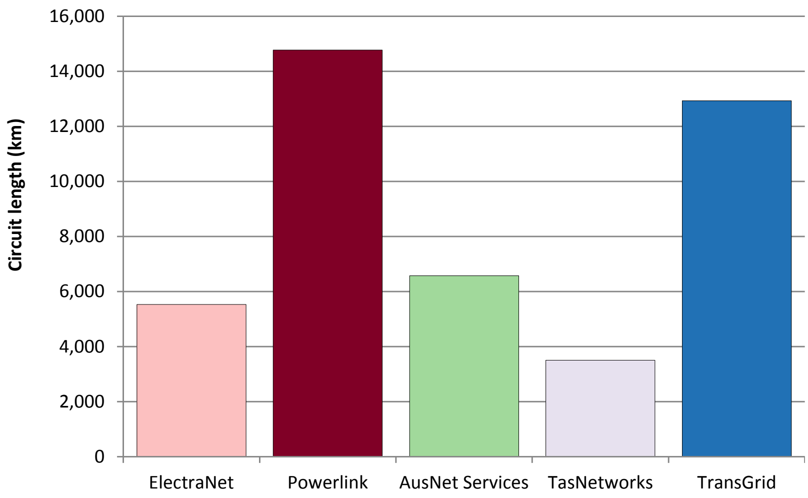
B.1.1 Line length

TNSPs must transport electricity between generators and downstream users. Line length reflects the distances over which TNSPs deliver electricity to downstream users from generators. TNSPs will typically operate networks that transport electricity over thousands of kilometres.

In this report, line length is measured in terms of circuit line length. The circuit line length 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.

In economic benchmarking metrics, we use circuit length because, in addition to measuring network size, it also approximates system capacity. System capacity represents the amount of network a TNSP must install and maintain to supply consumers with the quantity of electricity demanded at the places where they are located. Figure 12 shows each TNSP's circuit length, on average, over the five years from 2010 to 2014.

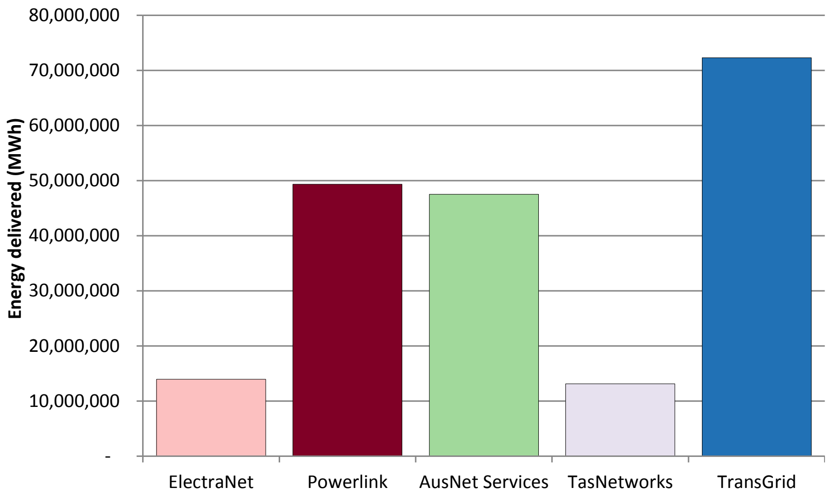
Figure 12 Five year average circuit length by TNSP (2010–14)



B.1.2 Energy throughput

Energy transported is the total volume of electricity throughput over time through the transmission network, measured in gigawatt hours (GWh).

Figure 13 Energy transported in 2014 (GWh)

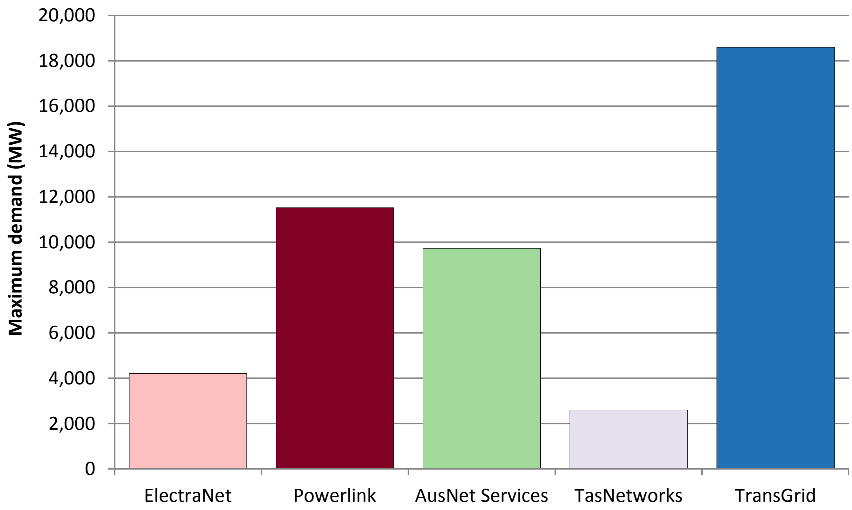


B.1.3 Maximum demand

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

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

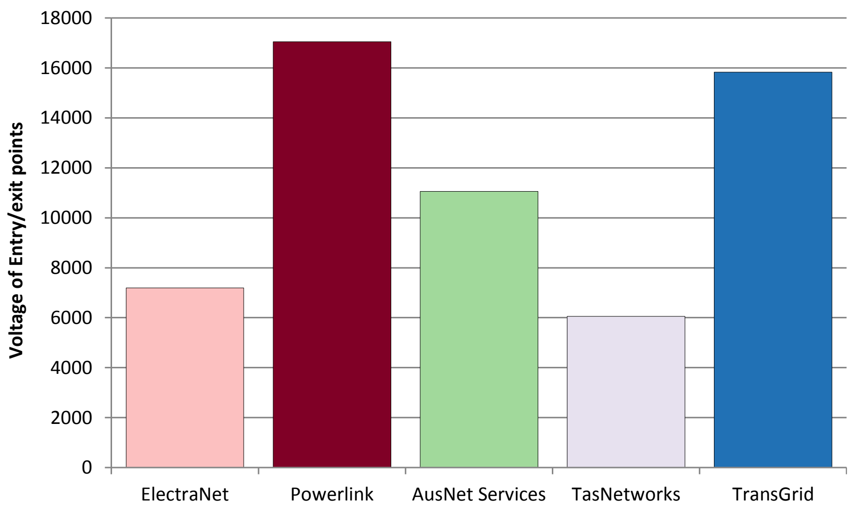
Figure 14 Maximum demand for 2014 (MW)



B.1.4 Voltage of entry and exit points

The number of entry and exit points represents the number of points to which a transmission network must connect. We use the summation of the total voltage of transmission node identifiers (TNIs) as the measure of the entry and exit points of the transmission networks.[10] The summation of the voltages of the connection points is required so that the aggregate measure reflects the differing sizes of TNIs across transmission networks. Specifically, higher voltage TNIs will typically require more assets as they will have a higher capacity. Where a single node services multiple distributors or a distributor and a generator, and hence has multiple TNIs, we have only counted this node once.

Figure 15 Aggregate voltage of entry and exit points (kV) for 2014



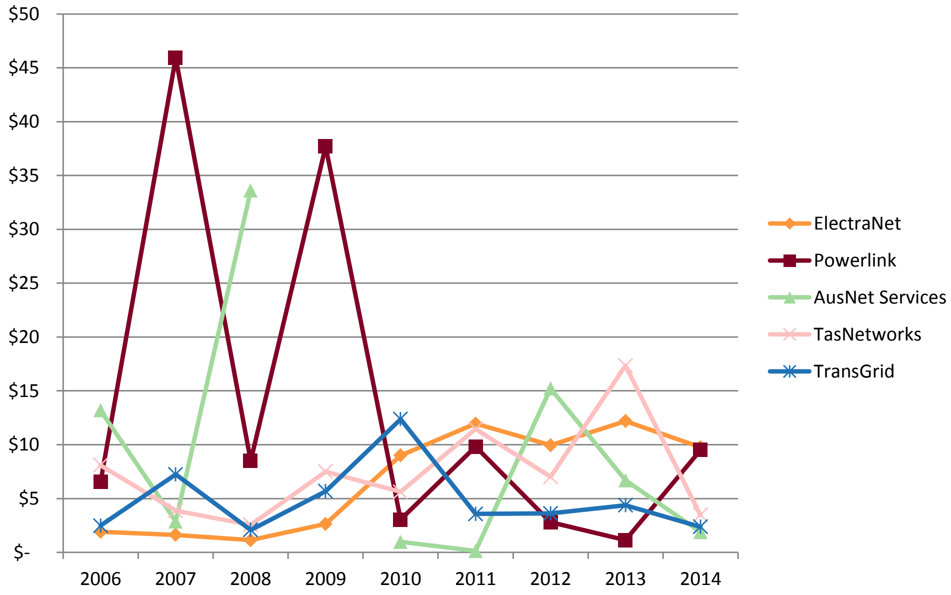
10 AEMO uses transmission node identifiers to calculate transmission losses. See: AEMO, List of NEM regions and marginal loss factors for the 2014-15 financial year, 5 June 2014, p. 7.

B.1.5 Reliability

Another dimension of the outputs of TNSPs is the reliability of their electricity supply. Transmission networks are designed to be very reliable because interruptions to supply at the level of transmission networks can affect a large number of consumers. One of the measures of transmission reliability is energy not supplied as a result of network outages (unsupplied energy). Unsupplied energy is a very small proportion of total energy (generally less than 0.005 per cent of all energy transported). However, the cost of transmission outages can be great. We have estimated the costs of unsupplied energy using AEMO's recently updated VCR values.[11] Figure 16 presents the estimated cost of unsupplied energy.

In the MTFP analysis, reliability has been measured using unsupplied energy as a negative output. Since 2010, unsupplied energy is relatively low for most transmission businesses. In Figure 16 we have excluded the cost of customer interruptions in AusNet Services' network for 2009 as these are anomalously large (about $400 million) and dwarf the other results.

Figure 16 Estimated customer cost of energy unsupplied due to supply interruptions ($million nominal)



B.1.6 Total outputs

Table 2 presents the average network outputs from 2009–14 for the TNSPs (with the exception of reliability).

[11] AEMO released its final report of its VCR review in September 2014, which provides updated state-level VCRs. Residential VCR values have not substantially changed since the 2007–08 values, although the values for the commercial sector are notably lower. AEMO, Value of customer reliability review: Final report, September 2014.

Table 2 TNSP outputs 2009–14 average

	Circuit line length (km)	Energy transported (GWh)	Maximum demand (MW)	Voltage of entry/exit points (KV)[12]
ElectraNet	5,518	14,006	4,130	7,092
Powerlink	13,970	50,518	11,139	15,642
AusNet Services	6,573	48,334	9,370	10,380
TasNetworks	3,495	12,991	2,504	5,964
TransGrid	12,777	67,700	17,700	15,714

B.2 Inputs

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

For our MTFP analysis we use physical measures of capital inputs. Using physical values for inputs has the advantage of best reflecting the physical depreciation profile of TNSP assets.[13] Our MTFP analysis uses three physical measures being the capacity of overhead lines, underground cables and transformers. The MTFP analysis also uses constant dollar opex as an input. The November 2014 Economic Insights report referenced in appendix A discusses this in further detail.

For the PPIs we use the constant price value of the regulatory asset base (referred to as 'asset cost') as the proxy for assets. Asset cost is the sum of annual depreciation and return on investment. 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.

Table 3 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.

[12] This is the sum of the voltage at each connection point.

[13] Economic Insights, *Memorandum TNSP MTFP Results*, July 2014, p. 5.

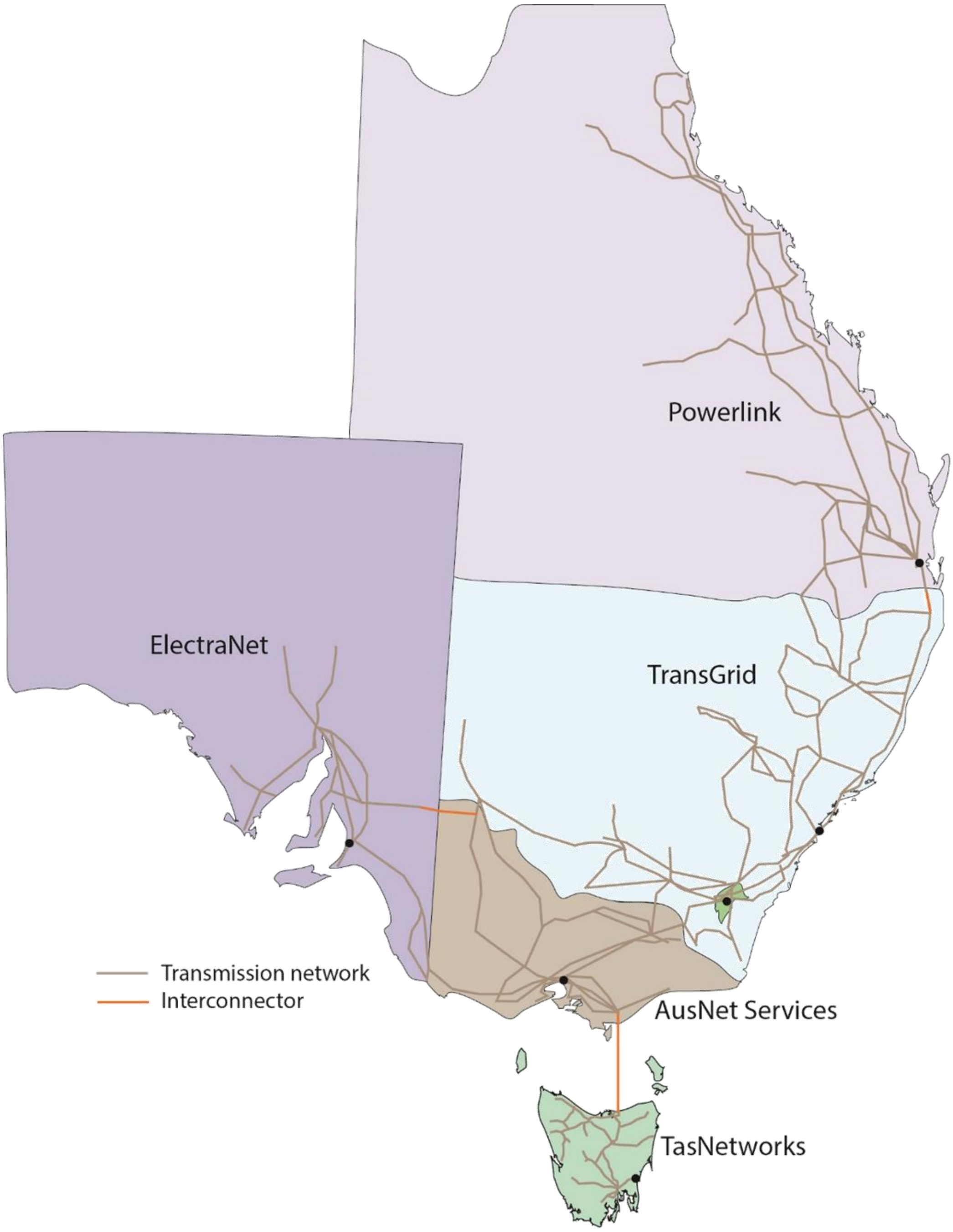
Table 3 Average annual costs for network inputs for 2010–14 ($m, 2014)

$2014 (‘000)	Opex	Capex	RAB	Depreciation	Asset cost
ElectraNet	72,926	179,199	1,660,216	72,991	174,148
Powerlink	174,657	546,104	5,882,794	231,076	589,517
AusNet Services	81,850	140,882	2,446,212	130,469	279,518
TasNetworks	50,002	137,447	1,193,223	59,173	131,877
TransGrid	161,804	422,562	5,252,530	207,969	528,008

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 17 illustrates the network areas for which the TNSPs are responsible.

Figure 17 Electricity transmission networks within the NEM



D List of submissions

We sought comment from TNSPs on a draft version of this report. We received submissions from:

- ElectraNet
- Grid Australia
- Powerlink
- TasNetworks
- TransGrid.

All submissions are available on our website.