Electricity transmission network service providers

Annual benchmarking report

November 2014

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
capex	Capital expenditure
MTFP	Multilateral total factor productivity
NEL	National Electricity Law
NEM	National Electricity Market
NER	National Electricity Rules
opex	Operating expenditure
PPI	Partial performance indicator
RAB	Regulatory asset base
TNI	Transmission node identifiers

Contents

Overview

In this report we (the AER) set out to describe the relative efficiency of electricity transmission networks.[1] 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. The report outlines the framework for our efficiency assessment, and presents the results of two benchmarking techniques, multilateral total factor productivity (MTFP), and partial performance indicators (PPIs).

We are obliged to publish the annual benchmarking report as a result of the recent amendments to the National Electricity Rules (NER) following the Australian Energy Market Commission (AEMC) review of network regulation in 2012. The AEMC intended that the annual benchmarking reports would be a useful tool for stakeholders (including consumers) to engage in the regulatory process and to have better information about the relative performance of regulated networks.[2]

In this report we examine the efficiency of transmission networks overall, unlike our determinations where we examine the efficiency of the transmission networks' forecast opex and capex. We must have regard to the benchmarking analysis presented in this report, as part of our revenue determinations.[3] However, when making our revenue determinations, we are likely to also undertake additional detailed modelling and benchmarking analysis that focuses on the opex and capex of the transmission networks.

The AER has consulted broadly on the benchmarking of electricity transmission networks. We initiated this consultation with a joint ACCC/AER report on benchmarking the capex and opex of energy networks published in 2012.[4] Subsequent to this, in 2013 as part of the Better Regulation program that followed amendments to the NER, we developed a new benchmarking and information framework.

As part of this work, we considered the data requirements for benchmarking and the application of benchmarking in our regulatory determinations. In doing this we hosted numerous workshops seeking feedback from stakeholders on the data requirements for the benchmarking of electricity networks.

We developed the benchmarking report using the data that we consulted on and collected using regulatory information notices (RINs) after the release of the guidelines. This data has been compiled in accordance with our consistent information requirements and five years of data has been audited by the transmission networks. We have published this data on our website.[5] While no dataset will likely ever be perfect, this data is the most consistent and thoroughly examined dataset of the transmission networks yet assembled in Australia.[6]

As required under the NER we circulated a draft of this report to the transmission networks and other stakeholders in August 2014. In light of comments made by stakeholders we have made some changes to the report.

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1 Under clause 6A.31(a) of the National Electricity Rules we are required to publish an annual benchmarking report. The purpose of this report is to describe, in reasonably plain language, the relative efficiency of each Transmission Network Service Provider in providing prescribed transmission services over a 12 month period.

2 AEMC, *Rule determination*, 29 November 2012, p. 108.

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

4 ACCC/AER Working Paper Series, *Benchmarking Opex and Capex in Energy Networks*, Working Paper no.6, May 2012.

5 This data is available at: https://www.aer.gov.au/node/483

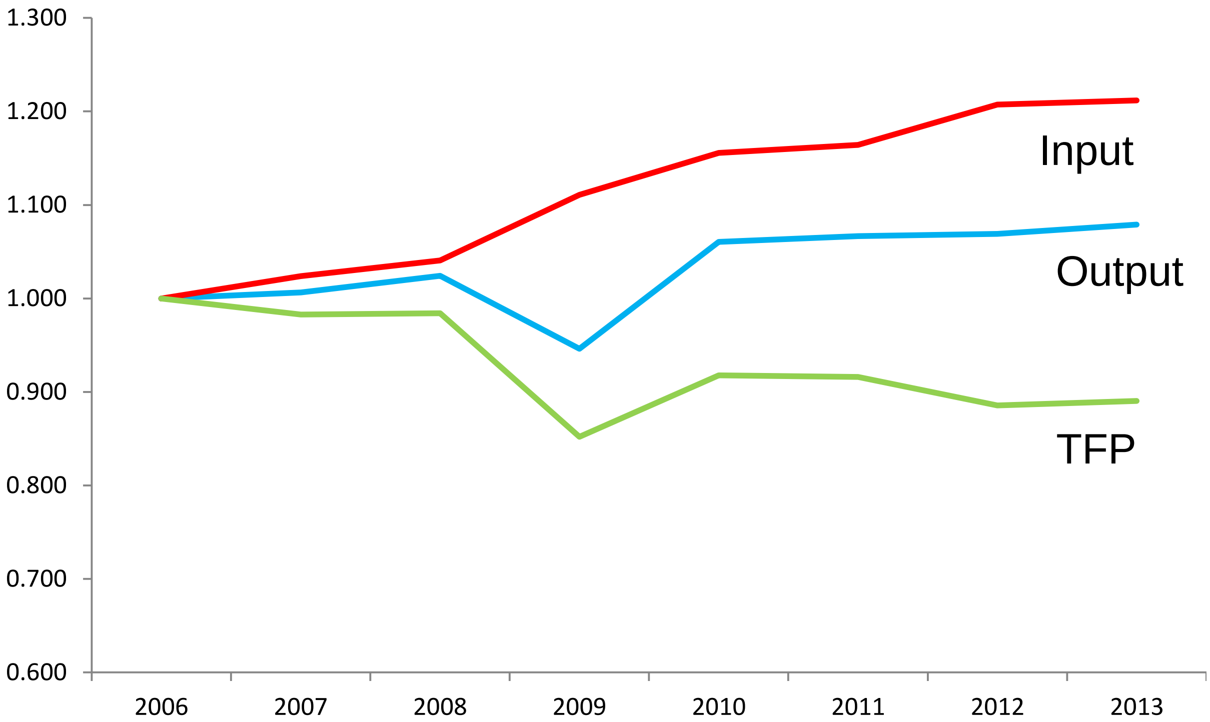
6 Economic Insights, *Economic benchmarking assessment of operating expenditure for NSW and Tasmanian electricity TNSPs*, November 2014, p. 3.

Though benchmarking of costs has been undertaken by transmission networks for a number of years whole of business benchmarking of electricity transmission networks is in its relative infancy.[7] Compared to the 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 data used is robust. The PPIs present expenditure against known drivers, and the MTFP specification by Economic Insights is consistent with established literature.[8]

We are confident we can draw conclusions on the change in transmission networks' productivity over time. Such analysis involves comparing a transmission network's performance with its past performance and thus avoids the complications of benchmarking across networks. Figure 1 aggregates the MTFP results into an industry wide measure; it shows that on average, productivity has been declining in across the transmission networks.[9] Productivity has been declining across the sector over the last eight years because overall input use by the transmission networks has outstripped output growth.

Figure 1 Industry wide input, output and MTFP



[7] The transmission networks partake in an international transmission operating and maintenance cost study. For instance see: TransGrid, Revenue proposal 2014-2019, May 2014, p. 24.

[8] Economic Insights, *Economic benchmarking assessment of operating expenditure for NSW and Tasmanian electricity TNSPs*, November 2014, pp. 2, 11–12.

[9] The drop in industry output in 2009 is attributed to an explosive failure at South Morang Terminal Station and a conductor drop on the Bendigo to Ballarat Line, affecting AusNet Services' network.

The benchmarking provides some insights into the relative efficiency of transmission networks. This benchmarking will also provide a good basis for the further development of transmission benchmarking in consultation with stakeholders.

We are required under the NER to provide a specific analysis focusing on a 12 month period.[10] However, because this is the first time we have presented expenditure benchmarking results, this report focuses on the 2006-2013 period, and the most recent historical year. With results presented over a longer period, stakeholders will gain insight into the transmission networks' current expenditure and productivity trends.

Charges for transmission network services are only part of the electricity prices paid by consumers. As such, the relative performance of each of the transmission networks shown in this report does not necessarily mean that consumers on less productive networks pay more overall. Other components of the electricity market, including the wholesale generation of electricity and the retail component, may lead to price differences. We consider the performance of electricity retailers in a separate report.[11]

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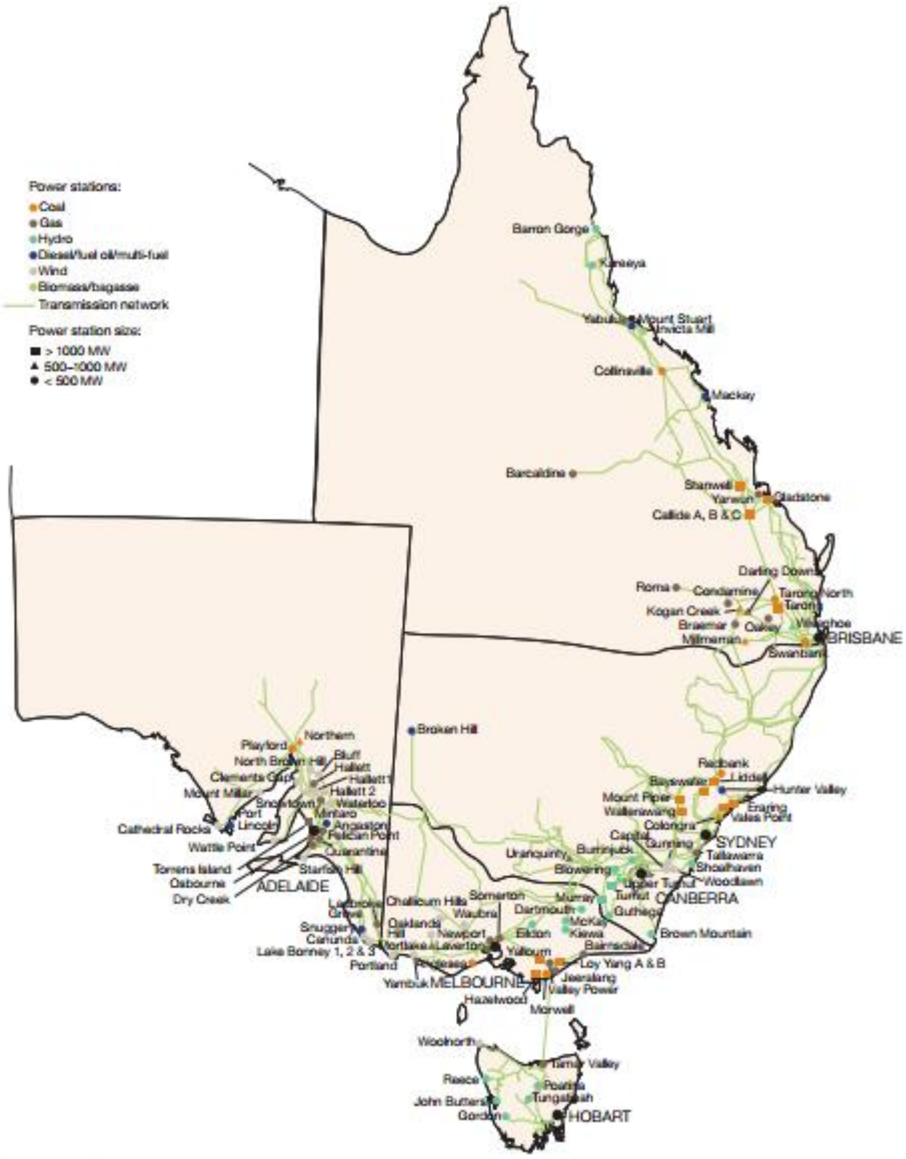
10 NER clause 6A.31(a)

11 AER, *Annual report on the performance of the retail energy market 2012–13*, February 2014.

1 Network characteristics

This benchmarking report considers the efficiency of the 5 transmission networks in the National Electricity Market (NEM).[12] The NEM connects electricity generators and customers from Queensland through to New South Wales, the Australian Capital Territory, Victoria, South Australia and Tasmania.

Figure 2 Transmission networks and generators in the National Electricity market



The transmission networks are responsible for transmitting electricity from generators to distribution networks and large electricity customers. They are not responsible for the production of electricity, the distribution of electricity to most customers or sale of electricity. These functions are the responsibility of generators, distributors and retailers respectively.

Figure 3 outlines the structure of the national electricity market.

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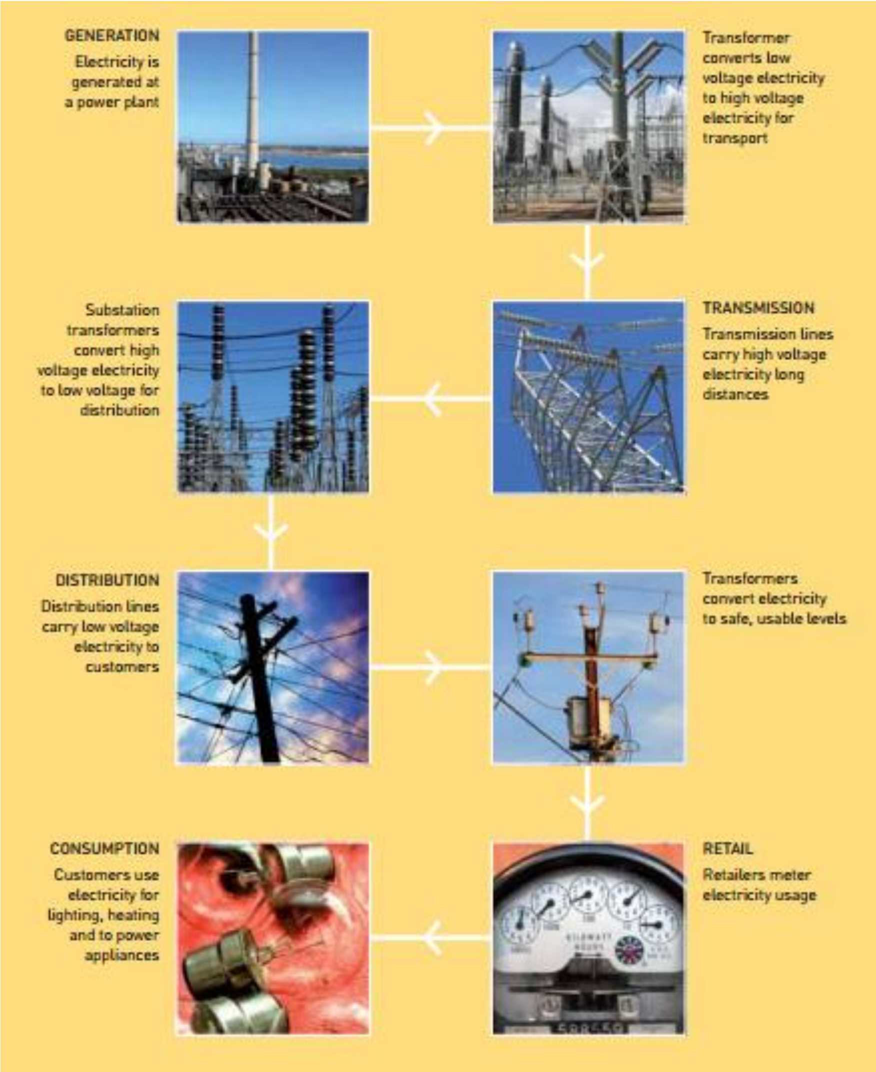
12 This does not include interconnector networks or those distribution network service providers that operate subtransmission assets.

Figure 3 **Structure of the national electricity market**



Benchmarking analysis considers the efficiency of a business in using inputs to deliver outputs given the operating environment within which they function. In the following sections we consider the inputs and outputs of transmission networks.

1.1 Framework for efficiency measurement

Our approach to benchmarking measures the efficiency of a business in using inputs to produce outputs by comparing its current performance to its own past performance and to the performance of other NSPs. All transmission networks use a range of inputs to produce the outputs they supply. If the transmission network is not using its inputs as efficiently as possible then there is scope to lower network service costs and, hence, the prices charged to energy consumers, through efficiency improvements.

Many benchmarking techniques compare the quantity of outputs produced to the quantity of inputs used and costs incurred over time and/or across transmission networks.[13] The relationship between outputs, inputs and efficiency measurement is considered in Box 1.

Box 1 Efficiency measurement

Economic efficiency is achieved when inputs are optimally selected and used in order to deliver outputs that align with customer preferences. Three components of economic efficiency were set out by Hilmer – 'productive efficiency', 'allocative efficiency' and 'dynamic efficiency'.[14]

Productive efficiency

Productive efficiency is achieved when transmission networks produce their goods and services at least possible cost. To achieve this, transmission networks 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.

Allocative efficiency

Allocative efficiency is achieved where resources used to produce a set of goods or services are allocated to their highest valued uses (i.e., those that provide the greatest benefit relative to costs). To achieve this, prices of the goods and services of transmission networks must reflect the productive 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 opportunities. Dynamic efficiency is achieved when transmission networks are both productively and allocatively efficient over time.

We consider that the benchmarking techniques in this report primarily assist us in forming a view on the productive efficiency of transmission networks. However measuring productive efficiency will assist us in assessing whether transmission networks are allocatively and dynamically efficient. Measuring productive efficiency will help us determine the efficient prices/revenues for services promoting allocative efficiency. Measuring productive efficiency over time provides an insight into the dynamic efficiency of transmission businesses.

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[13] Economic Insights, *Economic Benchmarking of Electricity Network Service Providers Report prepared for Australian Energy Regulator*, 25 June 2013, p. ii.

[14] Independent Inquiry into National Competition Policy (F Hilmer, Chair), *National Competition Policy*, Australian Government Publishing Service, Canberra, 1993.

The benchmarking metrics used in this report measure relative productivity.[15] The measurement of productive efficiency requires determining a firm's position relative to its industry's technological frontier. A firm's position relative to its industry's technological frontier can be inferred through observation of the relative productivity of firms (usually by assuming the most efficient firms in the sample lie on the efficient frontier).

The inputs and outputs of transmission networks are considered in the following sections. There has been discussion during the development of benchmarking techniques regarding the correct approach to measuring the inputs and outputs of electricity transmission networks. This includes:

- how the measure of services supplied by a transmission network should be construed
- whether line length should be considered an output
- whether maximum demand or network capacity should be used as an output
- how capital should be incorporated into benchmarking analysis

We considered these matters as part of our consultation on the measurement of the inputs and outputs of transmission network in 2013.[16] We have collected and published data that facilitates the measurement of inputs and outputs in accordance with the different approaches. This will allow stakeholders to conduct their own benchmarking analysis, testing different output specifications.[17] We encourage both networks and other stakeholders to do so. Using a common data set for analysing network performance will greatly assist transparency and constructive discussions between the networks and their customers.

1.2 Network outputs

In efficiency analysis, outputs are generally considered to be all of the goods and services produced by a business. There are many different facets to the outputs provided by transmission networks. Transmission networks transport electricity over long distances from generators to distribution networks and high voltage customers. They build their networks to meet and manage the expected maximum demand of users. They also build their networks to maintain a reliable supply of electricity. The outputs we have considered in our benchmarking analysis are outlined below.

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 between generators and downstream users and varies to

[15] Productivity can be defined as the ratio of aggregate output quantity to aggregate input quantity. Where a firm has one output and one input productivity can be measured as a simple ratio of the input to the output. However, where a firm has multiple outputs and multiple inputs, weights are required to construct and a total output quantity index and a total input quantity index. This allows for the calculation total factor productivity which is the ratio of an output and input index. The output and input indexes are normally weighted by the prices of outputs and inputs (where these prices are can be observed) and should reflect the unit costs of inputs and outputs. Coelli, A Estache, S Perelman, and L Trujillo, *A primer on efficiency measurement for utilities and transport regulators*, World Bank Publications, 2003, pp. 10-11.

[16] For a comprehensive outline of the discussions on input and output measurement see: Economic Insights, *Economic Benchmarking of Electricity Network Service Providers Report prepared for Australian Energy Regulator*, 25 June 2013, pp. 33–71.

[17] This data has been published on our website and is available here: https://www.aer.gov.au/node/483

route line length as sometimes two circuits are installed on a single transmission tower. We replaced route line with circuit line length as an output metric based on stakeholder feedback.[18]

Energy transported

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

Maximum demand served

Maximum demand is the maximum amount of electricity being transported over a transmission network at a point in time. This can be measured in two ways; in terms of coincident maximum demand and non-coincident maximum demand. Coincident maximum is the total demand on the network at a single point in time and non-coincident maximum demand is the summation of the maximum demand on specific network assets. We have adopted the use of non-coincident maximum demand as we consider this better reflects the needs of the consumers that are distributed across the network.[19]

Transformer Capacity

The capacity measure presented is the sum of the capacity of downstream network connections; including large industrial consumers, other TNSPs and distribution network service providers. This reflects the capacity that a transmission network requires to meet the needs of its downstream customers. This aligns with our measure of peak demand which is also measured at downstream connection points.

We received a submission noting that transformer capacity is being applied as an input by Economic Insights in its modelling and as an output by the AER in our PPIs.[20] Because benchmarking of transmission networks is in its infancy, we consider we should be open to presenting a number of possible metrics for benchmarking analysis.

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.[21] 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. The TNIs will not perfectly capture the transmission assets at each entry and exit point.[22] This was raised with us in submissions.[23] However the number of TNIs is the most consistent data that is currently available to us. Further we consider that the summation of

[18] Consumer Challenge Panel, Written comments on draft annual transmission benchmarking report, August 2014; Powerlink, *Powerlink feedback - AER draft economic benchmarking report*, August 2014, p. 2.

[19] For instance coincident peak demand can increase at the same time as the non-coincident demand on all individual assets decreases. In this circumstance investment in assets may not be required to manage the increase in peak demand.

[20] AusNet Services, Submission to draft annual transmission benchmarking report, August 2014, p. 6.

[21] 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.

[22] There may be variation in the capital stock related to TNI depending on the number and configuration of connections the TNI supplies. The number of connections supplied by a TNI will vary. Further the delineation between the distribution and transmission component of a TNI will differ.

[23] Consumer Challenge Panel, Written comments on draft annual transmission benchmarking report, August 2014; TransGrid, Submission to draft annual transmission benchmarking report, August 2014, pp. 1–2.

TNI voltages is a workable reflection of the number and significance of transmission network connections.

Reliability

Transmission networks are designed to be very reliable. This is because interruptions to supply at the level of transmission networks can affect a considerable geographic area and a large number of consumers. One of the measures of transmission reliability is energy that is not supplied as a result of network outages (unsupplied energy). Unsupplied energy is a very small proportion of total energy (generally being 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.[24] Figure 4 presents the estimated cost of unsupplied energy.

Figure 4 Estimated customer cost of energy unsupplied due to supply interruptions ($million nominal)[25]

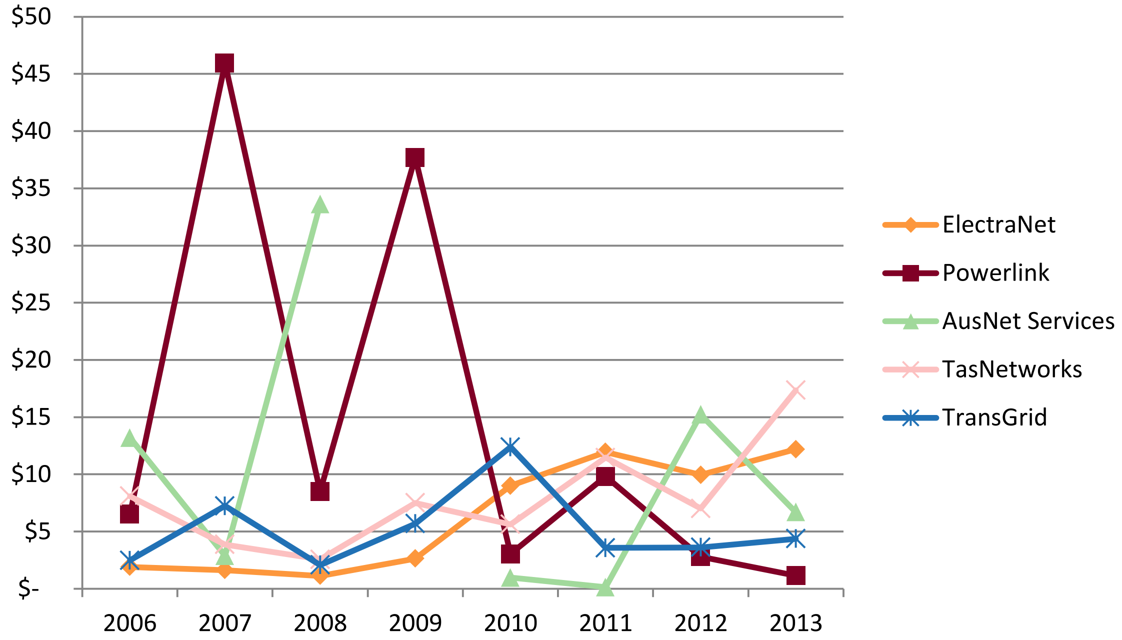

Table 1 presents the average network outputs from 2009–13 for the transmission networks (with the exception of reliability).

[24] 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.

[25] We have excluded the cost of customer interruptions to AusNet Services' network for 2009 as these are anomalously large (about $400 million) and dwarf the other results.

Table 1 **Transmission network outputs 2009–13 average**

	Circuit line length (km)	Energy transported (GWh)	Maximum demand (MW)	Transformer capacity (MVA)	Voltage of Entry/exit points (KV)[26]
ElectraNet	5,513	13,918	4,112	13,391	12,498
Powerlink	13,584	51,434	11,219	11,379	15,012
AusNet Services	6,573	48,206	9,337	17,257	11,915
TasNetworks	3,498	13,001	2,526	4,660	5,947
TransGrid	12,696	70,180	18,060	30,371	16,301

Other outputs

In this report we have chosen to focus on the core services involved in the transmission of electricity provided by transmission networks. The transmission networks provide other services such as:

- Supporting unrestrained competition within the NEM.
- Ensuring voltage stability
- System security functions such as maintaining load shedding, and restarting the system in the event of an outage

Though important, we consider that these measures may not be significant enough to warrant inclusion in whole of business benchmarking.[27]

1.3 Network inputs

Network inputs are the resources that transmission networks use to deliver outputs to their customers. The inputs used to provide transmission services can be separated into those that are consumed in the year that they are first used and those that may last several years or, in the case of energy networks, several decades. The former is normally referred to as operating expenditures (opex) and the latter as assets or capital stock.

Assets will provide useful service over a number of years. However benchmarking studies will typically focus on a shorter period of time, such as a year. As such, the incorporation of assets into benchmarking requires careful consideration.[28] A number of measures have been used to proxy the cost of asset input in benchmarking studies, including; capital expenditure (capex) and the constant

26 This is the sum of the voltage at each connection point.
27 TransGrid disagreed with this perspective. See: TransGrid, Submission to draft annual transmission benchmarking report, August 2014, p. 3.
28 For further consideration of this issue see: Economic Insights, *Economic Benchmarking of Electricity Network Service Providers Report prepared for Australian Energy Regulator*, 25 June 2013, pp. 47–71.

price value of the asset base (the regulatory asset base or RAB). These measures have various strengths and weaknesses.[29]

For the purpose of this benchmarking analysis we are using the 'asset cost' of transmission networks. The asset cost is the summation of annual depreciation and return on investment. This measure has the advantage of reflecting the total annual costs of assets for which customers are billed. Asset costs are described in more detail in Appendix B. These inputs are considered in more detail in Section 2.1.

Table 2 presents various measures of the cost of network inputs for the five transmission networks within the NEM. In this table we have presented the capex, the RAB and asset cost to represent the capital input. We have presented the average annual network costs over five years in this table to moderate the effect of any once-off fluctuations in expenditure.

Table 2 Transmission network input costs 2009–2013 average ($thousands 2013)[30]

$2013 thousands	Opex	Capex	RAB	Depreciation	Asset cost
ElectraNet	68,899	141,866	1,533,786	99,304	162,034
Powerlink	166,902	567,277	5,438,241	174,908	551,610
AusNet Services	81,598	111,665	2,406,896	108,764	272,872
TasNetworks	50,368	117,854	1,095,450	59,444	121,653
TransGrid	151,140	416,966	4,919,928	79,297	493,723

It should be noted that AusNet Services does not undertake the full suite of transmission functions that other transmission networks undertake. This affects the measurement of AusNet Services' inputs. These functions are undertaken by the Australian Energy Market Operator (AEMO). AEMO is responsible for planning and procuring new transmission capacity and for connecting generators and customers to AusNet Services' network. We have been unable to incorporate the costs of AEMO's functions into this analysis so the benchmarking results for AusNet Services should be interpreted with caution.

1.4 Operating environment factors

To measure the efficiency of transmission networks it is necessary to consider the environment within which they operate. While it may not be possible to account for every environment factor directly in our modelling, we can estimate the impact of the operating environment in other ways.

We have accounted for a number of operating environment differences in our benchmarking analysis. There are other differences between the operating environments of transmission networks in Australia. The impact of these operating environment factors is a matter of contention. In consultation on the economic benchmarking regulatory information notice the transmission networks noted a number of operating environment differences that may affect the ability to convert inputs into outputs. These include:

29 This is considered in greater detail in: AER, *Better regulation, expenditure forecast assessment guidelines for electricity distribution and transmission issues paper*, December 2012, pp. 62–71.

30 Nominal values have been converted into real $2013 using the ABS Weighted Average of Eight Capital Cities CPI. We have used this index to convert all nominal financial amounts into real $2013 in this report.

- Differences in the size and voltages of networks
- Differences in network terrain,
- Differences in climate, and
- Differences in jurisdiction specific requirements.

The way that we account for operating environment differences depends on the benchmarking technique that we apply. The multilateral total factor productivity analysis presented below accounts for more operating environment factors than the partial performance analysis. This is because the multilateral total factor productivity can accommodate more variables.

That being said, we have not accounted for every potential operating environment factor that may affect relative efficiency of transmission networks. As such, there may remain some unquantified operating environment factors. The presence of unquantified differences in the operating environment does not preclude us or other parties from forming a quantified view about the relative efficiency of transmission networks. It may be that the net impact of some operating environment factors will be immaterial to the consideration of efficiency. Further, the gap in relative efficiency may prove to be so great that operating environment factors alone could not account for the difference in relative efficiency.

1.4.1 Unaccounted for operating environment factors

We received submissions on our draft report noting that there are environmental factors that are material but haven't been taken into account in our models.[31] We have not been able to include these in our modelling. Because we do not draw conclusions on the relative productivity levels of the transmission networks, we have not formed a view on how environmental factors may affect those relative positions.

AusNet Services noted that we had included easement land tax in both the PPI and MTFP measures in the draft report, which is an exogenous cost.[32] We have removed expenditure for the easement land tax from the figures in this report. We consider the easement land tax, which has a significant effect on AusNet Services' opex, is outside of its control and hence should not be included in opex for benchmarking.

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[31] TransGrid, Submission to draft annual transmission benchmarking report, August 2014, p. 2; AusNet Services, Submission to draft annual transmission benchmarking report, August 2014, p.6; HoustonKemp, *Comments on the AER's draft annual benchmarking report*, August 2014, pp. 4–5, 11.

[32] AusNet Services, Submission to draft annual transmission benchmarking report, August 2014, pp. 2–4.

2 Benchmarking

There are many possible approaches to benchmarking the efficiency of transmission networks. These have been detailed in the ACCC/AER's working paper on benchmarking opex and capex in electricity networks and the AER's explanatory statement to the expenditure forecast assessment guideline.[33] These benchmarking approaches differ in complexity and have their advantages and disadvantages.

The benchmarking approaches that we have chosen to apply in this first report are PPIs and MTFP.

The PPIs presented in this report compare the performance of businesses in delivering one type of output. PPIs provide a useful means of comparison on certain aspect of the operation; for example, it may provide an indication of where certain expenditure may be above efficient levels.

Using MTFP we measure the productivity of transmission networks across time and relative to each other. MTFP measures total outputs relative to all input quantities and takes into account the multiple types of inputs and outputs of transmission networks. This differs to PPIs which only examine the ratio of input cost to a single output.

It should be noted that the ability to draw conclusions from the benchmarking of transmission networks within Australia may be limited by the number of networks and their diversity.

We present the time trend in expenditure over the 2006 to 2013 period. This allows the viewer to consider the trend in performance for each transmission network.

2.1 Partial performance indicators

In our partial performance analysis we consider the ratios of the transmission networks total cost against their outputs of voltage weighted entry and exit points, circuit line length, maximum demand served, and capacity.

We have chosen to represent inputs in our partial performance analysis as total cost. We discuss how we calculate total cost in Appendix B.[34] We consider that it is appropriate to examine each transmission output because the appropriate measurement of transmission outputs is a matter of ongoing consideration.[35]

It should be noted that AEMO undertakes the augmentation procurement functions for AusNet Services' transmission network; this work would normally be undertaken by the transmission network itself. As such, AusNet Services' reported capital expenditure—and total costs by extension—is less than it would be if it captured the full costs of augmentation capex.

Figure 5 shows the total cost per kilovolt (kV) of entry and exit points. This measure potentially favours the more dense transmission networks rather than the ones which have to transport electricity larger distances. Under this measure, Powerlink has the highest costs per entry and exit point voltage of all the transmission networks. ElectraNet has the lowest cost per voltage weighted connection

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33 ACCC/AER Working Paper Series, *Benchmarking Opex and Capex in Energy Networks*, Working Paper no.6, May 2012 AER, *Better Regulation Expenditure forecast assessment guidelines for electricity distribution and transmission, Issues paper,* December 2012, pp. 46–87.

34 Appendix B also provides insight into the overall expenditures of the transmission networks.

35 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.

point. Powerlink and TransGrid appear to have the highest cost per total kV of entry and exit points which aligns with these networks having the highest total costs.

Figure 5 Total cost per total kV of entry/exit points ($2013)

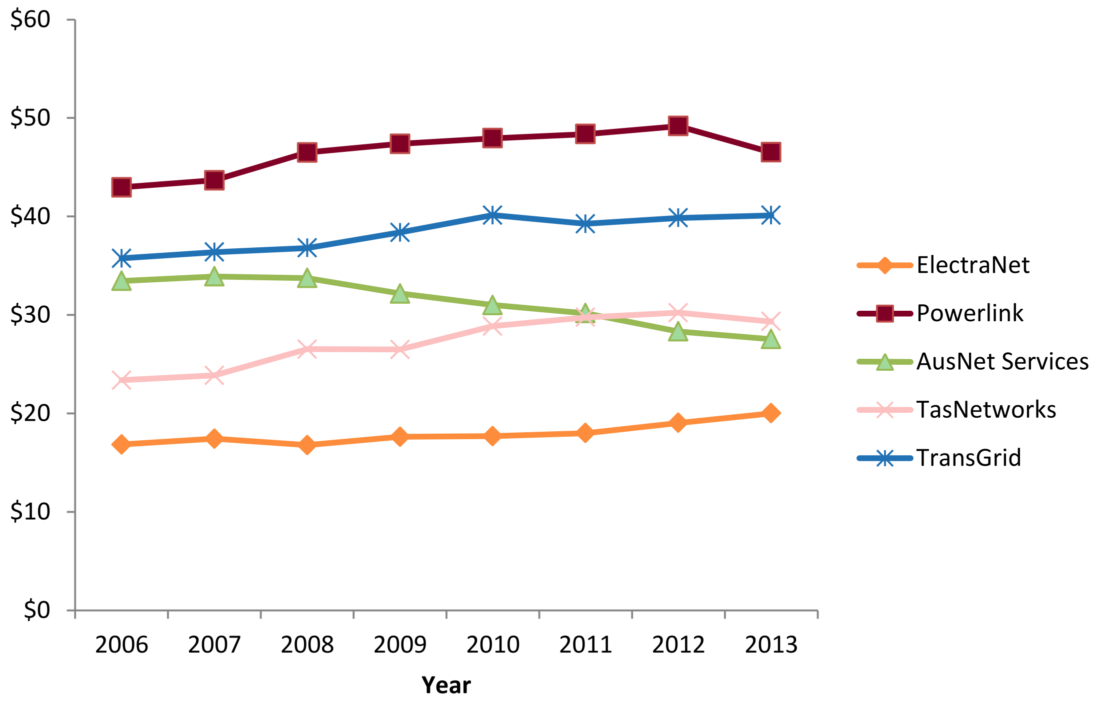
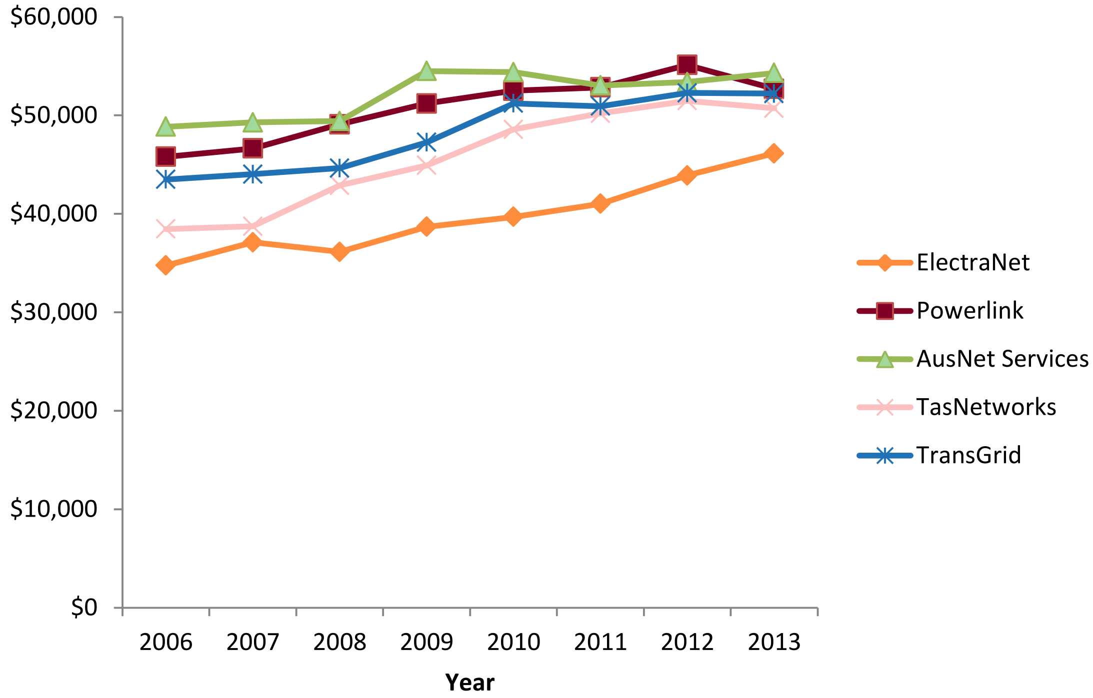


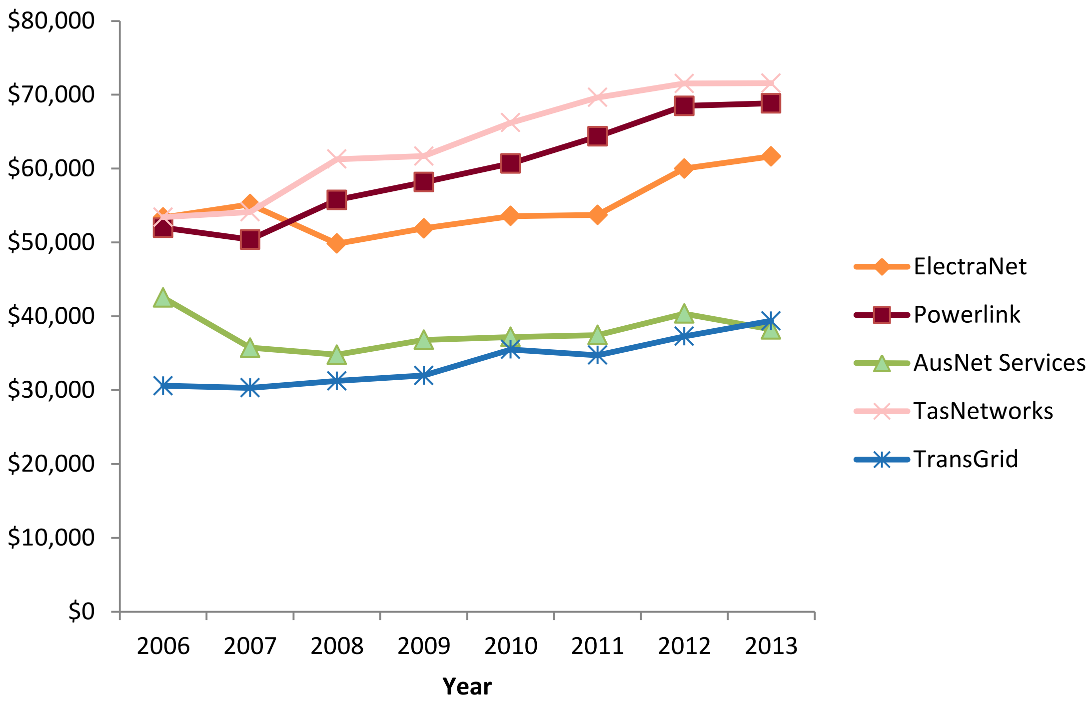
Figure 6 shows the cost per km of circuit line length of the transmission networks. There is less spread between the best and worst performing businesses of this metric relative to other metrics, with most businesses incurring a total cost of approximately $50 thousand per circuit km in 2013.

Figure 6 Total cost per km of transmission circuit length ($2013)



Total cost per MW of non-coincident maximum demand is presented in Figure 7. This measure potentially favours the more dense transmission networks rather than the ones which have to transport electricity through additional obstacles. The ordering of TNSPs under this measure differs to the other PPIs. Under this measure TasNetworks has the highest total cost per MW of maximum demand and TransGrid has 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 may explain its high cost per MW of maximum demand.

Figure 7 Total cost per MW of maximum demand served ($2013)



Maximum demand is often considered to be a customer or demand side measure of output. Benchmarking studies often use network capacity instead of maximum demand as this reflects the capacity that networks provide their customers and this is thus considered to be a supply side approach to measuring TNSP output.[36] The total cost per MVA of transmission capacity at downstream connection points is presented in Figure 8.[37]

Figure 8 shows that ElectraNet has the lowest cost per MVA of downstream connection point of transmission capacity, while Powerlink has the highest. Powerlink performs poorly under this measure with a very high total cost per MVA of connection point capacity. This may be because Powerlink has a significant number of connections to DNSP networks that are not through step-down transformers.[38] The TNSPs with greater distances between generation and load points will also be disadvantaged by this measure.

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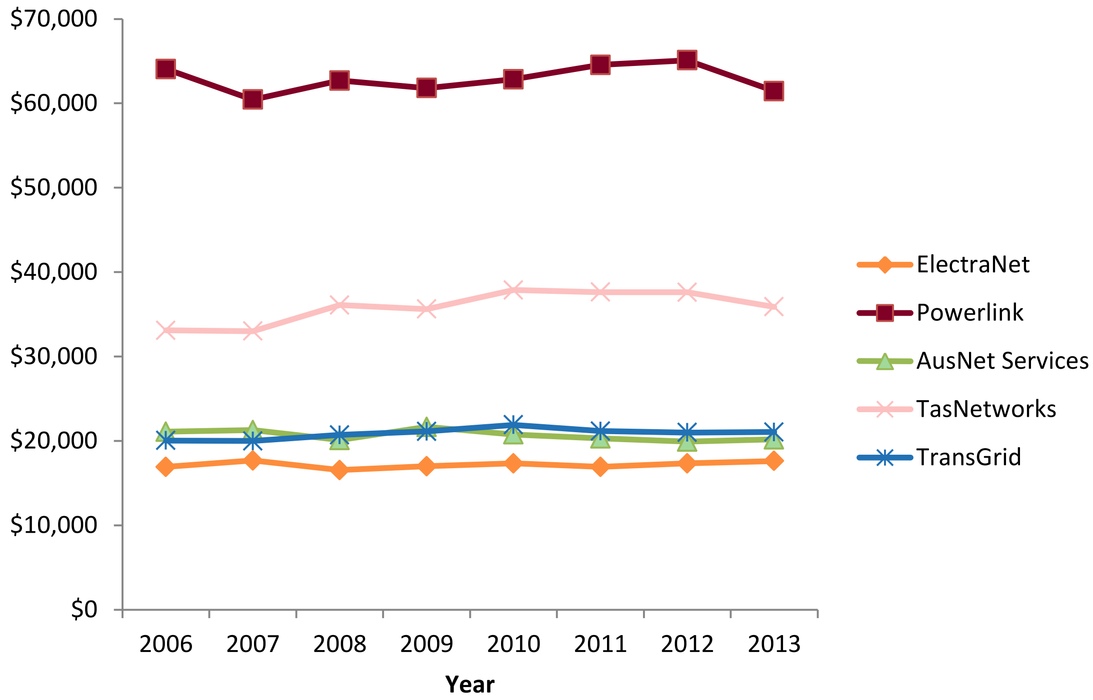
36 Economic Insights, *Economic benchmarking assessment of operating expenditure for NSW and Tasmanian electricity TNSPs*, November 2014, p. 8.

37 The downstream connection points are non-generation connection points. We have used the downstream connection point capacity because this aligns with how we measure maximum demand (at the downstream connection point).

38 There are a number of locations where Powerlink owns the 110kV or 132kV busbar and Energex or Ergon have 110kV or 132kV feeders that connect from the Powerlink busbar to the DNSPs remote substation. In these situations there is no transformer capacity at the terminal point to the DNSP system. The variety of transmission connection arrangements to the Powerlink network are described in Powerlink's Basis of Preparation for the Category Analysis RIN (pp. 62 – 66).

Figure 8 **Total cost per MVA of connection point capacity ($2013)**



The figures in Section 2.1 and Appendix A demonstrate that the transmission networks differ in their partial productivity depending on the PPI selected. It is difficult to form conclusions about efficiency from observing the PPI benchmarks as the PPIs only consider the delivery of individual outputs.

To form a view on the overall productivity of transmission networks it is necessary to weight all inputs against all outputs. MTFP measures the productivity of transmission networks in producing overall outputs relative to their use of all inputs. Section 2.2 considers the MTFP performance of the transmission networks.

2.2 Multilateral total factor productivity

We have engaged Economic Insights to undertake MTFP analysis of the transmission networks.[39] The findings of their analysis are presented in this section of the report.

In developing its preferred output specification, Economic Insights considered a number of other specifications. The MTFP scores of the transmission networks shifted somewhat depending on the model specification used. However, Economic Insights considers that the model specification presented here is currently the most appropriate and we agree. This model specification captures all the output dimensions included in our PPI benchmarking as well as reliability. Further, this specification uses a physical measure of capital inputs. This means that capital inputs are measured as the quantity of assets in place. The physical value of capital inputs avoids problems encountered when using monetary values of assets in benchmarking.[40]

Productivity is measured by constructing a ratio of output produced over inputs used. Total factor productivity (TFP) is one type of productivity measure, measuring total output relative to an index of all inputs used. Total factor productivity indexes are formed by aggregating output quantities into a measure of total output quantity and aggregating input quantities into a measure of total input quantity.[41]

This MTFP analysis compares the outputs (energy transported, ratcheted maximum demand, voltage weighted entry and exit points, circuit line length and reliability) against the inputs (opex and capital). In this analysis, capital is split into three distinct components – overhead lines, underground cables, transformers.

On the output side, maximum demand served has been measured as the highest maximum demand observed in the sample period up to that year for that TNSP (referred to as ratcheted maximum demand). This measure reflects the maximum demand that networks have had to install assets to meet.

Reliability has been measured using unsupplied energy as a negative output. Over the period unsupplied energy is relatively low for most transmission businesses.

MTFP results

Economic Insight's MTFP analysis is presented below. The analysis indicates that industry wide productivity has been declining. This is due to inputs increasing at a greater rate than outputs. Figure 9 presents the industry wide input, output and MTFP indexes.

The individual productivity of the transmission networks is presented in Figure 10. This illustrates that the productivity of most networks has declined from 2006 to 2013. The reason that overall productivity has been declining across the sector over the last eight years is that some outputs have remained relatively steady or declined while all or most transmission networks have increased input use

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

40 These problems include inconsistent asset valuation methods, differing depreciation rates and differing ages of assets which affect the value of the asset base.

41 Economic Insights, *Economic benchmarking assessment of operating expenditure for NSW and Tasmanian electricity TNSPs*, November 2014, p. 4.

significantly. We recognise however, that some of the decrease in productivity may be attributable to changes in the operating environment. This point was raised in submissions.[42]

Given the relatively low number of observations caution should be exercised when interpreting the finding of this MTFP benchmarking. However, the MTFP scores presented indicate that TasNetworks and ElectraNet have performed well in terms of overall productivity levels. That said, AusNet Services is also the only network to exhibit an improvement in productivity over the period.[43] Again we note that AusNet Services' performance may be affected by the delineation of responsibility between AusNet Services and AEMO.

A number of submissions commented on the accuracy of our MTFP analysis and the output specification used.[44] We consider that the MTFP benchmarking presented in this report is the best measure of relative productivity that we have available to us. Though we acknowledge that transmission benchmarking is in its relative infancy we consider that the results provide a useful contribution and should be presented. Over time we hope to further refine this analysis in light of stakeholder submissions. This refinement will include further consideration of the input and output specification in light of stakeholder comment.

We received a submission that the MVA-km input measure in the MTFP model should be modified as the relationship between capital cost and line capacity is not linear.[45] We consider that higher voltage assets are more complex and therefore more expensive to operate and maintain, and MVA-kms provides a reasonable proxy of this relationship. We also note that an appropriate weighting between line capacity and cost of operating and maintaining the line was not suggested.

[42] HoustonKemp, Submission to draft annual transmission benchmarking report, August 2014, pp. 11–12.
[43] The temporary downturn in AusNet's opex PFP in 2009 is due to an explosive failure at South Morang Terminal Station and a conductor drop on the Bendigo to Ballarat Line.
[44] AusNet Services, Submission to draft annual transmission benchmarking report, August 2014, pp. 2–3, 6–7; Grid Australia, Submission to draft annual transmission benchmarking report, August 2014, p. 2; TransGrid, Submission to draft annual transmission benchmarking report, p. 2; HoustonKemp, Submission to draft annual transmission benchmarking report, August 2014, pp. 6–9.
[45] AusNet Services, Submission to draft annual transmission benchmarking report, August 2014, pp. 6–8.

Figure 9 Industry wide input, output and MTFP

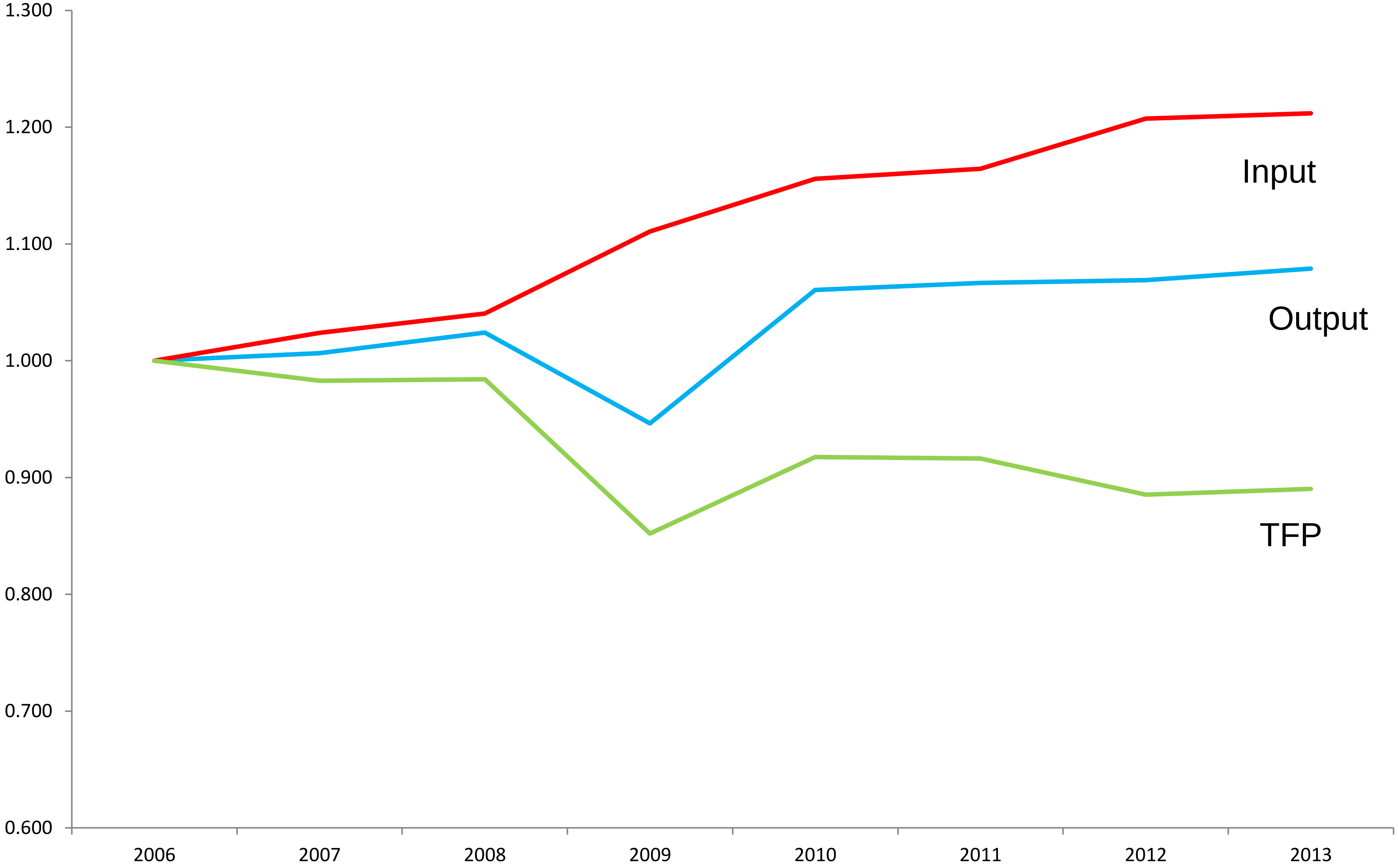
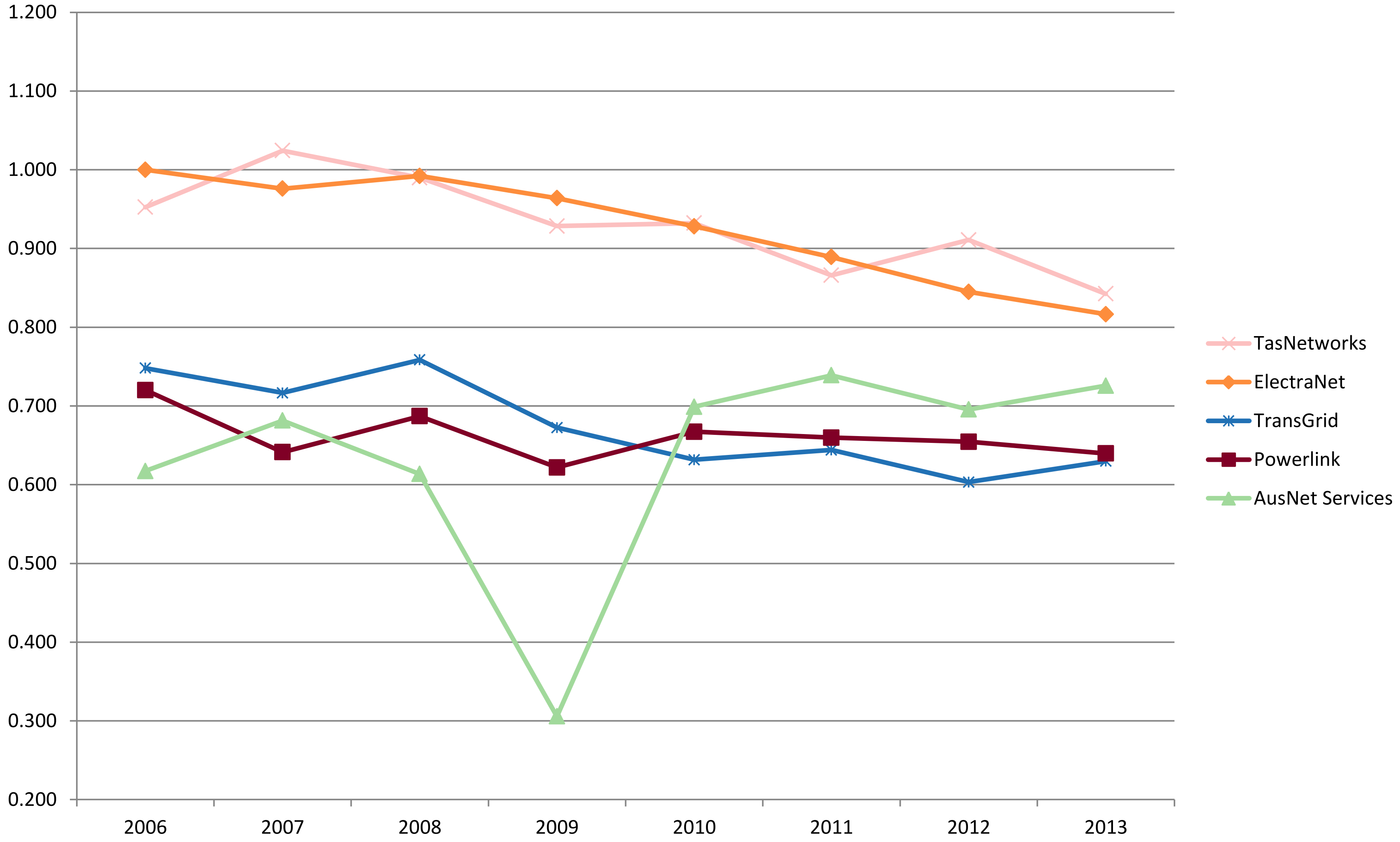


Figure 10 Relative MTFP performance of transmission networks



Appendix A

In this appendix we present partial productivity measures for opex and asset costs. These measures provide some insight into the relative partial productivity of the transmission networks with respect to opex and asset use respectively.

Opex PPIs

Figure 11 Opex per total entry/exit point voltage ($/kV, $2013)

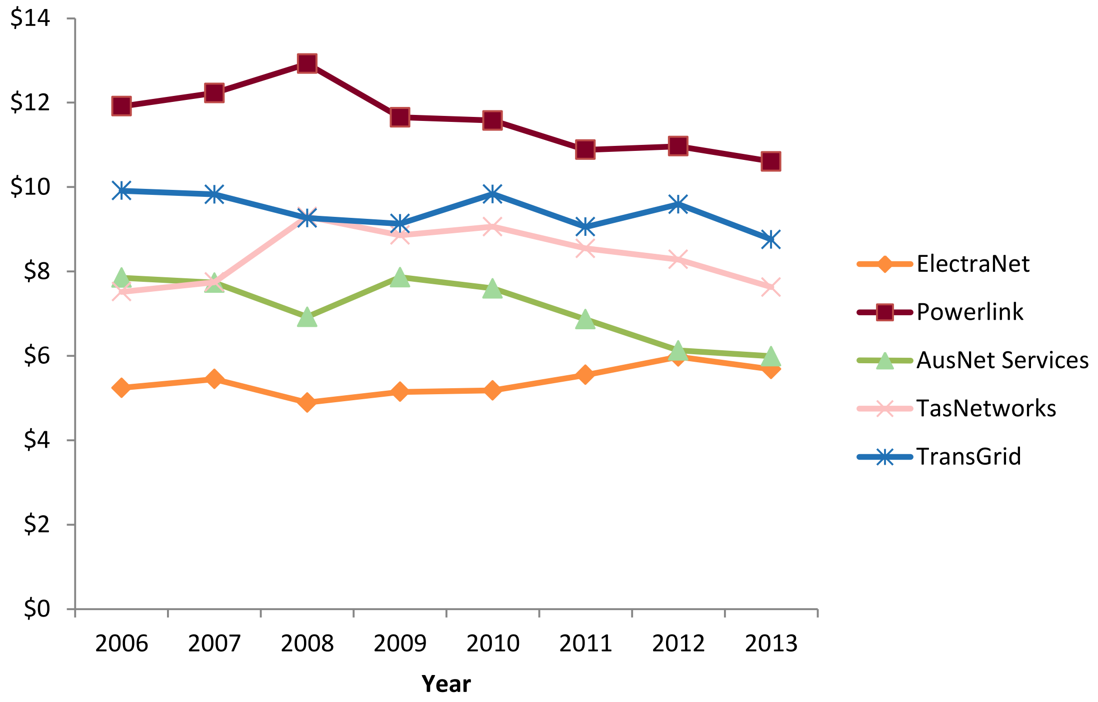


Figure 11 shows opex per kilovolt (kV) of entry and exit points. The results between this and the equivalent total cost metric (Figure 4) are not significantly different, with only AusNet Services performing slightly better and TasNetworks slightly worse. We note that opex is the lesser component of total cost.

Figure 12 **Opex per km circuit line length ($2013)**

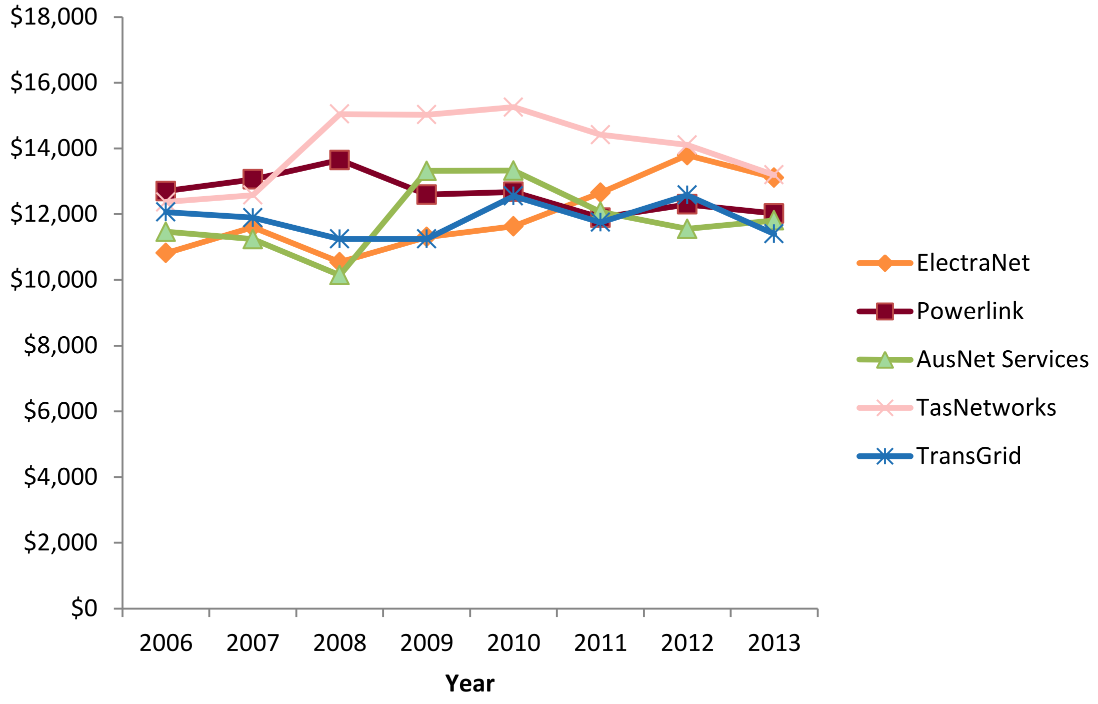
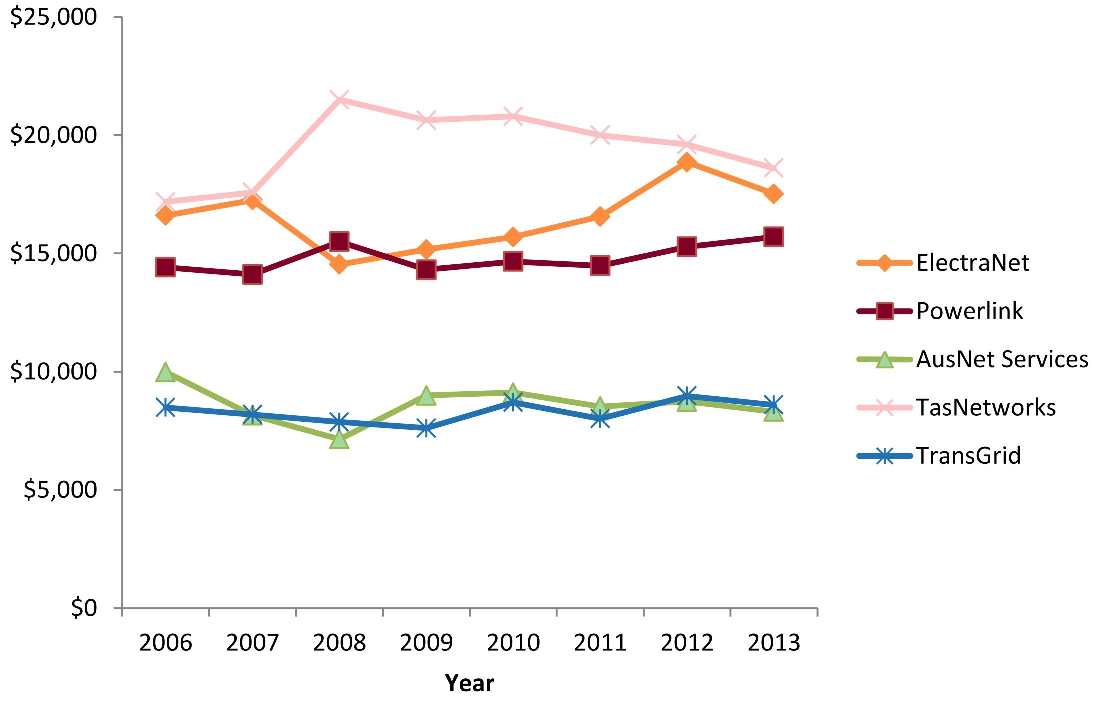


Figure 12 shows opex on per km of circuit length. On this metric there is not a significant spread of annual opex across the period. None of the transmission networks appears to be a standout performer on this metric.

Figure 13 **Opex per MW maximum demand served ($2013)**



Maximum demand is an indirect driver of opex as demand increases drive increased capex, and additional capital requires additional expenditure to maintain. Figure 13 shows that the relative efficiency of the businesses is similar to that found for total cost per MW of maximum demand (Figure 7). TransGrid performs well and TasNetworks performs poorly due to the demand characteristics of their respective networks.

Figure 14 Opex per MVA of downstream transmission capacity ($2013)

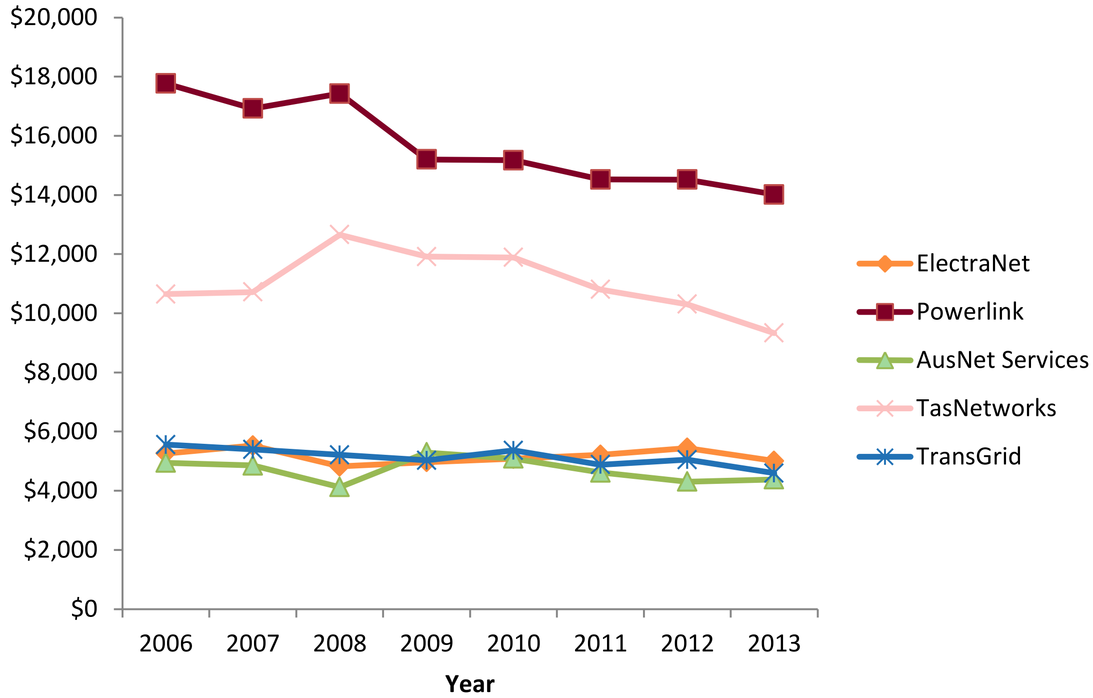


Figure 14 shows that Powerlink performs poorly on opex per MVA of downstream transmission capacity, as it did on the equivalent total cost metric (Figure 8).

Asset cost PPIs

Figure 15 Asset cost per total entry/exit point voltage ($2013)

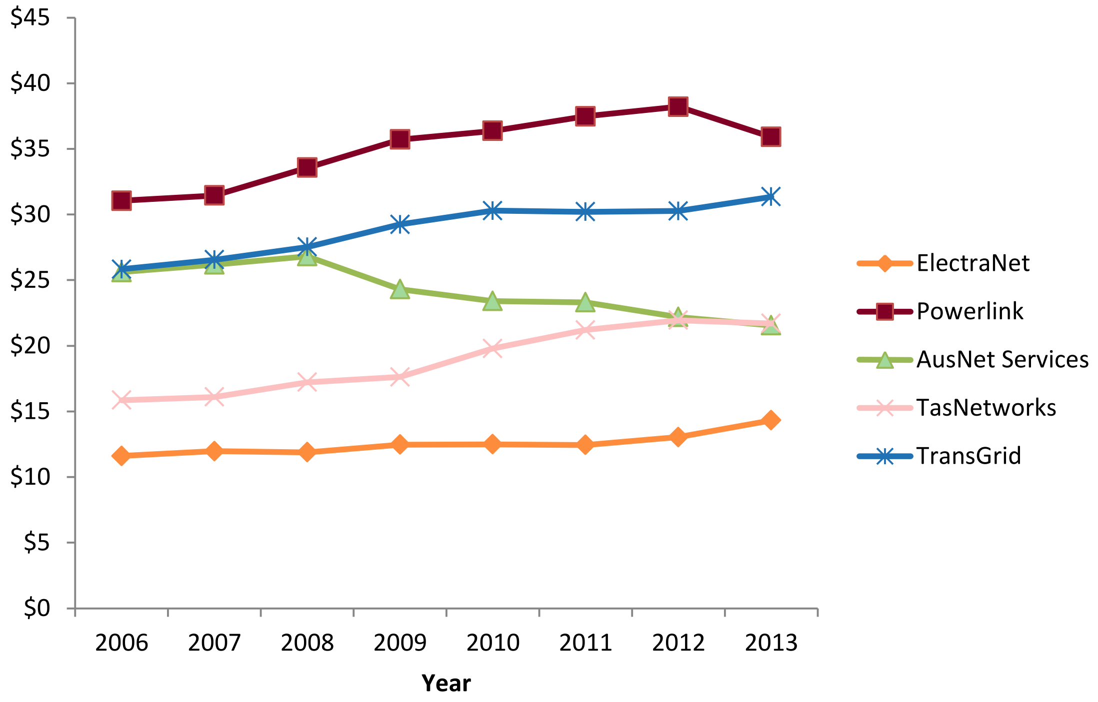


Figure 15 shows asset cost per kilovolt (kV) of entry and exit points. The results are indicative of total cost per kilovolt (kV) of entry and exit points (Figure 5) because asset cost is the larger component of total cost.

Figure 16 **Asset cost per km of circuit line length ($2013)**

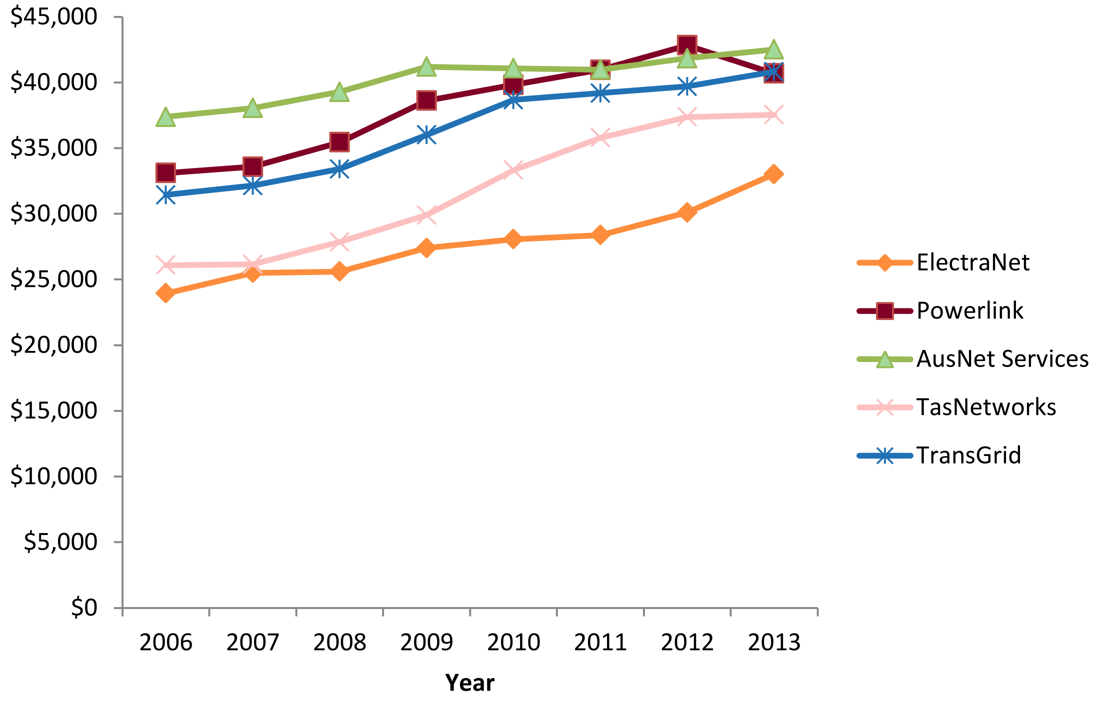
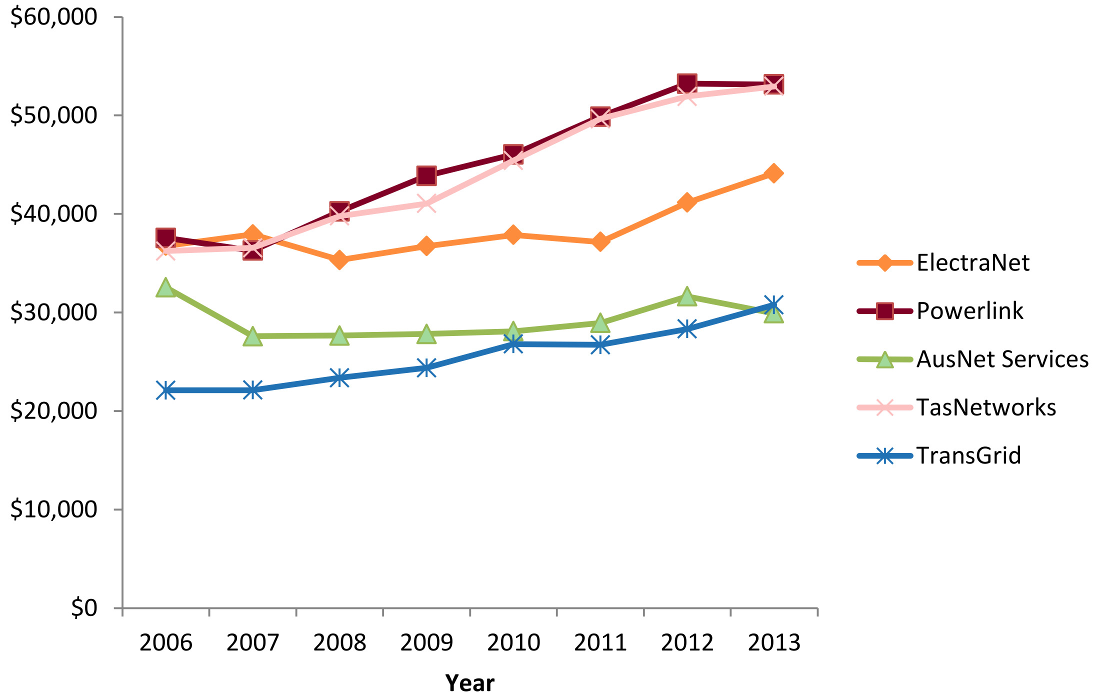


Figure 16 shows asset cost on a per circuit km basis. The results are indicative of total cost per circuit km (Figure 6).

Figure 17 **Asset cost per MW of maximum demand ($2013)**



Maximum demand is a driver of capex. We consider capex as asset cost, which indicates the amount that consumers are charged annually for the asset inputs of the transmission networks. The results of this asset cost metric are indicative of the equivalent total cost metric (Figure 7). TasNetworks performs favourably on this metric (relative to Figure 7) due to its high opex per MW of maximum demand (Figure 13).

Figure 18 Asset cost per MVA of downstream transmission capacity ($2013)

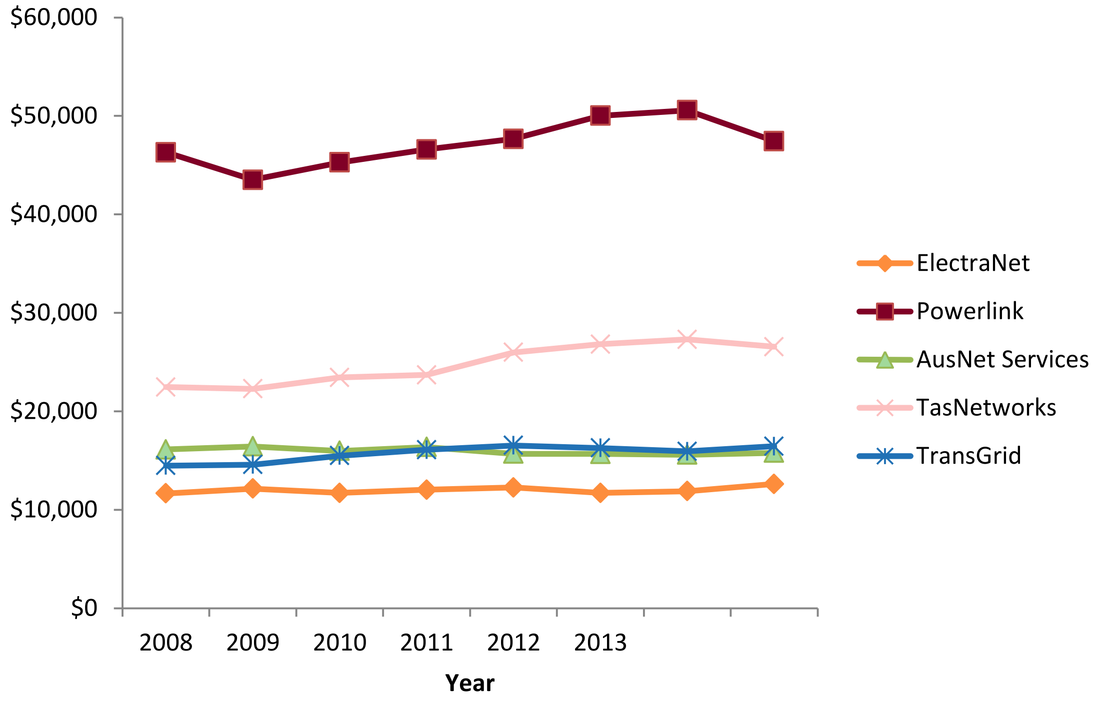


Figure 18 shows asset cost per MVA of transmission capacity. The results are indicative of total cost per MVA of transmission capacity (Figure 8).

Appendix B

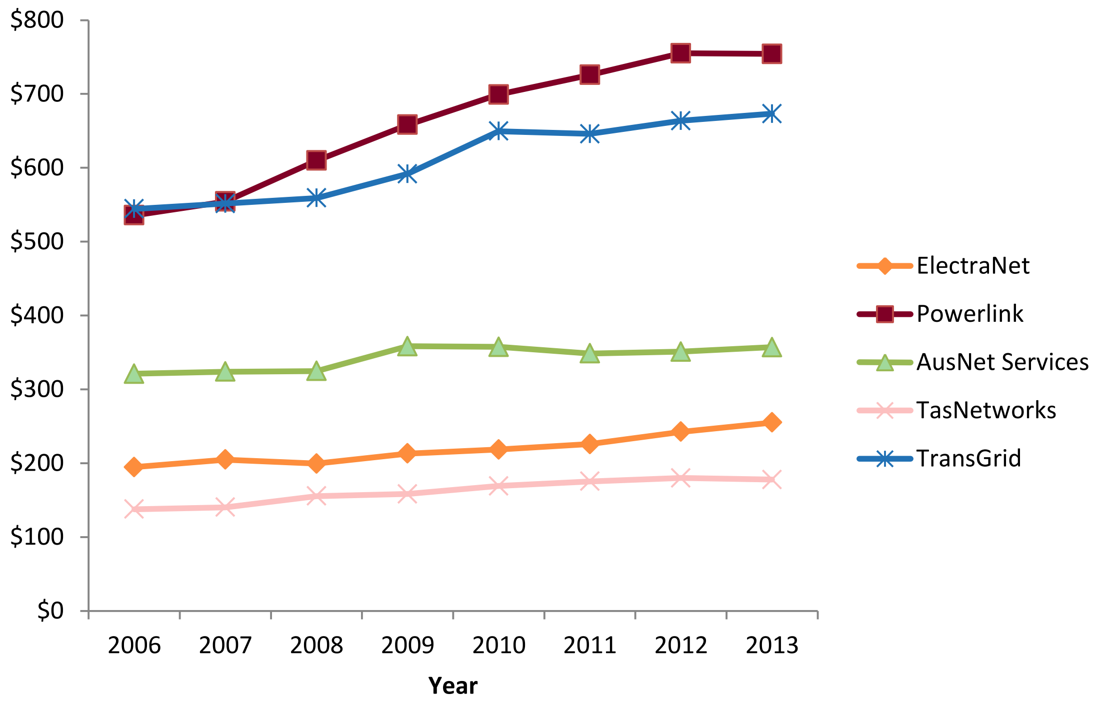
In this appendix we discuss how we calculate the total cost metric and provide insight into the overall expenditures of the transmission networks.

Total cost

Total cost are the sum of opex and asset cost. It shows the cost the end customer pays for the provision of the transmission network. Figure 19 presents the total cost of the networks over time. TransGrid and Powerlink incur the highest total costs, TasNetworks and ElectraNet incur the least; the total cost incurred reflects the size of each network.

As noted, AEMO undertakes the augmentation procurement functions for AusNet Services' transmission network; as such, AusNet Services' reported capital expenditure—and asset costs by extension—is less than it would be if it captured the full costs of augmentation capex.

Figure 19 Total costs of the transmission networks ($million 2013)



Opex

Total annual opex differs across each of the transmission networks, with Powerlink spending the most, approximately $172 million in 2013 and TasNetworks spending the least, approximately $46 million in the same year. The opex for each of the networks has been stable or shown only a small increase over the 2006–13 period.

Figure 20 **Opex ($million, 2013)**

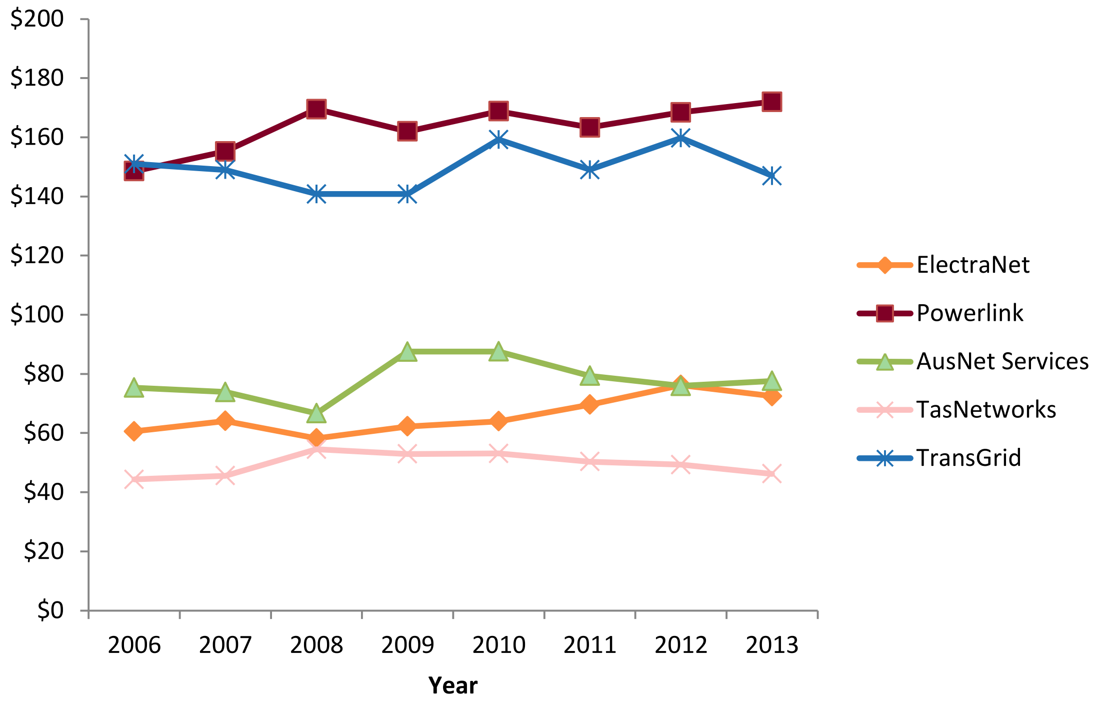


Figure 20 presents total opex. It illustrates that there is considerable difference in opex for each of the transmission networks, which reflects their respective sizes.

Asset cost

As opex is consumed in the period that it is first used it is relatively simple to compare it to outputs delivered in that period. The benchmarking of assets across transmission networks is more complex because assets will provide services over their economic life, which may be several decades. Comparing expenditure on assets (capital expenditure or capex) across networks may not be appropriate as capex may fluctuate from period to period. Capex also reflects new assets installed in the period which may have only provided services for part of the period. Further, such a comparison would not consider the total quantity of assets in place being used to provide services.

To measure the cost of assets used to provide transmission services we have chosen to use a measure of (annualised) asset cost to consumers (asset cost). This represents the amount that consumers are paying annually for the total assets of the businesses. The asset cost is made up of the annual allowances that the transmission networks receive to cover depreciation (return of capital) and the return on investment into their assets (return on capital).

To calculate the asset costs we have applied the average return on capital over the period.[46] Applying the average return on capital over the period accounts for variations in the return on capital across transmission networks and over time. We have adopted a consistent return on capital over time and across transmission networks to avoid differences in the return on capital being a source of difference in our benchmarking measures.

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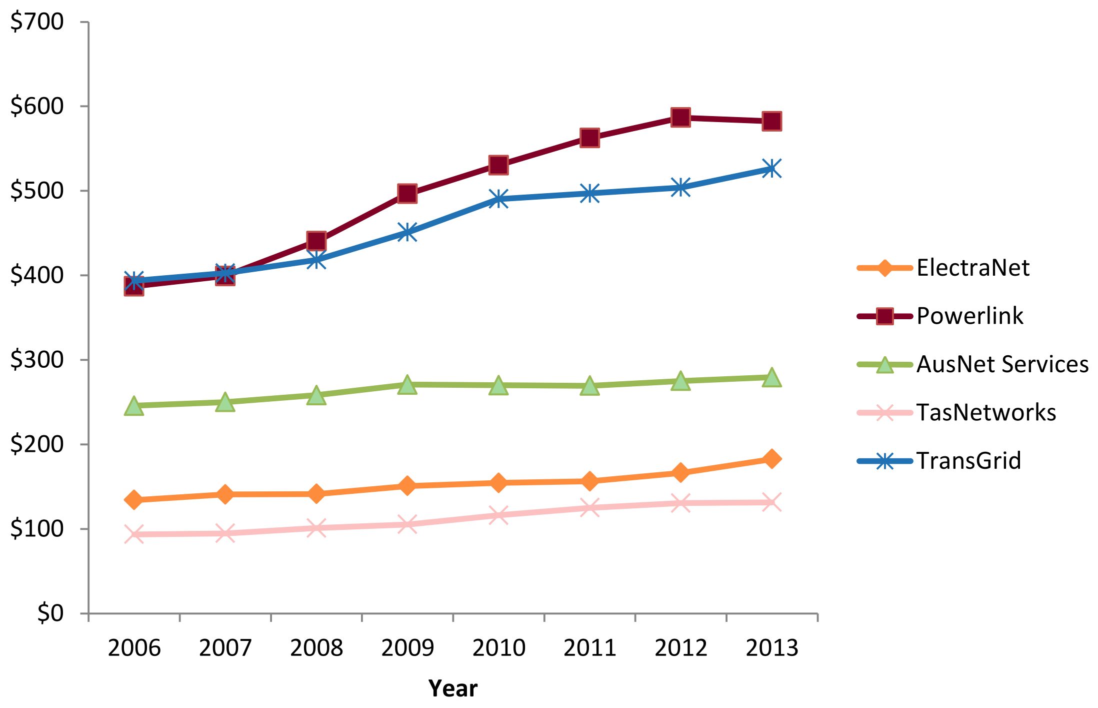
46 We have applied a real vanilla weighted average cost of capital of 6.09. In calculating this average return on capital, we applied the parameters in the AER's rate of return guideline where possible, used a market risk premium of 6.5 per cent based our most recent transmission determination, a risk free rate based on the yield 10 year CGS 365 day averaging period, and a debt risk premium based on an extrapolation of the Bloomberg BBB fair yield curve.

In the calculation of total cost we use straight line depreciation as reported by the transmission networks in their response to our economic benchmarking RIN. The RIN required that straight line depreciation be reported in accordance with the approach applied in calculating the regulatory asset base.[47]

Figure 21 presents the asset cost of the transmission networks. This is much less volatile than capex over the period (see Figure 22). Further, asset costs generally reflect the number and value of assets in place.[48] This is illustrated by the larger transmission networks having larger asset costs. The increase in asset costs overtime is due to the transmission networks capital expenditure to augment or replace the network. For example the increase in asset costs for Powerlink is driven by its increased capex from 2008. Again we note that AusNet Services' performance may be affected by the delineation of responsibility between AusNet Services and AEMO.

Figure 21 Asset cost ($millions 2013)



Our measure of asset costs tracks closely to the RABs of the transmission networks. This is expected as the asset costs are derived from the RAB (see Figure 23).

47 Straight line depreciation entails a constant rate of depreciation over the expected life of an asset. Under this measure asset age should not affect the rate of depreciation unless fully depreciated assets are still utilised. However, asset age will influence the return on investment. The return on investment is calculated as a percentage of the total value of the RAB. This means that as an asset base gets older the return that transmission networks earn on it will decrease with time.

48 Asset cost isn't a perfect measure of the number of assets in a transmission network. This is because asset cost is based upon depreciation and return on assets. The level of depreciation and return on investment will depend on the value of the RAB which is affected by the age of assets in the RAB.

Figure 22 Capex over time ($million 2013)[49]

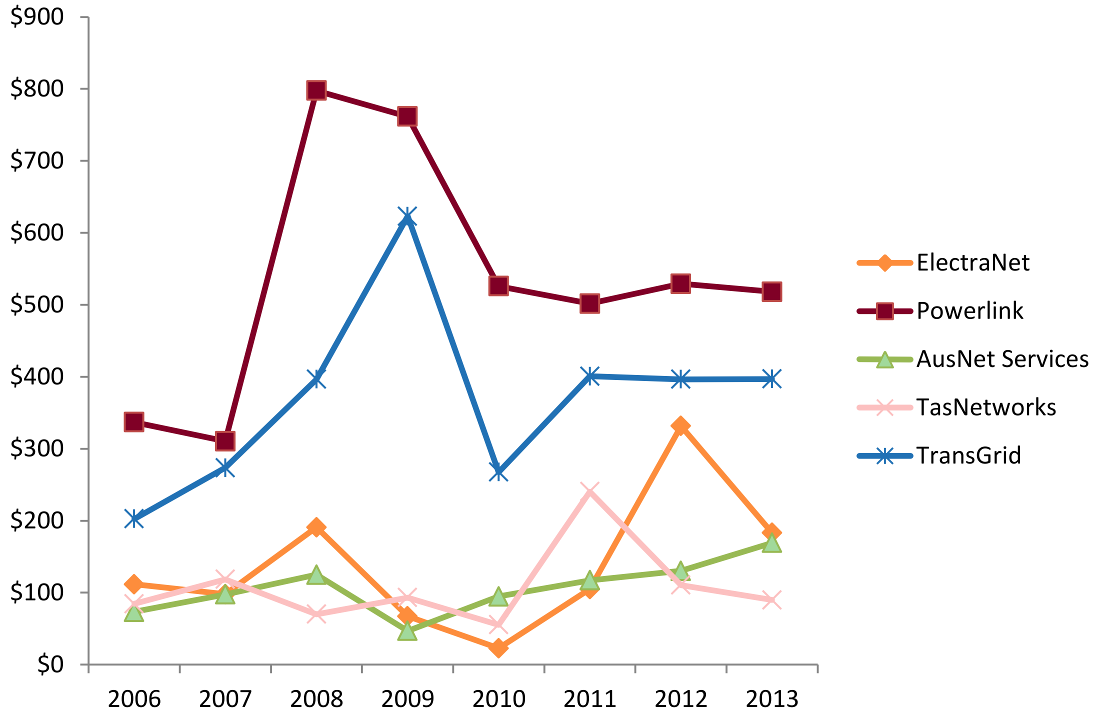


Figure 22 presents the capex spend of the transmission networks from 2006 to 2013, it illustrates the variability in capex from year to year. This variability means that the benchmarking of capex is sensitive to the comparison period selected. It will also depend on where each transmission network is in its network asset lifecycles. Those transmission networks with older assets are likely to spend more on asset replacement than those TNSPs with relatively young assets.

49 This has been converted into constant dollar terms using the ABS Weighted Average of Eight Capital Cities CPI.

Figure 23 Regulatory asset base ($millions 2013)

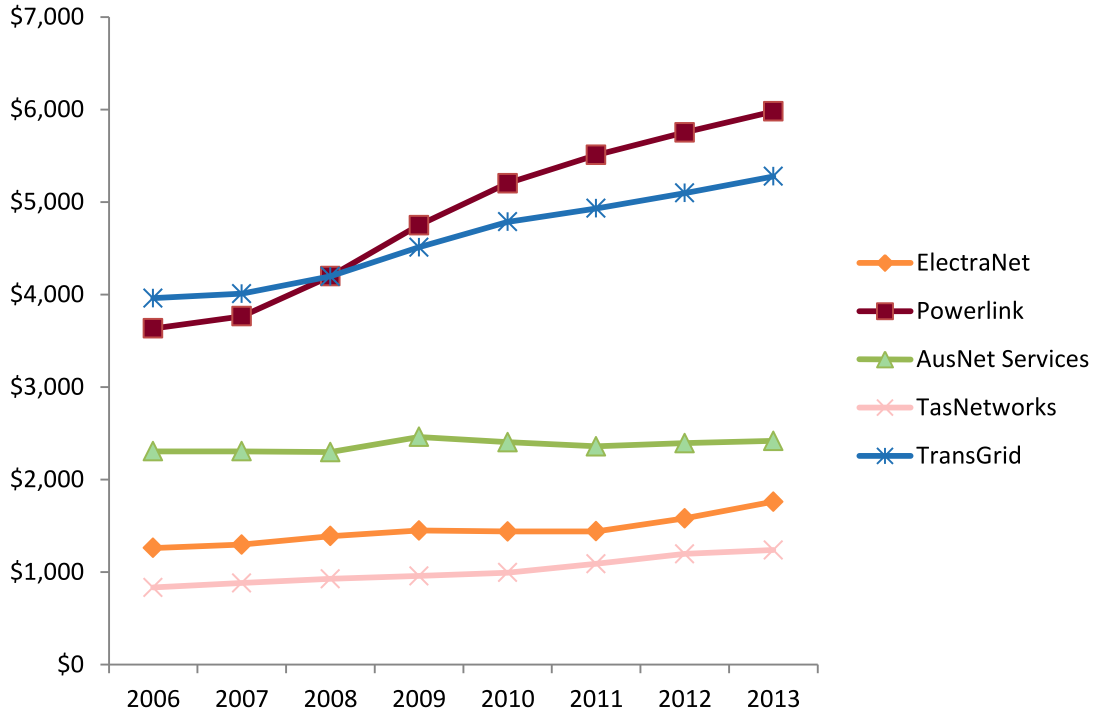


Figure 23 shows the change in the RAB for the transmission networks over the 2006–13 period. Increases in the RAB are attributable to increases in capex, as observed in Figure 22.

Figure 24 Average composition of total cost 2009-2013 ($million 2013)

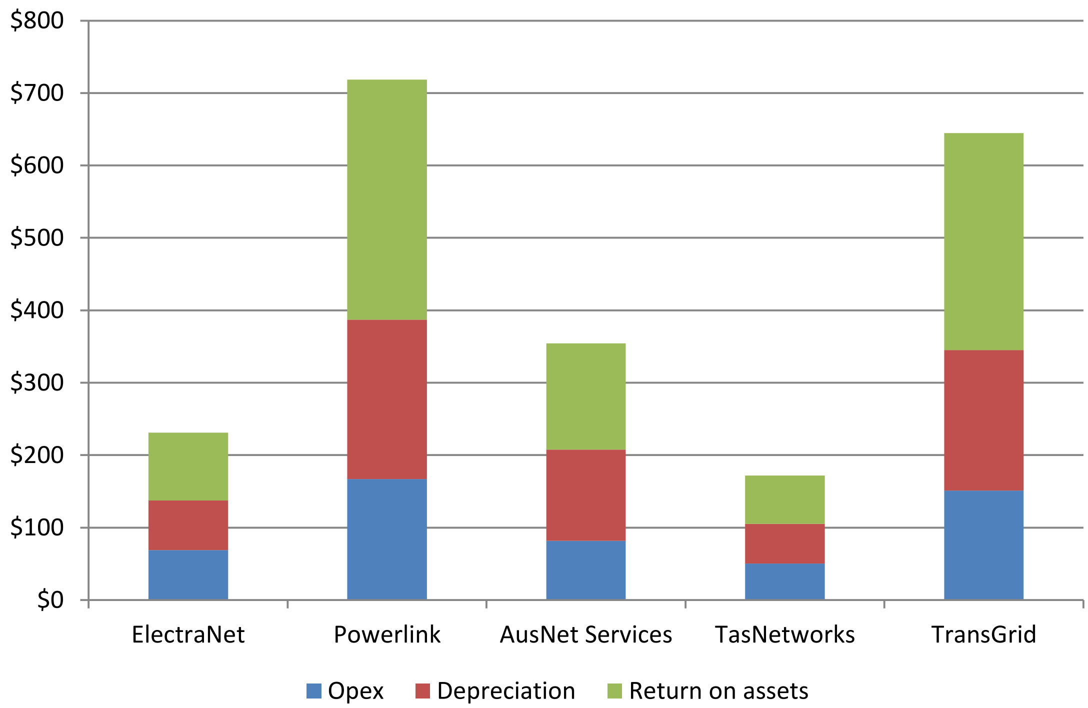


Figure 24 shows the average decomposition of total cost over a five year period. It illustrates the impact opex and the two components of asset cost have on the total annual cost consumers are charged.