# Annual Benchmarking Report

## Electricity transmission network service providers

November 2016

AUSTRALIAN ENERGY REGULATOR

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# Contents

# Shortened forms

| Shortened form | Extended form |
|---|---|
| AEMC | Australian Energy Market Commission |
| AEMO | Australian Energy Market Operator |
| AER | Australian Energy Regulator |
| ANT | AusNet Services (transmission) |
| capex | Capital expenditure |
| EB RIN | Economic Benchmarking Regulatory Information Notice |
| 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 |
| --- | --- |
| 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. It allows partial productivity levels as well as growth rates to be compared. |
| MTFP | Multilateral total factor productivity. MTFP is a PIN technique that measures the relationship between total output and total input. It allows total productivity levels as well as growth rates to be compared. |
| 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 TNSPs provide. |
| PIN | Productivity index number. PIN techniques determine the relationship between inputs and outputs using a mathematical index. |
| PPI | Partial performance indicator. PPIs 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. |
| VCR | Value of Customer Reliability. VCR represents a customer's willingness to pay for the reliable supply of electricity. |

# Overview

This benchmarking report sets out our findings on the overall efficiency of each transmission network service provider (TNSP) in the National Electricity Market (NEM).

This is the third annual benchmarking report. As with the previous reports, the benchmarking models presented in this report are the culmination of a substantial work program. This program commenced in 2012 after changes to the electricity rules removed impediments to the use of benchmarking in making regulatory determinations. We worked with leading economic measurement experts and consulted extensively with the TNSPs and electricity consumers to establish benchmarking data requirements, model specifications and a guideline setting out how benchmarking would be used in determinations.

We consider that the benchmarking analysis presented in this report is reasoned and comprehensive. At the same time, we recognise that benchmarking analysis is still in the development stage in its application to transmission networks. We will continue to invest in refining our benchmarking techniques into the future.

This report is based on the previous benchmarking reports we have released. The benchmarking techniques in this report are consistent with those presented in previous reports, but have been updated with data for 2015 by Economic Insights. 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. In addition to MTFP, we present partial factor productivity measures and Partial Performance Indicators (PPIs).

## Key messages

Overall, productivity across the industry has continued to decline. This can be seen in figure 1, which shows the combined industry inputs have increased at a greater rate than outputs since 2006.

Productivity has been declining because the resources used to maintain, replace and augment the networks are increasing at a greater rate than electricity network services delivered (measured in terms of voltage-weighted sum of connection points, line length, energy throughput, maximum demand and reliability). This is mainly attributable to the significant increase in capital inputs and thus the decline in capital productivity since 2007. The increase in opex is more modest, and opex productivity is relatively stable for the combined industry.

**Figure 1 Industry input, output and productivity indices, 2006 to 2015**

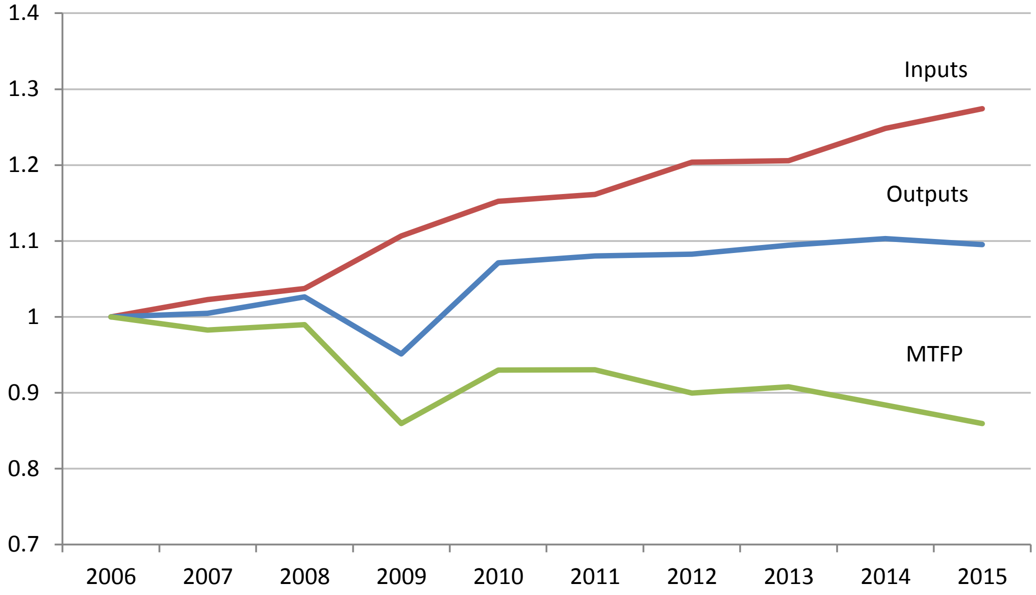
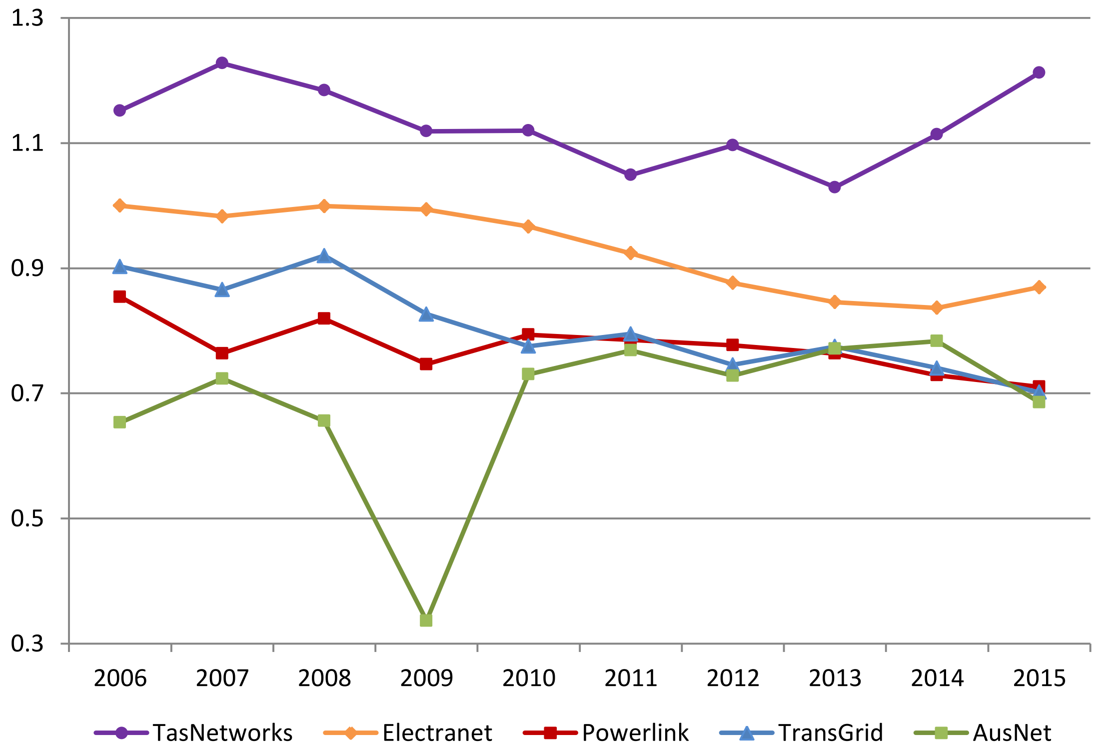



Figure 2 shows the declining industry productivity in 2015 has been driven by the declining productivity of AusNet Services, TransGrid and Powerlink. The results also show a notable exception to the overall downward trend is TasNetworks, which significantly improved its overall productivity between 2013 and 2015. ElectraNet also improved its productivity.

**Figure 2 Multilateral total factor productivity index by TNSP, 2006 to 2015**



# 1 Introduction

Electricity networks are 'natural monopolies' which, without regulation, could increase their prices above efficient levels and would face limited pressure to operate or invest efficiently. The AER regulates all electricity networks in the NEM. We set network 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 our third annual benchmarking report. It describes the relative efficiency of each TNSP in providing prescribed transmission services over a twelve month period. In doing this we consider the characteristics of each network, and how their productivity compares at the aggregate level and for each individual output they deliver.

This report is informed by expert advice provided by Economic Insights.[1] It presents the top down benchmarking techniques we use to measure each TNSP's efficiency in delivering network services to consumers. This ranks the TNSPs according to their relative efficiency of providing services in accordance with service standard obligations.

The benchmarking report examines the efficiency of transmission networks overall. This contrasts with our revenue determinations where we examine the efficiency of an individual TNSP's forecast opex and capex. We must have regard to the benchmarking report as part of our revenue determinations.[2] For example, we use opex MPFP in assessing the forecast rate of change for opex. But as part of a determination we are likely to also undertake additional modelling and benchmarking analysis that focuses on the opex and capex of the TNSP.

Reporting comparative performance information across jurisdictions:

- provides meaningful information to consumers and other stakeholders
- encourages participation and engagement in our regulatory processes
- identifies high performing TNSPs
- enables TNSPs to learn from peers that are delivering their services more efficiently
- generates additional incentives for TNSPs to improve their efficiency.

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1 Appendix A lists the Economic Insights publications which explain how it developed and applied the economic benchmarking techniques we used.

2 NER clause 6A.6.6(e)(4), 6A.6.7(e)(4).

## 1.1 Who the report compares

The electricity industry in Australia is divided into four 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. Networks transport power from generators to customers and this involves two stages:

- 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 focuses on the transmission sector. Five TNSPs (not including interconnectors) operate in the NEM. Appendix C presents a map of the NEM showing the service area for each TNSP.

## 1.2 Benchmarking techniques

Benchmarking approaches may be broadly classified into 'top down' and 'bottom up' techniques:

- Top down techniques measure a business's efficiency overall, taking into account efficiency trade-offs between components that make up the total.
- Bottom up techniques separately examine the components that make up the total, which are then built up to form the total. Bottom up techniques generally do not take into account efficiency trade-offs between all of the different components of a TNSP's operations.[3] They are also quite resource intensive to implement. Most regulators overseas use top down economic benchmarking techniques rather than bottom up techniques.[4]

This report presents top down benchmarking techniques which use an inputs and outputs framework. This examines the combination of inputs the TNSPs use to deliver their outputs. Inputs are the resources a TNSP uses (such as capital and labour) to provide services. Outputs are measures that represent those services (such as the number of customers and how much electricity they use).

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[3] 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.

[4] 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.

The report presents two types of top down benchmarking techniques. Each uses different methods for relating outputs to inputs (further information is at Appendix A):

- Productivity index number (PIN) techniques. These use a mathematical 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 techniques used in this report include:
  - Multilateral total factor productivity (MTFP). This relates total inputs to total outputs. The 'multilateral' method enables comparison of both productivity levels and productivity trends.
  - Multilateral partial factor productivity (MPFP). MPFP uses the same output specification as MTFP but examines the productivity of either opex or capital in isolation rather than both.
- Partial performance indicators (PPIs). These techniques relate one input to one output (contrasting with the above techniques that relate inputs to multiple outputs). They measure the average amount of input that is used to produce one unit of the chosen output.

MTFP is the primary technique we use to compare overall efficiency in this report. MPFP and PPIs are supporting techniques useful for assessing key aspects of efficiency and we take all of these into account in our revenue determinations.

## 1.3 Inputs and outputs

The benchmarking in this report examines the combination of inputs the TNSPs use to deliver their outputs. Inputs are the resources (such as capital and labour) a TNSP uses to provide services. Outputs are measures that represent those services (such as the line length and how much electricity they transport).

Since TNSPs use multiple inputs to provide multiple outputs to customers, we aggregate them to produce an efficiency measure. Appendix B has more information on our selection of inputs and outputs and how they are used in calculating the aggregate efficiency measure.

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. 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.
- Capital stock (assets). The physical assets TNSPs invest in to replace, upgrade or expand their network. We split capital into overhead lines, underground cables and transformers.

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. The outputs we use are:

- Line length. This is the distance over which TNSPs deliver electricity to downstream users from generators, measured in terms of circuit line length.
- Energy throughput. This is the total volume of electricity transmitted through the transmission network.
- 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.[5]
- Voltage-weighed sum 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.
- Reliability. 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, but the cost of transmission outages can be great. We have estimated the costs of unsupplied energy using AEMO's recently updated VCR values. [6]

Economic Insights (2014) details the input and output weights applied to constructing the productivity index numbers.[7]

## 1.4 Data

The benchmarking 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. We have tested and validated this data, and it is published on our website.[8] While no dataset is completely perfect, this dataset is the most consistent and thoroughly examined dataset of the transmission networks yet assembled in Australia.[9]

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5 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 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.

6 AEMO, *Value of customer reliability review: Final report*, September 2014.

7 The reference to the document is listed in Appendix A.

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

9 Economic Insights, *Economic benchmarking assessment of operating expenditure for NSW and Tasmanian electricity TNSPs*, November 2014, p. 3.

## 1.5 Differences in operating environments

When 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. [10]

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 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.

## 1.6 Limitations of transmission benchmarking

Transmission networks have undertaken cost benchmarking for a number of years, but whole of business benchmarking of electricity transmission networks is in its relative infancy. Compared to electricity distribution networks there have not been many whole of business benchmarking studies of transmission networks.

We have not drawn conclusions on the relative efficiency of the transmission networks because the relative rankings observed are currently sensitive to the model specification. MTFP analysis is in its early stage of development in application to transmission networks. Further, there are only a few electricity transmission networks within Australia which makes efficiency comparisons at the aggregate expenditure level difficult.

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

[10] We note the Australian Energy Market Operator (AEMO) undertakes the augmentation procurement functions for AusNet Services' transmission network in Victoria. Other TNSPs in the NEM undertake these functions themselves. As a result AusNet Services' reported total cost is less than it otherwise would be if it had to capture all augmentation expenditure. We expect this would have a small impact on the benchmarking results.

# 2 Benchmarking results

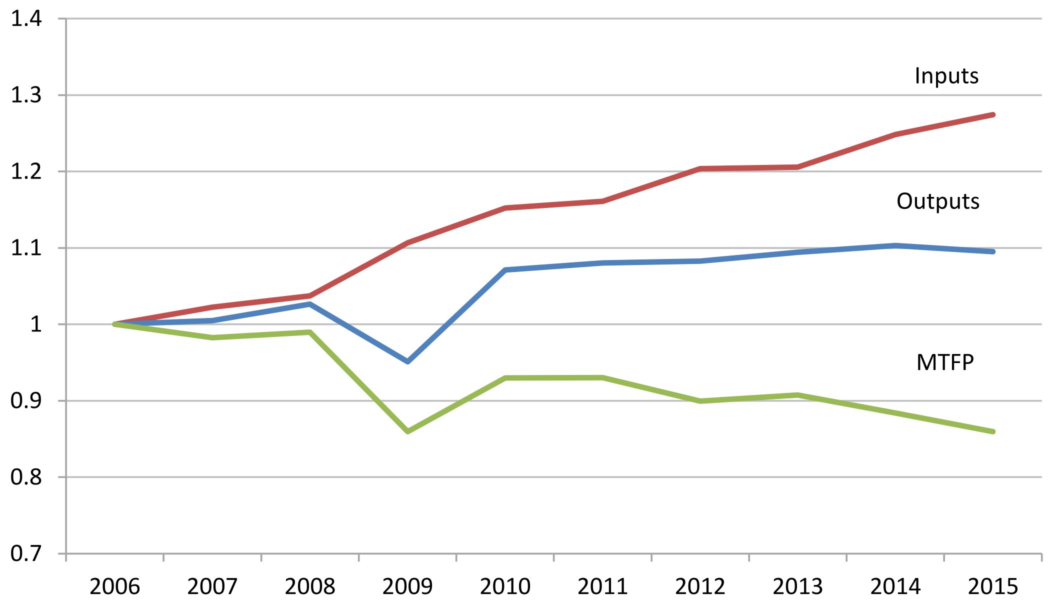
## 2.1 Multilateral total factor productivity results

This section presents the benchmarking results for the MTFP benchmarking technique. This is the primary technique we use to measure overall efficiency.

### 2.1.1 Industry MTFP

Figure 3 presents the industry (all TNSPs combined) output and input indices and the resultant productivity index over a ten year period from 2006 to 2015. It shows the declining productivity trend for the industry has continued in the twelve months between 2014 and 2015.

**Figure 3 Industry input, output and productivity indices, 2006 to 2015**



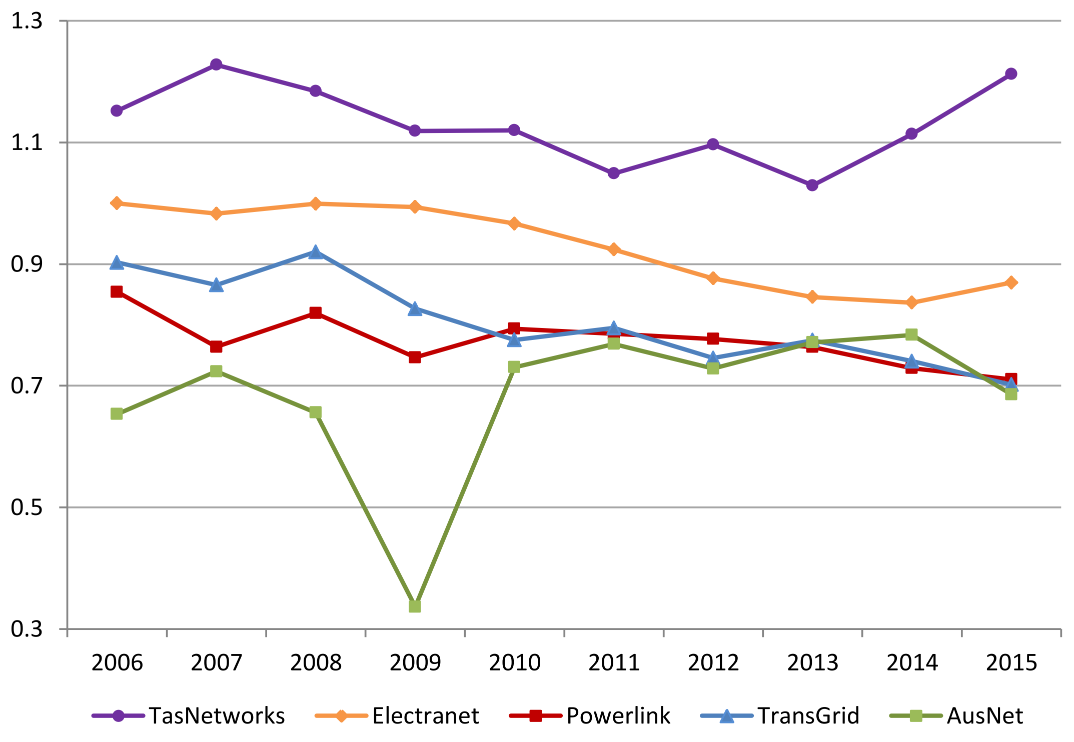

Since 2007 inputs have increased at a greater rate than outputs. That is, the rate of growth in expenditure has exceeded the rate of growth in the key factors that impact the supply of transmission services, such as demand. In particular, capital inputs have increased significantly while the increase in opex has been relatively modest. As such the measure of productivity is declining across the sector, with the exception of 2013 which showed small positive productivity growth.

### 2.1.2 MTFP by TNSP

Figure 4 presents the MTFP results for each TNSP over the 2006 to 2015 period. The individual productivity results show the declining industry trend between 2014 and 2015 has been driven by the declining productivity of AusNet Services, TransGrid and Powerlink. The results also show a notable exception to the overall downward trend is TasNetworks, which significantly improved its overall efficiency between 2013 and

2015. The productivity of ElectraNet slightly improved. The 2015 results are presented in more detail in table 1.

### Figure 4 MTFP index by TNSP 2006 to 2015




Note: In 2009 AusNet Services' MTFP result was significantly lower as it had large customer interruptions.

### 2.1.3 Observations for 2014–15

Consistent with the rules, this report describes the relative efficiency of each transmission network service provider in 2015.[11] Table 1 ranks each TNSP according to its 2015 MTFP score and its period-average.[12] We compare 2015 performance and average performance from 2006 to 2015 because one-off factors in a particular year can influence the results. Table 1 also shows the percentage change in score between 2014 and 2015, and between the period average and 2015. TasNetworks and ElectraNet improved their productivity from 2014, while AusNet Services, TransGrid and Powerlink's productivity decreased.

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11 NER, Cl. 6A.41.

12 There have been a small number of data revisions to the economic benchmarking regulatory information notice data included in the MTFP analysis. Most of these relate to calculation of the voltage–weighted entry and exit points output variable and the MVA rating of lines. TransGrid has revised its numbers of entry and exit points for the whole period. AusNet, ElectraNet and TransGrid have made minor refinements to the MVA rating of particular line categories in some years. ElectraNet has corrected an error in its reported maximum demand data for 2014. In addition, the latest WACC data are used and a change has been made to the method used to index the value of consumer reliability (VCR).

## Table 1 TNSP MTFP scores and rankings

| TNSP | Rank (average) | Rank (2015) | Score (average) | Score (2015) | % change between average and 2015 | % change between 2014 and 2015 |
|---|---|---|---|---|---|---|
| TasNetworks | 1 | 1 | 1.131 | 1.213 | 7.26% | 8.84% |
| ElectraNet | 2 | 2 | 0.930 | 0.870 | -6.44% | 3.94% |
| TransGrid | 3 | 4 | 0.805 | 0.702 | -12.80% | -5.22% |
| Powerlink | 4 | 3 | 0.774 | 0.711 | -8.22% | -2.49% |
| AusNet Services | 5 | 5 | 0.684 | 0.686 | 0.29% | -12.47% |

Note: Period average is for 2006–15.

The rankings in table 1 are only indicative of relative performance because there may be other operating environment variables not captured in the MTFP model.

There has been a long history of benchmarking by international regulators for electricity distribution networks. In contrast, the benchmarking of transmission networks is relatively new. As a result, and because our models cannot directly incorporate all relevant OEFs, the comparison of productivity levels between TNSPs should be treated with caution.

## 2.2 Results from supporting benchmarking techniques

### 2.2.1 Multilateral partial factor productivity

The MPFP techniques use the same output specification as the MTFP technique 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 from 2006 to 2015. The input specification is the same as the capital index in the MTFP model, so this considers the productivity of each TNSP's use of overhead lines, underground cables and transformers at the same time. Figure 5 shows a declining trend in capital productivity. In 2015, ElectraNet improved its capital productivity. Capital productivity for TasNetworks and Powerlink remained relatively steady while capital productivity for TransGrid and AusNet Services fell.

**Figure 5 Capital partial factor productivity index, 2006 to 2015**

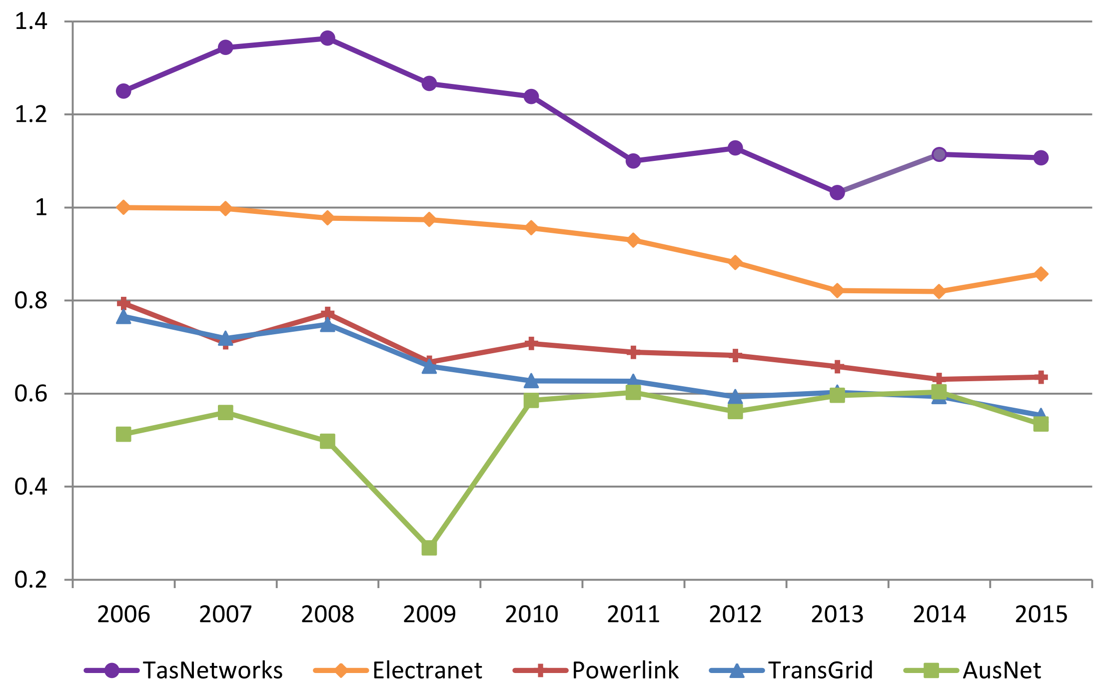
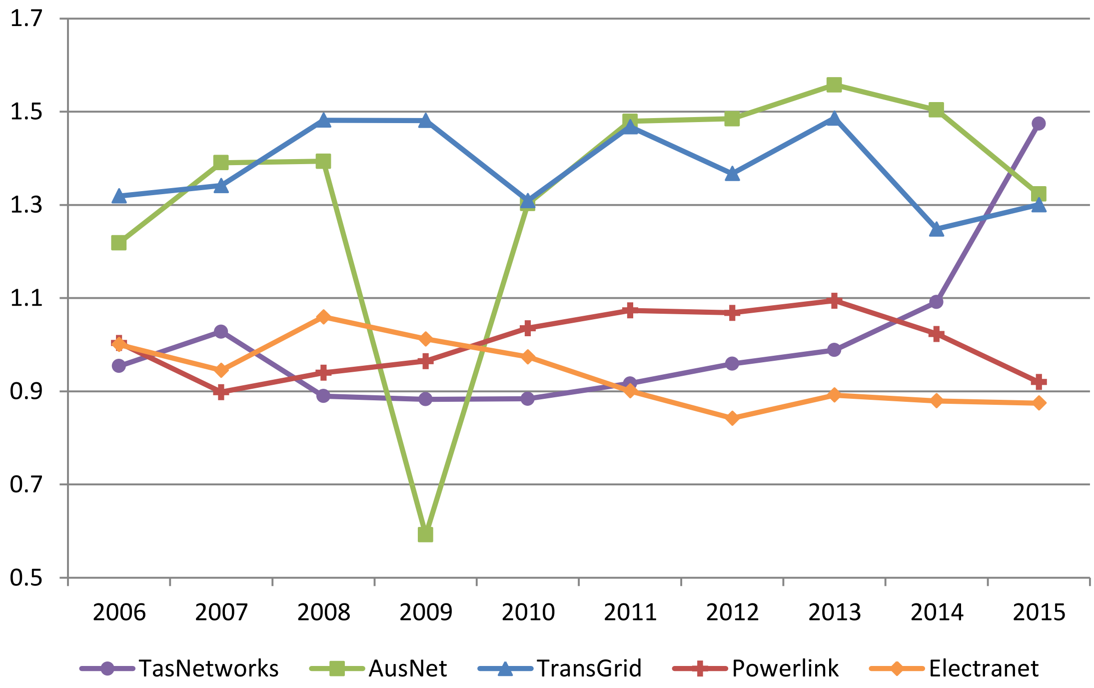


Figure 6 displays opex MPFP for all TNSPs over the same period. TasNetworks and AusNet Services are the only two service providers whose opex productivity has increased since 2006. In 2015, TasNetworks significantly improved its opex productivity. TransGrid had a moderate improvement in opex productivity. ElectraNet remained relatively stable while AusNet Services' and Powerlink's opex productivity declined. Powerlink attributed its opex increases to redundancy costs associated with downsizing in line with a flat or falling demand forecast outlook, and writing off non-proceeding capital works.[13]

## Figure 6 Opex partial factor productivity index, 2006 to 2015




The ranking of the TNSPs changes somewhat under the two MPFP results, which reflects differing input combinations. For example, AusNet Services is ranked lower under the capital MPFP metric but ranks higher under the opex MPFP. Conversely, ElectraNet ranks higher under the capital measure and lower under the opex measure.

[13] Powerlink, *Submission on 2016 Draft Annual Benchmarking Report – Electricity TNSPs*, 17 October 2016, p. 3.

### 2.2.2 Partial performance indicators

PPIs provide a simple visual representation of the input costs used to produce particular outputs. The PPIs we use support the MTFP analysis because they provide 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 the user cost of assets. The outputs we use are voltage-weighted sum of entry and exit points, circuit line length, maximum demand served and energy transported. We examine each of these outputs below, noting that the appropriate measurement of transmission outputs is a matter of ongoing consideration.

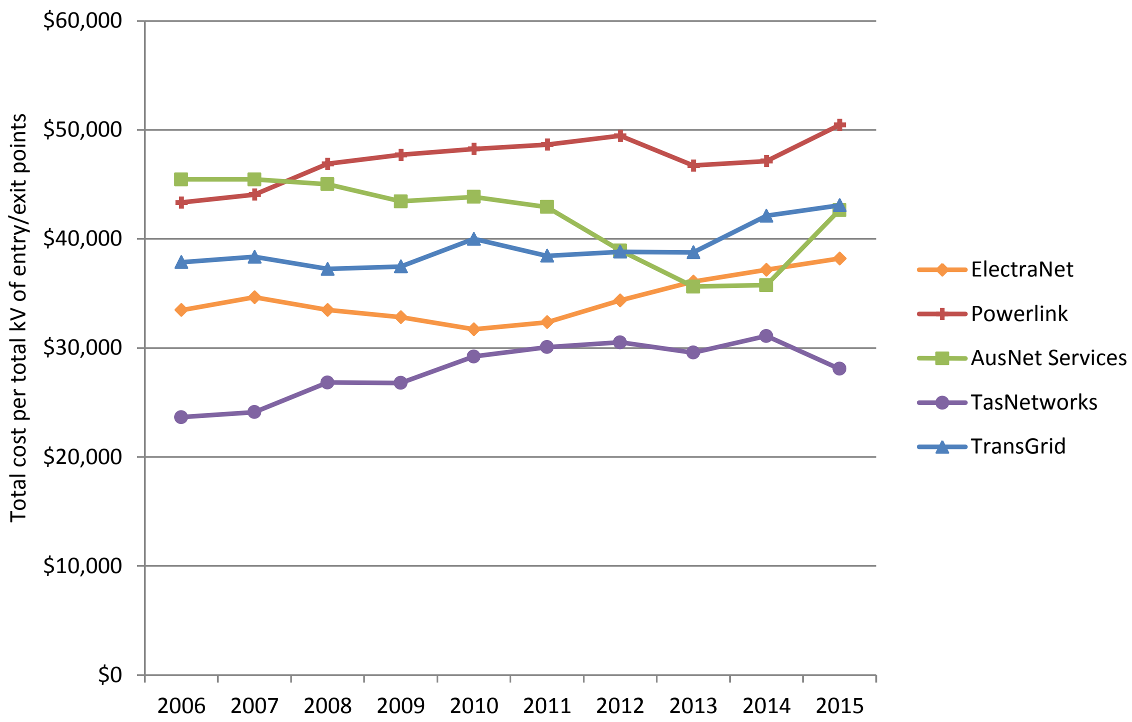
Finally, we note that TasNetworks has genearlly improved its performance on the PPI metrics in 2015. In particular, for all the outputs other than energy transported, TasNetworks' cost per unit decreased from 2014 to 2015, while all of the other transmission networks' costs per unit increased. This improvement in performance is likely explained by efficiencies gained when TasNetworks merged with the distribution network in Tasmania.

#### *Total cost per kilovolt (kV) of entry and exit points*

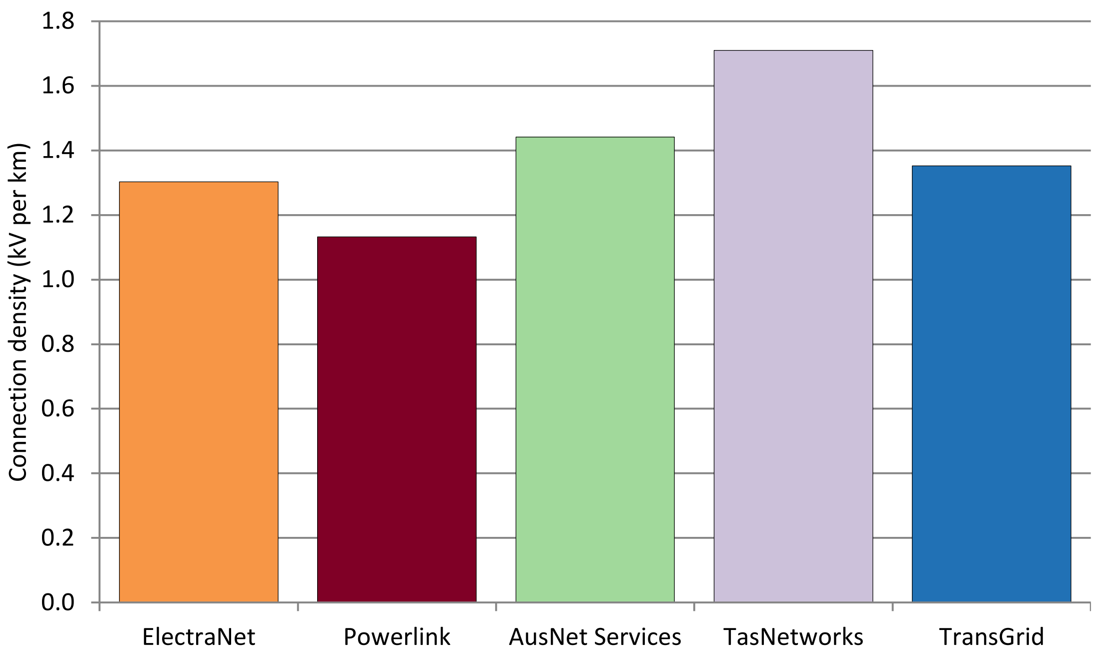
Figure 7 shows the total cost per kilovolt (kV) of entry and exit points. In 2015, Powerlink continues to have the highest cost per entry and exit point voltage of all the transmission networks. TasNetworks continues to have the lowest cost per entry and exit point voltage.

We note this measure potentially favours more dense transmission networks (where density is measured in terms of voltage of connection points per circuit km). The more dense transmission networks tend to have more entry and exit points per km and hence are required to maintain fewer lines per connection point. Figure 8 shows the average connection density of the transmission networks over the years 2011 to 2015. From this, Powerlink has the lowest connection density, whereas TasNetworks has the highest connection density.

## Figure 7 Total cost per kV of entry/exit points ($2015), 2006 to 2015



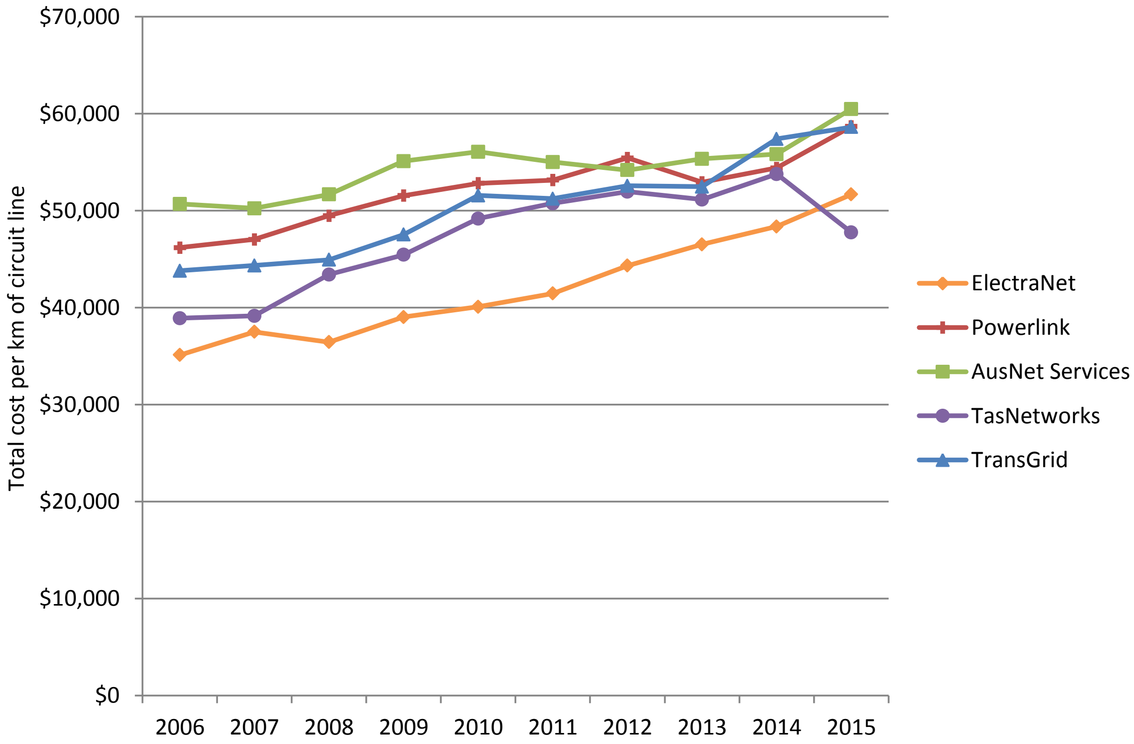

## Figure 8 Connection density (kV of connection points per circuit km, 2011–15 average)



### *Total cost per km of transmission circuit length*

Figure 9 shows the cost per kilometre of circuit length. In 2015, most transmission networks incurred a total cost of between approximately $45,000 and $60,000 per circuit kilometre. In 2015, TasNetworks has the lowest cost per kilometre of circuit length, whereas AusNet Services, Powerlink and TransGrid have the highest cost per kilometre of circuit length. We note this measure potentially favours transmission networks with lower connection densities because they have to service fewer connections per km.

**Figure 9 Total cost per km of transmission circuit length ($2015), 2006 to 2015**

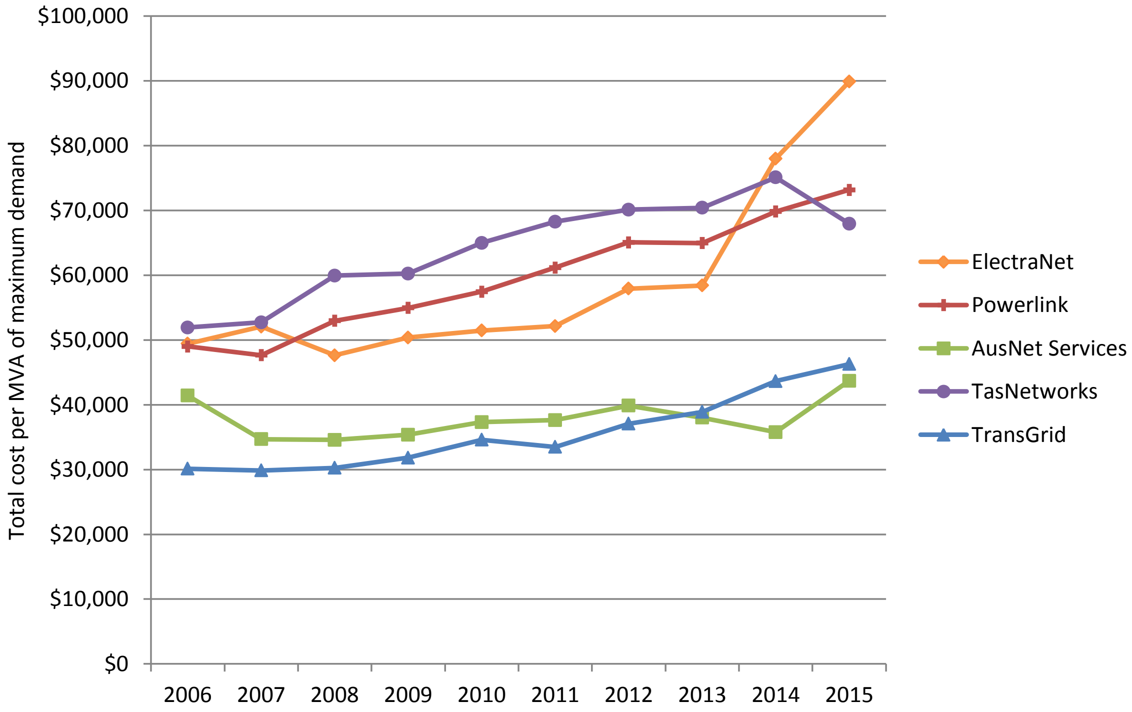



### *Total cost per MVA of non-coincident maximum demand*

Figure 10 shows the total cost per MVA of non-coincident maximum demand. Under this measure, ElectraNet has the highest cost per MVA of maximum demand in 2014 and 2015.[14] This is mostly due to a substantial drop in maximum demand over 2014 and 2015. TransGrid and AusNet Services have the lowest cost per MVA of maximum demand (over the entire period).

14 ElectraNet, Email 27 October 2016, ElectraNet stated that maximum demand declined due to transmission losses.

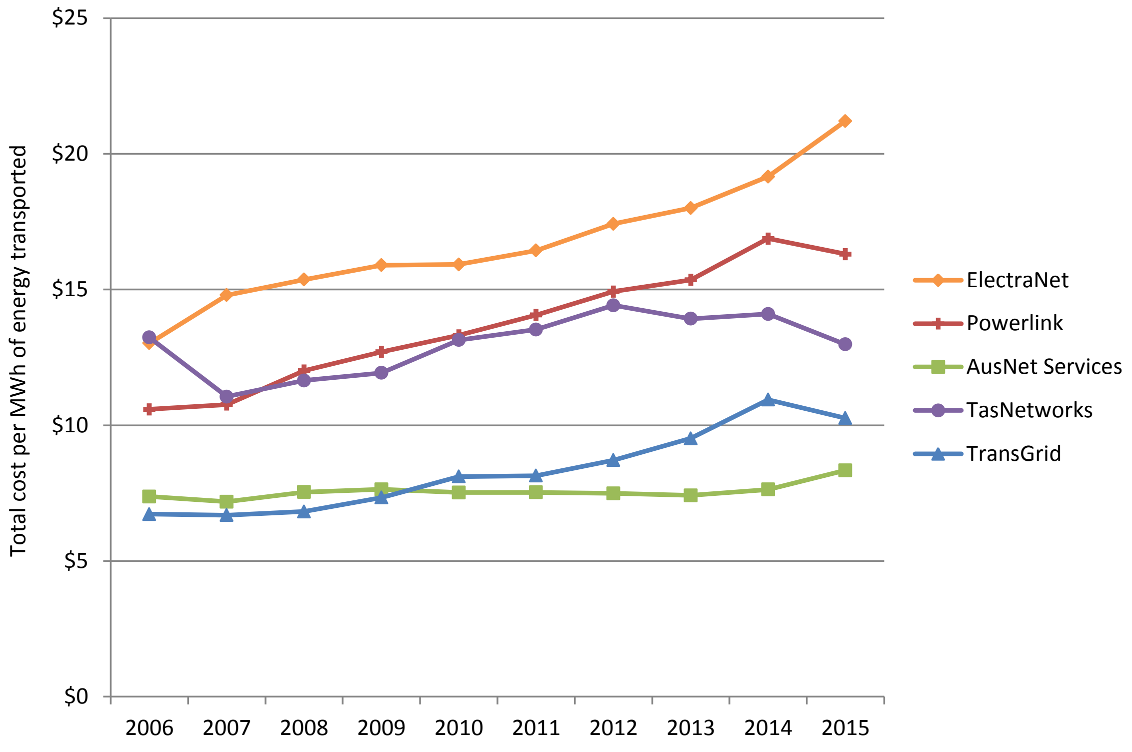
## Figure 10 Total cost per MVA of maximum demand served ($2015), 2006 to 2015




### *Total cost per MWh of energy transported*

Figure 11 shows the total cost per MWh of energy transported. Under this measure, ElectraNet has the highest cost per MWh of energy transported in each year except for 2006. AusNet Services has the lowest cost per MWh of energy transported from 2010 to 2015.

## Figure 11 Total cost per MWh of energy transported ($2015), 2006 to 2015



# 3 Conclusion

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, most notably the capital inputs, are increasing at a greater rate than the demand for electricity network services (measured in terms of maximum demand, line length, energy throughput, voltage-weighted sum of connection points and reliability). That being said, TasNetworks and ElectraNet have improved their productivity. TasNetworks is the only network to improve its productivity in successive years with substantial improvements of more than 8 per cent in both 2014 and 2015.

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

# 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, *Memorandum – TNSP MTFP Results*, November 2016.
- 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, we applied economic benchmarking forecast the change in 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 about the inputs and outputs used in the benchmarking techniques. The November 2014 Economic Insights report referenced in Appendix A explains and justifies the input and output specifications used in this report.

## B.1 Outputs

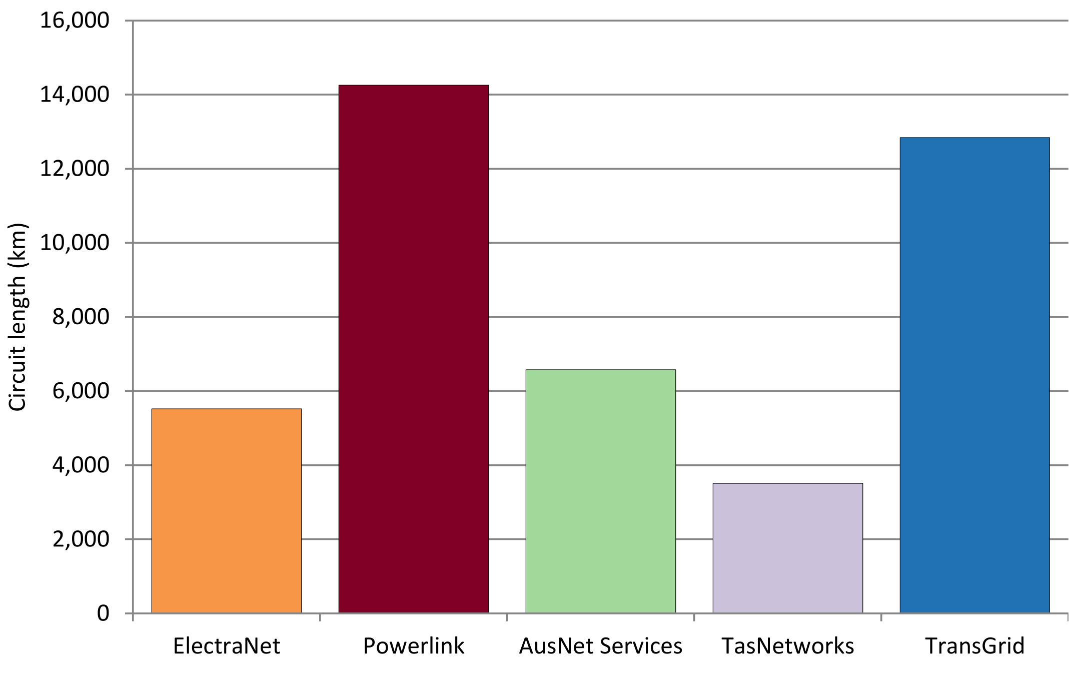
Outputs are measures that represent the services the TNSPs provide. TNSPs exist to provide customers with access to a safe and reliable supply of electricity. The outputs we use are outlined in this section.

### B.1.1 Line length

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

We use circuit length because, in addition to measuring network size, it also approximates the line length dimension of system capacity. System capacity represents the amount of network a TNSP must install and maintain to supply 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 2011 to 2015.

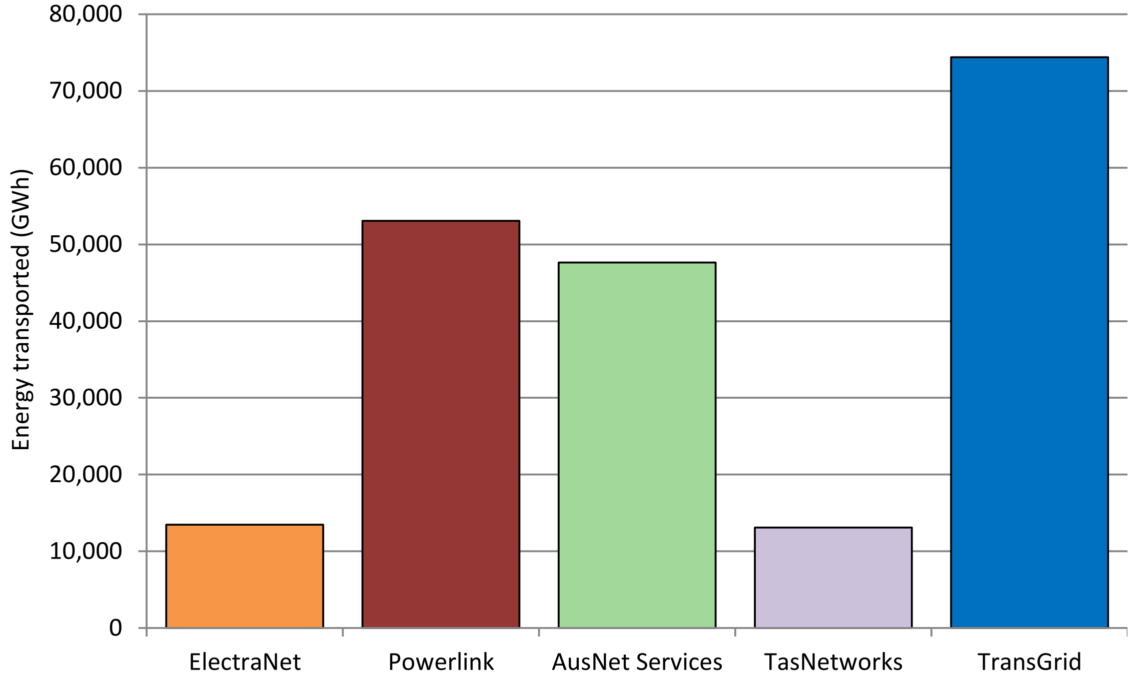
**Figure 12 Five year average circuit length by TNSP (2011 to 2015)**



## B.1.2 Energy transported

Energy transported is the total volume of electricity throughput over time through the transmission network, measured in megawatt hours (MWh). We use it because energy throughput is the TNSP service directly consumed by end–customers. Therefore, it reflects services 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 13 shows each TNSP’s energy transported in 2015.

**Figure 13 Energy transported in 2015 (GWh)**



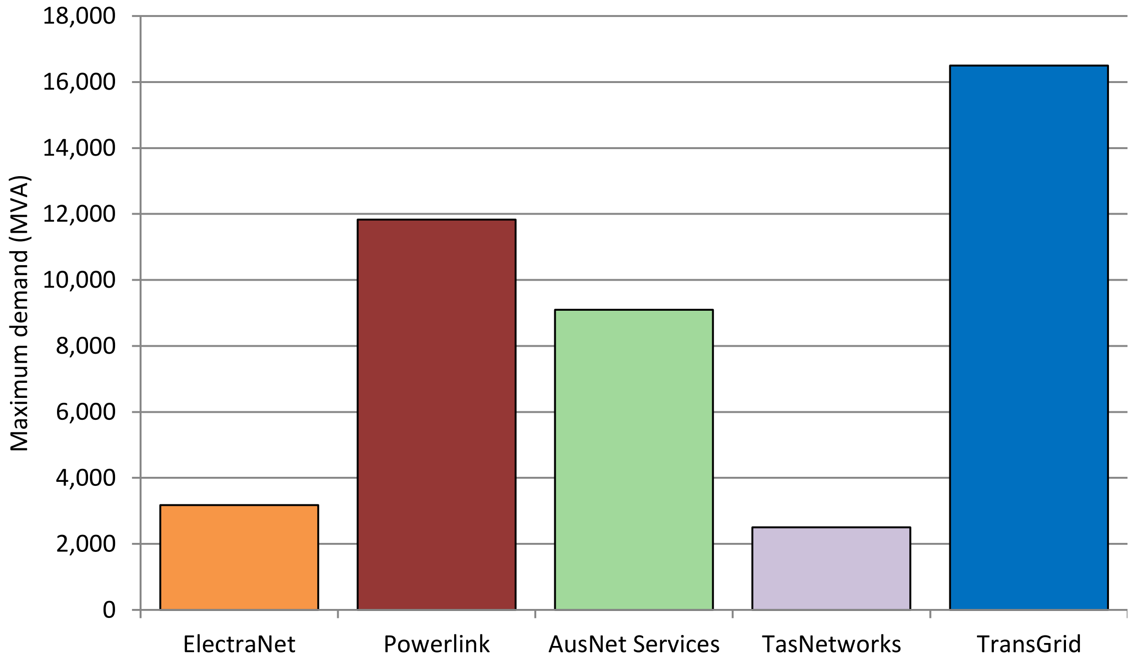

## B.1.3 Maximum demand

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 time 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 14 shows each TNSP’s maximum demand in 2015.

For the PPI analysis we used the annual maximum demand for each of the transmission networks not the ratcheted maximum demand.

### Figure 14 Maximum demand for 2015 (MVA)

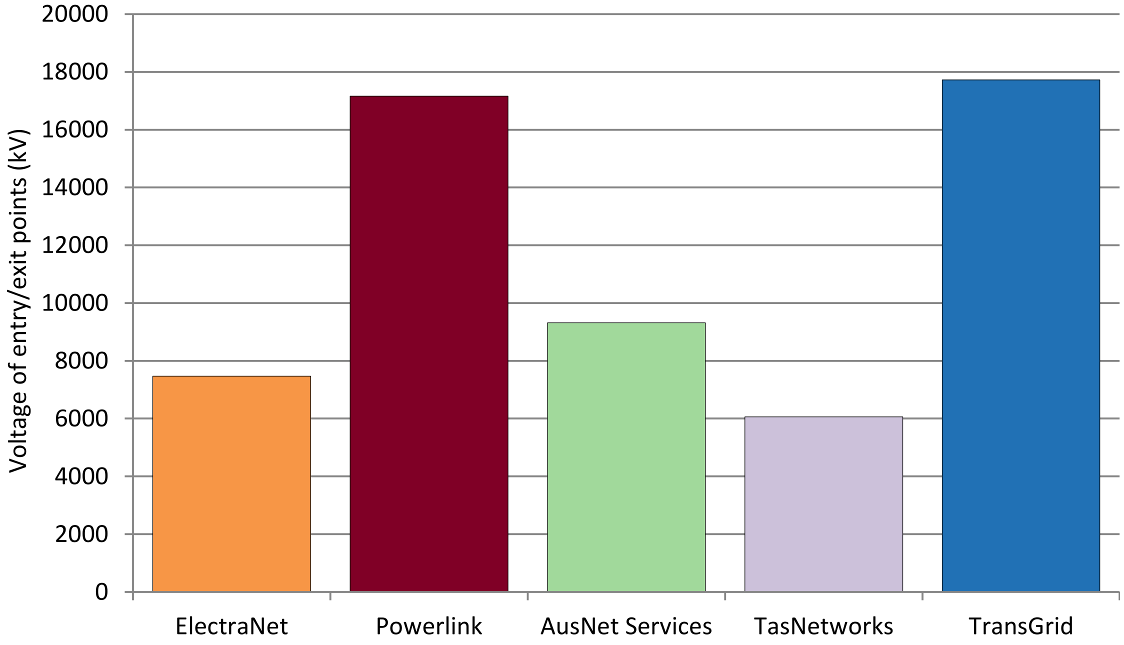



## B.1.4 Voltage of entry and exit points

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.[15] 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 shows each TNSP's aggregate voltage of entry and exit points in 2015.

15 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.

### Figure 15 Aggregate voltage of entry and exit points (kV) for 2015



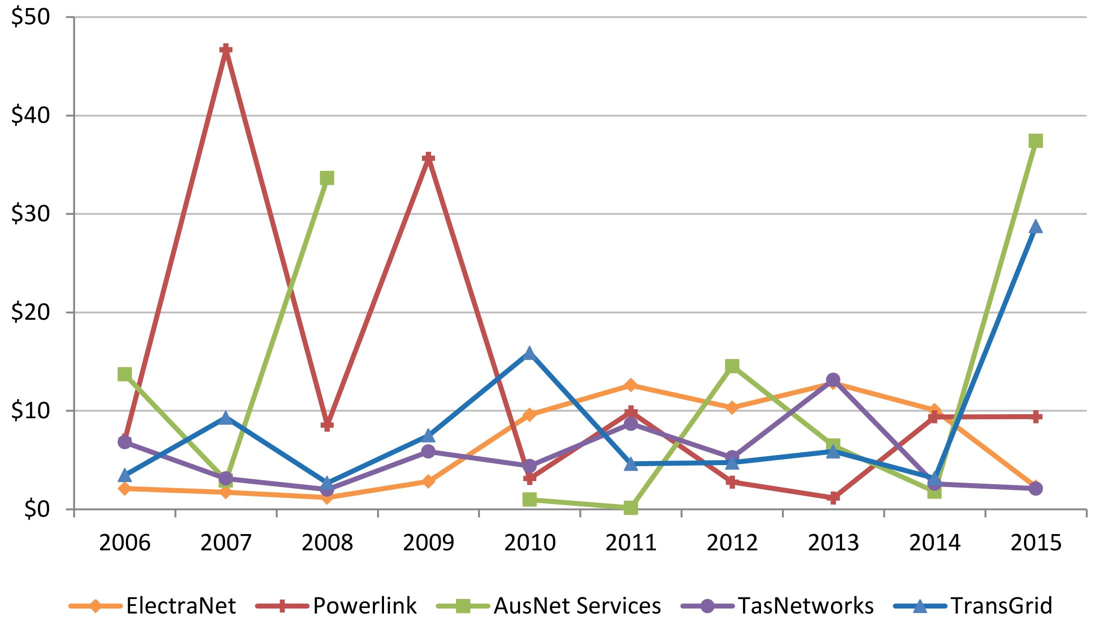

## B.1.5 Reliability

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.[16] Figure 16 presents the estimated cost of unsupplied energy.

In the MTFP analysis, reliability has been measured using unsupplied energy as a negative output. It is a negative output because a decrease in supply interruptions is equivalent to an increase in 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.

16 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.

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




Note: We 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.

## B.1.6 Total outputs

Table 2 presents the average network outputs from 2011 to 2015 for TNSPs, with the exception of reliability.

## Table 2 TNSP outputs 2011 to 2015 average

| | Circuit line length (km) | Energy transported (GWh) | Maximum demand (MVA) | Voltage of entry/exit points (KV)[17] |
|---|---|---|---|---|
| ElectraNet | 5,522 | 13,928 | 3,923 | 7,195 |
| Powerlink | 14,256 | 50,566 | 11,724 | 16,158 |
| AusNet Services | 6,573 | 48,070 | 9,494 | 9,472 |
| TasNetworks | 3,511 | 13,007 | 2,549 | 6,004 |
| TransGrid | 12,845 | 73,940 | 17,660 | 17,377 |

17 This is the sum of the voltage at each connection point.

## 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 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.
- Capital stock (assets). The physical assets TNSPs invest in to replace, upgrade or expand their network. 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.[18]
  - For the PPIs we use the real value of the regulatory asset base as the proxy for assets as the starting point in deriving the real cost of using those assets. Asset cost is the sum of annual depreciation and return on investment.[19] 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.

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

19 To calculate asset costs relevant to PPIs, MTFP and Capital MPFP, where possible we have applied annual weighted average cost of capital values calculated in accordance with the AER's approach to setting rate of return in the most recent determination. See Ausnet Services, *Draft Decision Ausnet Services Transmission Decision*, *Rate of return factsheet*, July 2016. These include a market risk premium of 6.5 per cent, and a risk free rate based on the yield of ten year CGS (noting we use a 365 day averaging period for each year in the benchmarking report). For this benchmarking report, we choose to continue to use our the previous approach used 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 averages ten year maturity BBB yields from the RBA and Bloomberg (appropriately extrapolated out to ten years where necessary). However, historical data going back to 2006 is not available for the RBA curve. Given this, we have continued to rely solely on estimates based on the Bloomberg fair value curve data. Where relevant, the tax component uses gamma of 0.4.

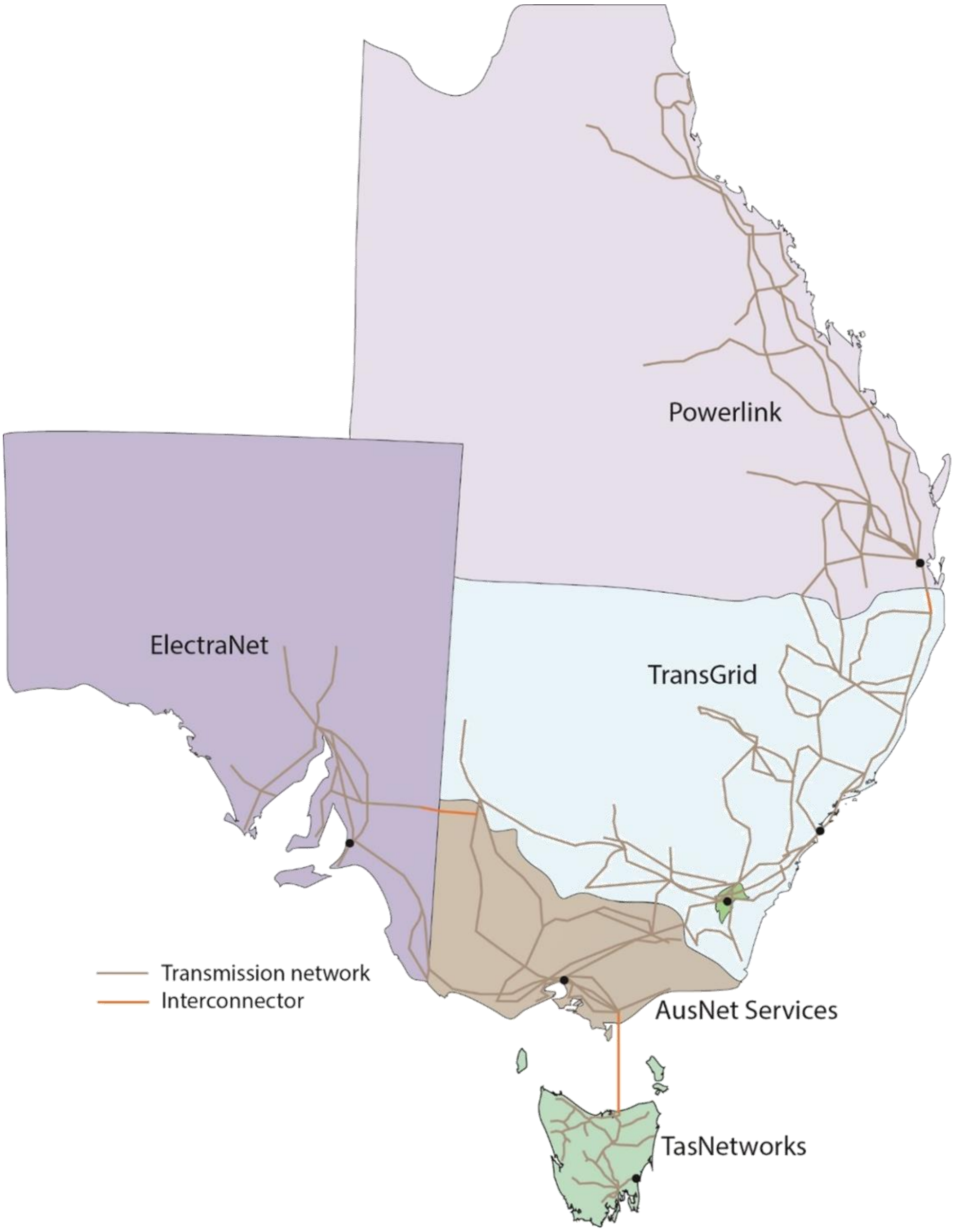
### Table 3 Average annual costs for network inputs for 2011–15 ($'000, 2015)

| | Opex | Capex | RAB | Depreciation | Asset cost |
|---|---|---|---|---|---|
| ElectraNet | 76,692 | 195,930 | 1,789,243 | 77,405 | 179,926 |
| Powerlink | 184,621 | 493,123 | 6,213,135 | 242,737 | 598,739 |
| AusNet Services | 83,381 | 163,453 | 2,589,424 | 137,447 | 285,816 |
| TasNetworks | 46,661 | 133,683 | 1,282,031 | 59,192 | 132,650 |
| TransGrid | 164,821 | 431,900 | 5,521,243 | 218,733 | 535,090 |

# 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:

- AusNet Services transmission
- ElectraNet
- Powerlink
- TransGrid.

All submissions are available on our website.

Submissions concerning Economic Insight's MTFP analysis have been addressed in Economic Insight's memo which is available on our website.