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Economic Benchmarking Results for the Australian Energy Regulator's 2022 DNSP Annual Benchmarking Report

Report prepared for Australian Energy Regulator

17 November 2022

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Acronyms & Abbreviations

DNSP names

Abbreviation	*DNSP name*	*State*
EVO	Evoenergy	Australian Capital Territory
AGD	Ausgrid	New South Wales
AND	AusNet Services Distribution	Victoria
CIT	CitiPower	Victoria
END	Endeavour Energy	New South Wales
ENX	Energex	Queensland
ERG	Ergon Energy	Queensland
ESS	Essential Energy	New South Wales
JEN	Jemena Electricity Networks	Victoria
PCR	Powercor	Victoria
SAP	SA Power Networks	South Australia
TND	TasNetworks Distribution	Tasmania
UED	United Energy	Victoria

Other Abbreviations

Abbreviation	*Description*
AEMO	Australian Energy Market Operator
AUC	Annual user cost of capital
CAM	Cost allocation methodology
CMOS	Customer minutes off supply
DNSP	Distribution network service provider
EBRIN	Economic Benchmarking Regulatory Information Notice
LSECD	Least squares econometrics Cobb–Douglas model
LSETLG	Least squares econometrics translog model
MPFP	Multilateral partial factor productivity
MTFP	Multilateral total factor productivity
MVA	Megavolt ampere
MVAkms	Megavolt ampere kilometres
NEM	National Electricity Market
PFP	Partial factor productivity
RMD	Ratcheted maximum demand
SFACD	Stochastic frontier analysis Cobb–Douglas model
SFATLG	Stochastic frontier analysis translog model
TFP	Total factor productivity
TNSP	Transmission network service provider
VCR	Value of customer reliability

1 Introduction

Quantonomics has been asked to update the electricity distribution network service provider (DNSP) multilateral total factor productivity (MTFP) and multilateral partial factor productivity (MPFP) results presented in the Australian Energy Regulator's 2021 DNSP Benchmarking Report (AER 2021b).

This annual update closely follows the methods used previously by Economic Insights (2021). It includes data for the 2020-21 financial year reported by the DNSPs in their latest Economic Benchmarking Regulatory Information Notice (EBRIN) returns.

In addition to the presentation of updated productivity indexes, we also update:

- The analysis of the drivers of DNSP productivity change by quantifying the contribution of each individual output and input to total factor productivity (TFP) change. This follows Economic Insights (2017) and subsequent reports.
- The opex cost function econometric results. This analysis uses a data sample of Australian, New Zealand and Ontario DNSPs for the 16-year period from 2006 to 2021, and for the 10-year period from 2012 to 2021. This follows previous analyses by Economic Insights (2014; 2015a; 2015b; 2017; 2018; 2019; 2020a; 2021).

1.1 Updates to Productivity Measurement Methods

The methods of analysis used in this report are the same as those used in Economic Insights (2021).

Up to 2020, Victorian distribution network service providers (DNSPs) have reported data on a calendar year basis. Effective from 1 July 2021, Victorian DNSPs will report on a financial year (ending 30 June) basis, and they have provided audited Economic Benchmarking Regulatory Information Notice (EBRIN) data for the financial year ending June 2021. In this study, Victorian DNSPs' audited calendar year data for 2006 to 2020 is combined with audited data for financial year (FY) 2021. The inconsistency of periods is addressed by calculating growth rates between calendar 2020 and FY 2021 taking account that only half a year separates them. Likewise, time-trend variables in econometric analysis need to be suitably defined.

1.2 Specifications Used for Productivity Measurement

This report uses two broad types of economic benchmarking techniques to measure DNSPs' productivity growth and efficiency levels: productivity index numbers and econometric opex cost functions. The latter is discussed in section 1.5.

We use total factor productivity (TFP) indexes and partial factor productivity (PFP) indexes to measure productivity growth of electricity distribution at the Australian industry, State and individual DNSP levels. TFP is measured using the multilateral Törnqvist TFP (MTFP) index method developed by Caves, Christensen and Diewert (1982), and explained in Appendix A. These indexes provide a second order approximation to any underlying production structure. This means they can accurately model both the level and shape of the underlying production function. They provide an accurate measure of productivity growth over time and provide a convenient way of decomposing overall TFP growth into components due to changes in individual outputs and inputs. We also use the multilateral productivity indexes for time–series, cross–section (or panel data) comparisons of productivity levels. This ensures that a comparison between any two observations in the sample is invariant to whether the comparison is made directly or indirectly via a third observation.

The MTFP method is used for all the index-number based productivity analysis. When the MTFP method is applied to data for a single productive unit (eg, a DNSP), it provides information on the *changes over time* in productivity for that unit. When data is pooled over several units (eg, pooled across DNSPs or across states), the MTFP method also provides information on the *comparative productivity levels* of those units (in addition to information on productivity trends). Chapter 3 and Chapter 4 (section 4.1) present the comparative productivity analysis that compares productivity level of DNSPs and states respectively. The industry-, state-, and DNSP-level analyses in Chapters 2, 4 (section 4.2), and 5 respectively, examine patterns of output, input, and productivity over time. Individual output and input contributions to productivity change are also examined.

1.3 Defining Outputs

The output index for DNSPs is defined to include five outputs:

(a) Energy throughput in GWh (with 8.6 per cent share of gross revenue,[1] equivalent to 9.7 per cent of total revenue on average[2]),

(b) Ratcheted maximum demand (RMD) in Megawatts (MW) (with 33.8 per cent share of gross revenue, equivalent to 38.3 per cent of total revenue on average),

(c) Customer numbers (with 18.5 per cent share of gross revenue, equivalent to 21.0 per cent of total revenue on average),

(d) Circuit length in kms (with 39.1 per cent share of gross revenue, equivalent to 44.4 per cent of total revenue on average), and

[1] 'Gross revenue' is defined as the sum of total revenue plus the value of energy not supplied. See Appendix A.

[2] Average across all observations (DNSPs and years).

(e) (minus) Customer Minutes Off–supply (CMOS) (with the weight based on current AER VCRs, being –12.0 per cent of gross revenue on average and equivalent to –13.6 per cent of total revenue on average).[3]

Outputs (a) to (d) are referred to as the 'non-reliability outputs', and output (e) is the 'reliability' output. With the exception of RMD, the outputs are all directly reported by the DNSPs, which also report Maximum Demand for each year in MVA from which RMD is derived. RMD, in any given year *t*, is the maximum of the series of maximum demands from 2006 up to and including year *t*.

The weights applied to the non-reliability outputs are based on estimated shares of marginal cost which the provision of each output accounts for. These are derived from the coefficients of an econometrically-estimated Leontief cost function. This cost analysis was last carried out by Economic Insights (2020a) and the method is described in Appendix A. This report does not repeat that analysis because the resulting weights are intended to be held constant for several years before updating them (Economic Insights 2020a).

1.4 Defining Inputs

The DNSP MTFP measures include six inputs:

(a) Opex (network services opex deflated by a composite labour, materials and services price index), making up 37.3 per cent of total costs on average,[4]

(b) Overhead subtransmission lines (quantity proxied by overhead subtransmission MVAkms), making up 4.1 per cent of total costs on average,

(c) Overhead distribution lines (quantity proxied by overhead distribution MVAkms), making up 17.3 per cent of total costs on average,

(d) Underground subtransmission cables (quantity proxied by underground subtransmission MVAkms), making up 1.8 per cent of total costs on average,

(e) Underground distribution cables (quantity proxied by underground distribution MVAkms), making up 12.9 per cent of total costs on average, and

(f) Transformers and other capital (quantity proxied by distribution transformer MVA plus the sum of single stage and the second stage of two stage zone substation level transformer MVA), making up 26.7 per cent of total costs on average.

These inputs are grouped into two broader categories: input (a) is referred to as 'non-capital inputs', or 'opex input', whilst inputs (b) to (f) are together the 'capital inputs'. The capital

[3] The weights of the first four outputs sum to more than 100 per cent as reliability enters as a negative output and the sum of all five outputs is 100 per cent.

[4] Average across all observations (DNSPs and years).

inputs are aggregated for the purpose of calculating quantity indexes of capital inputs and partial factor productivities (PFPs) for capital inputs.

The weights applied to each input are based on estimated shares of total cost which each input accounts for. The cost of the non-capital input is measured by nominal Opex. For the capital inputs taken together, the annual user cost of capital (AUC) is taken to be the return on capital, the return of capital and the benchmark tax liability, all calculated in a broadly similar way to that used in forming the building blocks revenue requirement. The AUC is computed individually for each asset type in the RAB for each DNSP in each year. See Appendix A for further information.

1.5 Opex Cost Function Methodologies

While the productivity index number method presented above has the advantage of producing robust results even with small datasets, it is a deterministic method that does not facilitate the calculation of confidence intervals. When analysing opex productivity, we also include econometric modelling of operating cost functions, which allow for statistical noise and potentially allow the direct inclusion of, and hence control for, operating environment factors. The econometric approach also allows the calculation of confidence intervals for efficiency estimates. We estimate opex cost function models rather than total cost function models as opex efficiency assessment is a key component of implementing building blocks regulation, which involves separate efficiency assessments of, and determinations on, DNSP's opex and capex.

Because there is insufficient time–series variation in the Australian data and an inadequate number of cross–sections to produce robust parameter estimates, we include data on New Zealand and Ontario DNSPs. We include country dummy variables for New Zealand and Ontario to pick up systematic differences across the jurisdictions, including particularly differences in opex coverage and systematic differences in operating environment factors (OEFs), such as the impact of harsher winter conditions in Ontario. Because we include country dummy variables, it is not possible to benchmark the Australian DNSPs against DNSPs in New Zealand or Ontario, nor is this the objective of the AER's benchmarking. Rather, the inclusion of the overseas data was used to increase the data variations in the sample to improve the robustness and accuracy of the parameter estimates.

Alternative specifications used for the econometric opex cost function are based on:

- *Functional form*: The two most commonly used functional forms in econometric estimation of cost functions are the Cobb–Douglas and translog functional forms. The simpler Cobb-Douglas function is linear in logs and implies that the elasticities of real opex to each output are constant at all levels of outputs. The more flexible translog function is quadratic in logs, allowing the elasticities of real opex to each output to vary with different output levels.

- *Method of identifying firm-specific inefficiency*: Two alternative methods are used. One method is to use a variant of ordinary least squares (OLS) regression, incorporating dummy variables for 12 of the 13 Australian DNSPs.[5] The parameters of these dummy variables are converted to a measure of comparative inefficiency among these DNSPs. The other method uses stochastic frontier analysis (SFA). In the SFA models opex efficiency scores are calculated in the model relative to the directly estimated efficient frontier.

The combinations of these methods yield four different econometric models. Details of the methods used are provided in Appendix A (section A4). The opex cost efficiency measures from these four models are then averaged. Efficiency measures are obtained using the sample period from 2006 to 2021 and the sample period from 2012 to 2021. The results of this analysis are presented in chapter 3 (section 3.2) and Appendix C.

1.6 DNSP comments on draft report

In line with previous practice, the AER made the draft version of this report available to the 13 DNSPs for comment. Most submitters agreed with the AER's approach to the Victorian DNSPs' transition of financial to calendar years, whereby the calendar year data collected for the period 2006 to 2020 is combined with financial year data for 2021 (and henceforth). For example, Ausgrid, Essential Energy, Jemena, and SA Power Networks. In particular, Essential Energy noted that any recasting and estimation of historical data from 2006 is problematic, and Jemena stated that it does not have audited data for the 2019 and 2020 financial years, so it would not be cost-effective to develop actual financial year data for those years either.

Some of the DNSPs' comments related to operating environment factors (OEF) and the adjustments made to efficiency scores. AusNet emphasised that it is preferable to take account of OEFs directly within the benchmarking analysis, rather than unduly rely on *ex post* OEF adjustments. It also suggested that the report include sensitivity analysis for the effects of OEFs within the report. AusNet commented on the AER's proposed measurement of vegetation management for OEF adjustments. It was also concerned that some relevant OEFs, such as differences in terrain or remoteness, or in the characteristics of the customer base, have not been accounted for.

AusNet suggested we acknowledge the effects that differences in capitalisation policies can have on benchmarking results. It also emphasised that it would be desirable, where possible, to explicitly remedy inconsistencies due to different capitalisation policies. The issues of

[5] That is, one DNSP is treated as the base and the estimated coefficients on the dummy variables for other Australian DNSPs represent their systematic variation against the base. Overseas DNSPs do not have individual dummy variables, but rather a dummy variable for each country (with Australia as the base country, and hence with no such dummy variable). The efficiency scores are invariant to the choice of DNSP as the base since comparative efficiency measures are subsequently scaled against the DNSP with greatest efficiency.

capitalisation policy are subject of an AER consultation process currently underway. We understand that although EBRIN data is collected on the basis of 'frozen' cost allocation methods (CAMs), there remain differences in some aspects of capitalisation policy, such as choices about the proportion of corporate overheads which are expensed or capitalised, which may differ both between DNSPs and for the same DNSP over time. The outcomes of the AER's current consultation will shed light on the extent of such effects on benchmarking results.

AusNet had concerns about the inclusion of Guaranteed Service Levy (GSL) payments in opex for the purposes of benchmarking. It also questioned the plausibility of Opex Partial Factor Productivity (OPFP) results, particularly by comparison with Powercor, which it considered is largely driven by the inclusion of GSL payments and the use of Powercor's opex under its frozen 2014 CAM for benchmarking purposes. The large difference in OPFP trends over the period are driven by different trends in the measured opex input, resulting in different levels of measured OPFP at the end of the period. As mentioned, issues relating to capitalisation policy are being addressed in a separate consultation, and it would be desirable to gain a better understanding of such issues within the context of that consultation. Similarly, we understand the AER will be further examining the inclusion of GSL payments on the benchmarking results.

It was also argued that comparisons of DNSPs' input and output growth against the industry average are not meaningful without an examination of the reasons for those differences. Our aim is mainly limited to reporting the comparative levels and movements of inputs, outputs and productivity measures. In our view, comparisons against the industry average provide the reader with a useful reference scale.

As noted by Ausgrid and Jemena, and set out in section 3.2, there are ongoing issues with the performance of the Translog econometric cost function models and these are the subject of a separate memorandum investigating these concerns, a process which was supported by several DNSPs such as Ausgrid given the potential use of these models in assessing efficiency of opex in the base year. The memorandum, which has been provided to DNSPs for comment, explores the option of replacing the Translog models with a 'hybrid' model (which has fewer second-order terms than the full Translog model) when the Translog model has too many monotonicity violations. Stakeholders have requested and will need further time to respond to the memorandum, and further testing of these options and possibly the exploration of other options is appropriate. This further work and consultation may be undertaken following the release of the AER's 2022 benchmarking report.

It is important to note that the productivity measures in this report do not take account of operating environment factors (OEFs) except the degree of undergrounding of electricity lines and differences in customer density. At this stage, further adjustment of the benchmarking results via OEFs is beyond Quantonomics' current remit and this is addressed by the AER in its annual benchmarking reports and as a part of its assessment of revenue resets. In this respect, when the results of this benchmarking analysis are used by the AER, it does take OEFs into account when forming its efficiency assessments. The AER will also respond in its report in relation to the broader OEF feedback received.

There were some very minor changes to data for two DNSPs, and the analysis has been updated to reflect those changes.

2 Industry–level Distribution Productivity Results

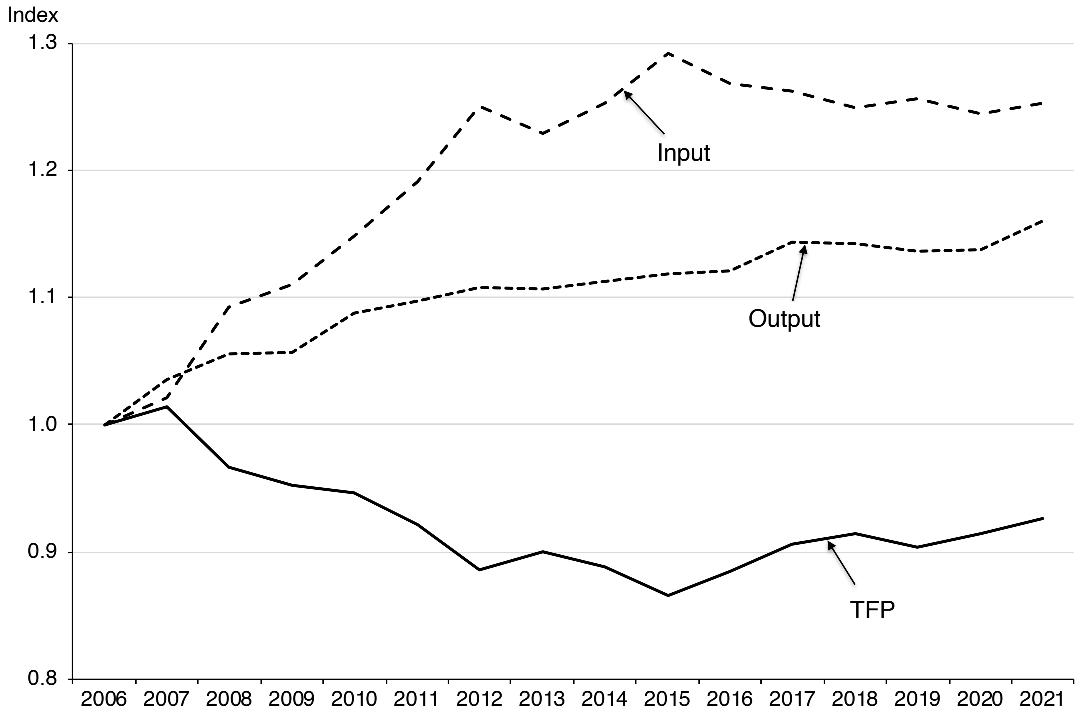
This chapter presents productivity results for the electricity distribution industry across the NEM states and territories in aggregate.

2.1 Industry TFP

Distribution industry-level total output, total input and TFP indexes are presented in Figure 2.1 and Table 2.1. Opex and capital partial factor productivity indexes are also presented in Table 2.1.

Over the 16-year period 2006 to 2021, industry level TFP *declined* at an average annual rate of 0.5 per cent.[6] Although total output increased at an average annual rate of 1.0 per cent, total input use increased faster at a rate of 1.5 per cent. Since the average rate of change in TFP is the average rate of change in total output less the average rate of change in total inputs, this produced a negative average rate of productivity change. Although the long-run average TFP change was negative, TFP change was positive in seven years: 2007, 2013, 2016–2018 and 2020–2021. TFP growth performance was thus better in the period since 2015, than in the period from 2006 to 2015, as shown in Figure 2.1.

Figure 2.1 DNSP industry output, input and TFP indexes, 2006–2021



[6] In keeping with common practice in productivity studies, reported annual growth rates are generally calculated on a natural logarithm basis. This approach is based on a continuous time growth framework rather than a discrete time framework. It also more readily facilitates identification of the contributors to a given growth rate when the multilateral Törnqvist indexing method is used (see Appendix A).

Table 2.1 shows that over the period 2006 to 2012, TFP *decreased* at an average annual rate of 2.0 per cent. From 2012 to 2021, TFP *increased* at an average annual rate of 0.5 per cent. Between 2020 and 2021, TFP increased by 1.5 per cent.

Table 2.1 DNSP industry output, input, TFP and PFP indexes, 2006–2021

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	1.035	1.021	1.014	1.038	0.999
2008	1.056	1.093	0.966	0.924	0.994
2009	1.057	1.110	0.952	0.935	0.962
2010	1.087	1.148	0.947	0.923	0.960
2011	1.098	1.191	0.922	0.879	0.947
2012	1.108	1.250	0.886	0.812	0.932
2013	1.107	1.229	0.901	0.881	0.911
2014	1.112	1.253	0.888	0.875	0.895
2015	1.118	1.291	0.866	0.835	0.885
2016	1.121	1.268	0.884	0.903	0.873
2017	1.143	1.262	0.905	0.949	0.881
2018	1.142	1.249	0.914	0.995	0.869
2019	1.136	1.257	0.904	0.992	0.856
2020	1.138	1.244	0.914	1.044	0.845
2021	1.160	1.252	0.926	1.067	0.851
Growth Rate 2006-2021	1.0%	1.5%	-0.5%	0.4%	-1.1%
Growth Rate 2006-2012	1.7%	3.7%	-2.0%	-3.5%	-1.2%
Growth Rate 2012-2021	0.5%	0.0%	0.5%	3.1%	-1.0%
Growth Rate 2021	2.3%	0.7%	1.5%	2.5%	0.8%

2.2 Partial factor productivity trends

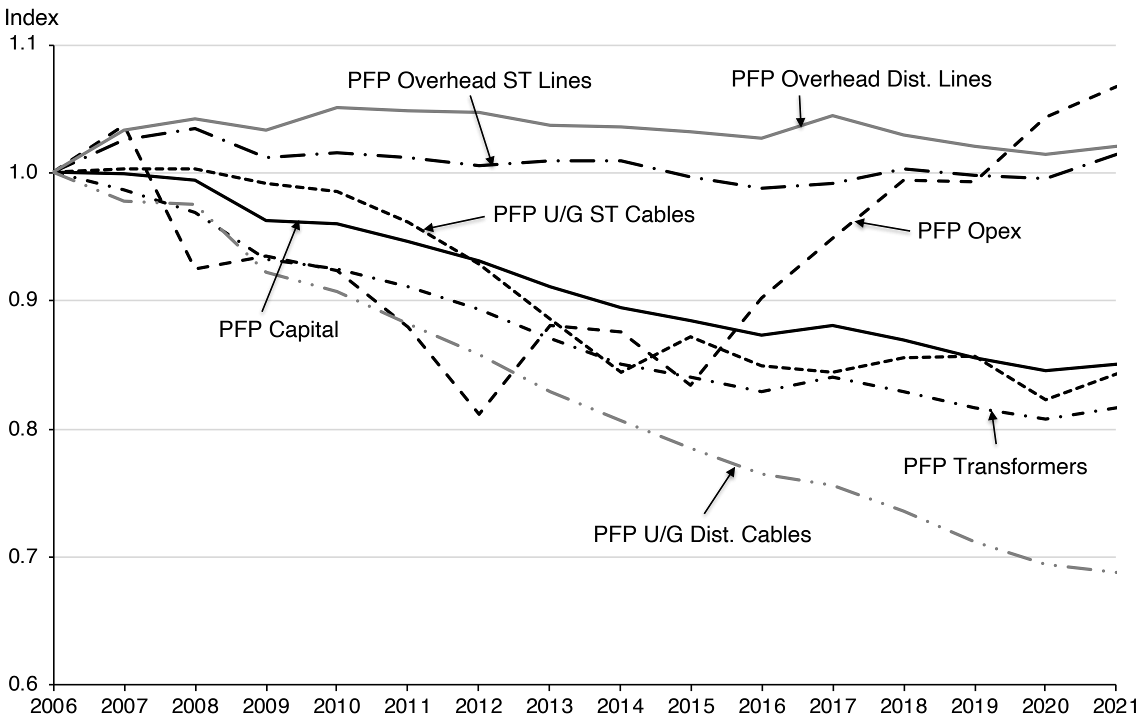
Partial factor productivity (PFP) is a measure of output relative to a single input. The PFP indexes for Opex and Capital in Table 2.1 and Figure 2.2 represent ratios of the total output index to indexes of these two main inputs for the distribution industry. Figure 2.2 also shows PFP indexes for each individual capital input. Movements in the aggregate capital PFP index declined reasonably steadily over the sample period, following an essentially inverse pattern to capital input quantities (since as Figure 2.1 shows, the total output index has a reasonably stable upward trend). PFP indexes for most individual capital inputs also decreased over the same period. Opex PFP declined through to 2012 but has generally improved since then, as opex use has trended down. The PFP of opex inputs increased slightly overall between 2006 and 2021.

In 2021, opex PFP was 6.7 per cent above its 2006 level. Among the capital inputs:

- Overhead distribution lines PFP in 2021 was 2.1 per cent higher than in 2006, and the overhead sub-transmission lines PFP was 1.4 per cent higher over the same period.
- Underground distribution cables PFP was 31.2 per cent lower in 2021 than in 2006, and underground sub-transmission PFP *declined* by 15.7 per cent over this period. As noted above, this is because underground cables have increased rapidly from a small base.
- Transformer PFP *declined* by 18.4 per cent between 2006 and 2021.

Tables showing the average growth rates of individual outputs and inputs, and average growth rates for PFP by individual input, are presented in Appendix D for the industry overall and for individual DNSPs.

Figure 2.2 DNSP industry partial factor productivity indexes, 2006–2021

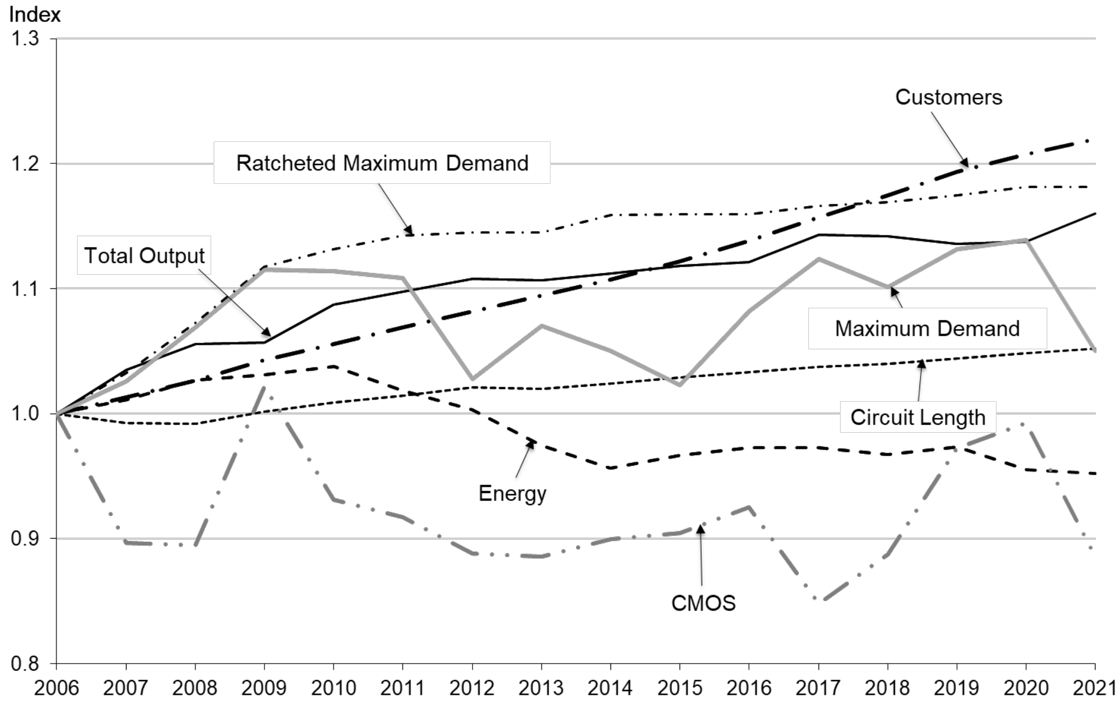


2.3 Distribution industry output and input quantity changes

This section considers the changes in the quantities of the five separate outputs that make up the output index, and the six inputs that make up the input index. Quantity indexes for individual outputs are shown in Figure 2.3 and for individual inputs in Figure 2.4. In each case the quantities are converted to index format with a value of one in 2006 for ease of comparison. Later, in section 2.4, we present results that show the contributions of each output and each input to TFP change taking account of the change in each component's quantity over time and its weight in forming the TFP index.

From Figure 2.3 we see that circuit length—the output component with the largest weight in the output index—grew very modestly over the 16 years and by 2021 was only 5.2 per cent higher than in 2006. This reflects the fact that most of the increase in customer numbers over the period has been through 'in fill' development (i.e., new dwellings which could be supplied off the existing network), not requiring large increases in network length. The bulk of population growth has occurred on the fringes of cities and towns, in areas already supplied with electricity and in higher density development of cities, so that required increases in network length are modest compared to the increase in customer numbers being serviced.

Figure 2.3 DNSP industry output quantity indexes, 2006–2021



The customer numbers index increased steadily over the period and was 22.0 per cent higher in 2021 than it was in 2006. This steady increase is to be expected as the number of electricity customers will increase roughly in line with growth in the population. However, we see that energy throughput for distribution peaked in 2010 and fell steadily through to 2014. Although there was a marginal increase since then, energy throughput stayed below its 2006 level. In 2021 energy throughput was slightly less than in 2014 and 4.8 per cent less than it was in 2006. This broadly reflects the increasing impact of energy conservation initiatives and more energy-efficient buildings and appliances.

Ratcheted maximum demand (RMD) (i.e., the highest maximum demand up to a particular date) is used as a measure of the capacity supplied to users. It has the second highest weight in forming the output index. This measure reflects the fact that the provision of capacity to service the earlier higher maximum demands does not diminish with decreases in maximum demand or necessarily vary with year-to-year variations in maximum demand. RMD shown in Figure 2.3 is the sum of ratcheted maximum demands across the 13 DNSPs (rather than first summing the maximum demands and then calculating the ratcheted quantity).[7] RMD increased rapidly in the period up to 2009, and more slowly since then, even though energy throughput declined after 2010. By 2021, RMD was 18.1 per cent higher than in 2006. Also shown in Figure 2.3 is (non-ratcheted) maximum demand. It decreased over the period from 2010 to 2015, in line with energy demand, but maximum demand has since increased. Over the period from 2006 to 2021, the ratio of maximum demand to energy throughput increased, but it decreased significantly in 2021. Over the whole period to 2021, this ratio increased by 10.3 per cent. The ratio between RMD and energy use continued to increase steadily and by 2021 was 24.1 per cent higher than it was in 2006. Distribution networks, thus, have to service a steadily increasing number of customers and, at least in aggregate, need to meet a slowly growing maximum demand, at a time of weak or falling annual energy throughput.

The last output shown in Figure 2.3 is aggregate CMOS. This enters the total output index as a negative output since a reduction in CMOS represents an improvement and a higher level of service for customers. Conversely, an increase in CMOS reduces total output as customers are inconvenienced more by not having supply for a longer period. We see that, with the exception of 2009, CMOS appears to have generally trended downward up to 2017, hence contributing more to total output than was the case in 2006. However, since 2017 there appears to be some fluctuation. By 2021, CMOS was 11.4 per cent below the 2006 level.

Since the circuit length and ratcheted maximum demand outputs together receive an average weight of 83.9 per cent of total revenue in forming the total output index (see Table A.2 in Appendix A), in Figure 2.3 we see that the total output index is largely bounded by these two output indexes. The total output index also lies close to the customer numbers output index which received the third highest weight. The output index is also significantly influenced by the comparatively volatile movements in the CMOS output (noting again that an increase in CMOS has a negative impact on total output and is given an average weight of –15.0 per cent of total revenue on average for the industry in aggregate (see Table A.2, Appendix A). For example, the large increases in CMOS between 2017 and 2020 caused total output to decline slightly despite increases in the other four outputs. Energy throughput is given a comparatively small average weight of 9.9 per cent of total revenue, since changes in throughput generally have relatively low marginal cost. Reductions in throughput after 2010, hence, have had a more muted impact on total output.

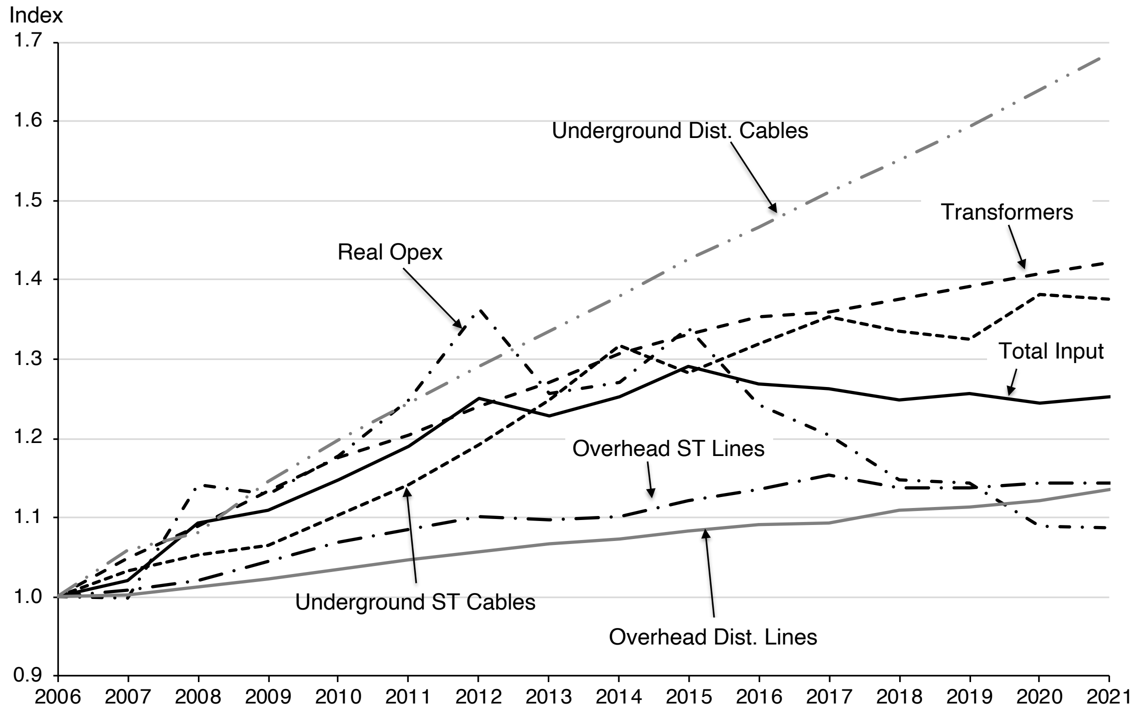
Turning to the input side, quantity indexes for the six individual inputs and the total input index are presented in Figure 2.4. Opex has the largest average share in total costs at 37.3 per

[7] For this reason, the RMD for the industry can increase in a year when aggregate maximum demands did not increase as seen for 2010 and 2011 in Figure 2.3.

cent and so is an important driver of the total input quantity index (where weights are based on cost shares; see Table A.3 in Appendix A). The quantity of opex (i.e., opex in constant 2006 prices) increased sharply between 2006 and 2012, being 36.4 per cent higher in 2012 than it was in 2006. It then fell in 2013 – a year that coincided with revenue determinations of several large DNSPs – before increasing again in 2014 and 2015. Since then it has decreased consistently, so that by 2021 real opex was 8.7 per cent higher than in 2006.

Another input with a large weight is transformers, which accounts for 28.8 per cent of total cost for the industry. The quantity of transformers has increased steadily over the period and by 2021 was 42.2 per cent above its 2006 level. It is by the use of more or larger transformers in zone substations and on the existing network that DNSPs can accommodate ongoing increases in customer numbers with only small increases in their overall network length.

Figure 2.4 DNSP industry input quantity indexes, 2006–2021



The next key components of DNSP input are the quantities of overhead distribution and overhead sub-transmission lines (measured in MVA-km). These two input quantities have increased over the period from 2006 to 2021 to be 13.6 and 14.4 per cent respectively of the 2006 level. Overhead line input quantities take account of both the length of lines (in km) and the overall 'carrying capacity' of the lines (in MVA). The fact that both overhead distribution and sub-transmission quantities have increased substantially more than circuit length reflects the fact that the average capacity of overhead lines has increased over the period as new or upgraded lines have higher carrying capacity than older lines. Overhead distribution and sub-transmission lines together account for 20.2 per cent of total DNSP costs on average.

The fastest growing input quantity is that of underground distribution cables whose quantity was 68.6 per cent higher in 2021 than it was in 2006. However, this growth starts from a quite small base and so a higher growth rate is to be expected, particularly seeing that many new land developments require the use of underground distribution and there is a push in some areas to make greater use of undergrounding for aesthetic reasons. Underground distribution quantity increases faster than underground sub-transmission quantity (which increased by 37.6 per cent over the period), again likely reflecting the increasing use of undergrounding in new subdivisions and land developments. Although the length of overhead lines is several times higher than the length of underground cables, underground cables are considerably more expensive to install per kilometre. Consequently, despite their relatively short length, underground distribution and sub-transmission have an average share in total costs of 13.8 per cent.

From Figure 2.4 we see that the total input quantity index lies close to the quantity indexes for opex and transformers (which together have a weight of 66.1 per cent of total costs on average). The faster growing underground distribution cables quantity index generally lies above this group of quantity indexes which in turn lie above the slower growing overhead lines quantity indexes.

2.4 Distribution industry output and input contributions to TFP change

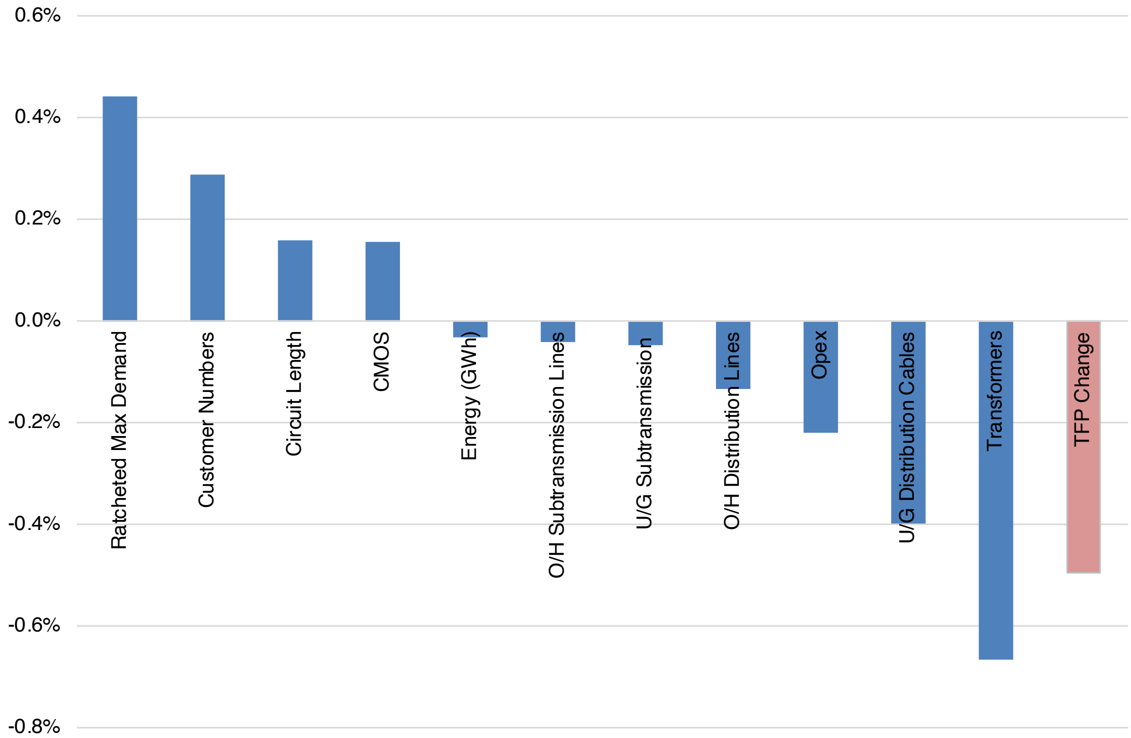
Having reviewed movements in individual output and input components in the preceding section, we now examine the contribution of each output and each input component to annual TFP change. Or, to put it another way, we want to decompose TFP change into its constituent parts. Since TFP change is the change in total output quantity less the change in total input quantity, the contribution of an individual output (input) will depend on the change in the output's (input's) quantity and the weight it receives in forming the total output (total input) quantity index. However, this calculation has to be done in a way that is consistent with the index methodology to provide a decomposition that is consistent and robust. In Appendix A we present the methodology that allows us to decompose productivity change into the contributions of changes in each output and each input.

In Figure 2.5 and Table 2.2 we present the percentage point contributions of each output and each input to the average annual rate of TFP change of –0.50 per cent over the 16-year period 2006 to 2021. In Figure 2.5 the blue bars represent the percentage point contributions of each of the outputs and inputs to average annual TFP change which is given in the red bar at the far right of the graph. The contributions appear from most positive on the left to most negative on the right. If all the (blue bar) positive and negative contributions in Figure 2.5 are added together, the sum will equal the red bar of TFP change at the far right.

In Figure 2.5 we see that the highest (i.e. most positive) contribution to TFP change over the 16-year period comes from RMD which, despite weaker growth after 2011, had the second highest average annual output growth rate over the period of 1.1 per cent. Combined with its average total revenue weight of 38.8 per cent (see Table A.2, Appendix A), this led to RMD contributing 0.44 percentage points to TFP change over the period.

The second highest contribution to TFP change comes from customer numbers which have grown steadily by 1.3 per cent annually over the whole period. Customer numbers have the third largest weight of the output components at 21.3 per cent on average and the highest growth rate of the output components and contributed 0.29 percentage points to TFP change over the period.

Figure 2.5 Distribution industry output and input percentage point contributions to average annual TFP change, 2006–2021



Despite only increasing at an average annual rate of 0.3 per cent, circuit length receives an average weight of 45.0 per cent of the total output index, and so it made the third highest contribution to TFP change at 0.16 percentage points. Customer minutes off-supply performance effectively made a similar contribution to TFP improvement. The CMOS output receives a weight of –15.0 per cent on average in the total output index and, combined with an average annual change of –0.8 per cent (i.e. reduction in CMOS which increases output), contributed 0.16 percentage points to average annual TFP change. Since energy throughput fell over the 16-year period at an average annual rate of –0.3 per cent and it only has an average weight of 9.9 per cent in total revenue, it made a marginal negative percentage point contribution to TFP change of –0.03 percentage points.

All six inputs made negative contributions to average annual TFP change. That is, the use of all six inputs increased over the 16-year period. Overhead sub-transmission and distribution lines both had average annual input growth rates of 0.9 per cent, and because they also have low weights in total input of 4.7 per cent and 15.4 per cent on average respectively, they made small negative contributions to TFP change: –0.04 and –0.13 percentage points respectively. Despite having a high average annual growth rate of 2.1 per cent, the underground sub-transmission cables input only has a weight of 2.3 per cent in total inputs and so made only a negligible negative contribution to TFP change at –0.05 percentage points.

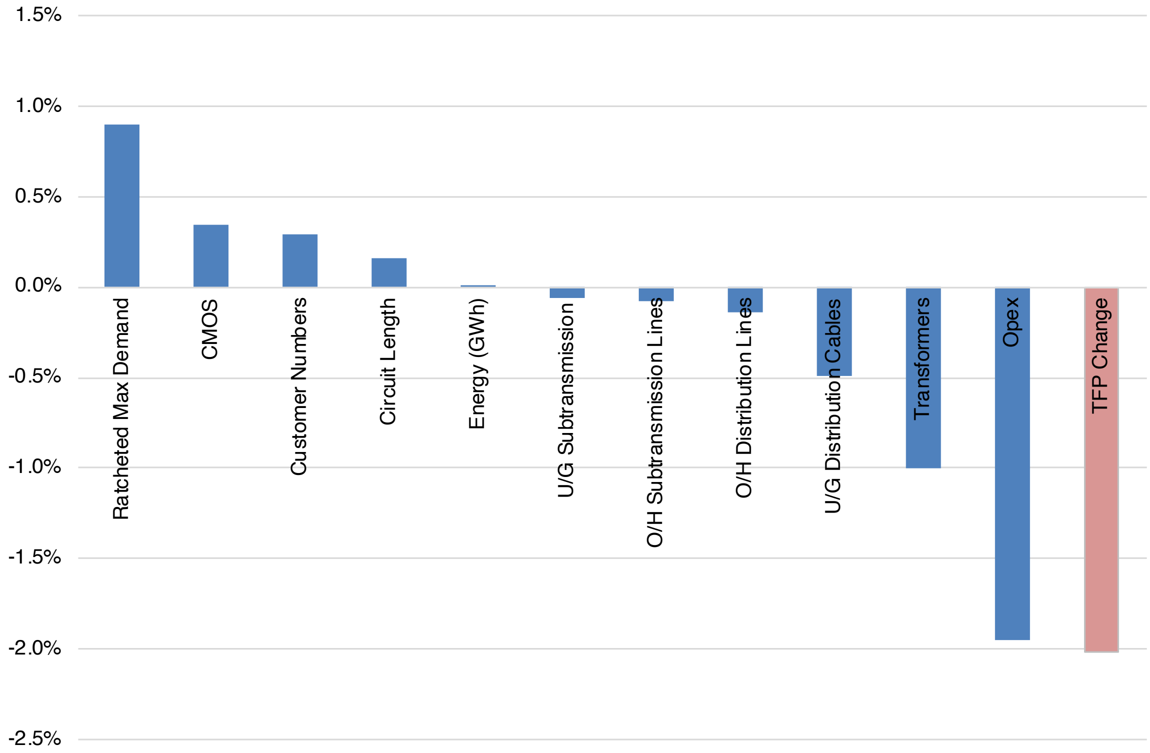
Underground distribution cables had the highest rate of average annual input growth over the period at 3.5 per cent and having a weight of 11.5 per cent in the total input index; they made a substantial negative contribution of –0.40 percentage points to TFP change. The two inputs with the largest average shares in the total input index are transformers and opex, with shares of 28.8 per cent and 37.2 per cent, respectively. Since transformer inputs have the second highest input average annual growth rate at 2.4 per cent, they make the largest negative contribution to TFP change at –0.67 percentage points. Opex has a lower average annual growth rate at 0.6 per cent and makes the third most negative contribution to TFP change at –0.22 percentage points.

Table 2.2 Distribution industry output and input percentage point contributions to average annual TFP change : Various periods

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2021*
Energy (GWh)	-0.03%	0.00%	-0.06%	-0.03%
Ratcheted Max Demand	0.44%	0.90%	0.14%	-0.01%
Customer Numbers	0.29%	0.29%	0.29%	0.24%
Circuit Length	0.16%	0.16%	0.15%	0.17%
CMOS	0.16%	0.35%	0.03%	1.89%
Opex	-0.22%	-1.95%	0.94%	0.12%
O/H Subtransmission Lines	-0.04%	-0.08%	-0.02%	0.00%
O/H Distribution Lines	-0.13%	-0.14%	-0.13%	-0.22%
U/G Subtransmission	-0.05%	-0.06%	-0.04%	0.01%
U/G Distribution Cables	-0.40%	-0.49%	-0.34%	-0.32%
Transformers	-0.67%	-1.00%	-0.44%	-0.34%
TFP Change	-0.50%	-2.02%	0.52%	1.51%

We next look at contributions to average annual TFP change for the period up to 2012 and then for the period after 2012. Table 2.2 also shows the contributions to TFP growth in these two sub-periods. The results for the period from 2006 to 2012 are also presented in Figure 2.6, and those for the period from 2012 to 2021 are presented in Figure 2.7.

Figure 2.6 Distribution industry output and input percentage point contributions to average annual TFP change , 2006–2012



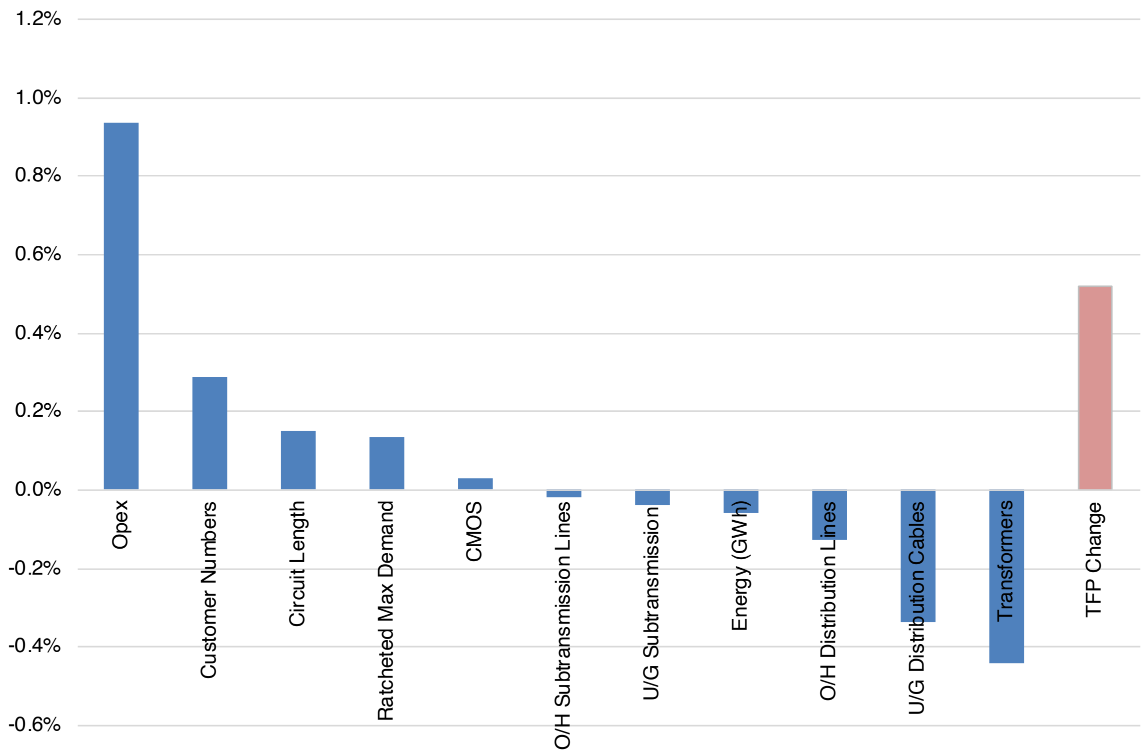
Average annual TFP change for the 2006 to 2012 period was more negative at –2.02 per cent. From Figure 2.6 we can see a similar pattern of contributions to TFP change for most outputs and inputs for the period up to 2012 as for the whole period with two main exceptions. The contributions from the RMD and CMOS outputs are somewhat higher in the period up to 2012 at 0.90 percentage points and 0.35 percentage points, respectively. This coincides with the period where RMD was increasing most strongly, and CMOS was at close to its lowest point (i.e. most positive contribution to total output).

The second, and most significant, difference of the period up to 2012 relates to the contribution of opex to average annual TFP change. Opex increased rapidly from 2006 to 2012, and its average annual growth rate over this period was 5.2 per cent. This high growth rate in opex likely reflects responses to meet new standards requirements, with many of those responses relating to changed conditions following the 2009 Victorian bushfires and lack of cost control from constraints imposed by government ownership. A detailed discussion of these issues can be found in AER (2015). This high growth rate of opex, together with its large weight in the total input index, made for a very large negative contribution of –1.95 percentage points to average annual TFP change over the period up to 2012.

In the period from 2012 to 2021, TFP change was positive with an annual average growth rate of 0.52 per cent, and the contributions to this growth are presented in Figure 2.7 and Table 2.2. The most significant change relative to the earlier period is the contribution of opex to

TFP change, which changed from being the most negative contributor up to 2012 to being the most positive contributor after 2012. Since 2012 opex has fallen at an average annual rate of change of –2.6 per cent. This has led to opex making a positive contribution of 0.94 percentage points to average annual TFP change over this period. Drivers of this turnaround in opex performance include efficiency improvements in response to the AER 2015 determinations, improvements in vegetation management and preparation of some DNSPs for privatisation. The introduction of the AER's economic benchmarking program has likely also played a role.

Figure 2.7 Distribution industry output and input percentage point contributions to average annual TFP change, 2012–2021



Other contributors to improved TFP performance after 2012 are reductions in the negative contributions to TFP change from (i) transformers whose contribution fell from –1.00 percentage points (pre-2012) to –0.44 after 2012; and (ii) underground distribution cables, which decreased from –0.49 to –0.34 percentage points. However, offsetting this has been reductions in the contributions from some outputs, with RMD's contribution to average annual TFP change falling from 0.90 (up to 2012) to 0.14 percentage points after 2012 and CMOS's contribution falling from 0.35 to 0.03 percentage points. Reductions in energy throughput made its contribution to average annual TFP change marginally negative (by comparison its contribution was zero pre-2012 and –0.06 after 2012).

Table 2.2 also shows the contributions to the TFP growth of 1.51 per cent in 2021. Among the outputs, energy throughput and RMD make a negligible contribution to the 2021 TFP growth.

Customer numbers and circuit length make similar small contributions as they did in the period 2012 to 2021. CMOS makes a large positive contribution of 1.89 percentage points in 2021. This is the largest single factor explaining the strong productivity growth in 2021. The contributions of the inputs in 2021 were broadly similar to their, mostly negative, contributions in the period 2012 to 2021, with the main exception being Opex. Although Opex reductions made a particularly strong positive contribution to TFP growth in the 2012 to 2021 period, but their contribution in 2021 of 0.12 percentage points, was much smaller.

Tables 2.3 and 2.4 present the annual changes in each output and each input component and their percentage point contributions to annual TFP change for each of the years 2007 to 2021.

Table 2.3 Distribution industry output and input annual changes, 2006–2021

Year	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
Energy	1.11%	1.52%	0.42%	0.67%	-1.92%	-1.48%	-2.92%	-1.88%	1.10%	0.63%	-0.06%	-0.56%	0.69%	-1.95%	-0.34%
RMD	3.20%	3.83%	4.08%	1.24%	0.95%	0.20%	0.00%	1.23%	0.06%	0.02%	0.58%	0.25%	0.43%	0.59%	0.00%
Customer No.	1.30%	1.32%	1.57%	1.24%	1.23%	1.19%	1.20%	1.13%	1.34%	1.41%	1.66%	1.53%	1.55%	1.20%	1.15%
Circuit Length	-0.76%	-0.04%	0.97%	0.69%	0.60%	0.61%	-0.12%	0.42%	0.48%	0.39%	0.43%	0.27%	0.41%	0.40%	0.38%
CMOS	-10.95%	-0.19%	13.27%	-9.23%	-1.57%	-3.23%	-0.25%	1.55%	0.56%	2.24%	-8.65%	4.55%	9.12%	2.04%	-12.97%
Opex	-0.23%	13.53%	-1.08%	4.11%	5.89%	8.82%	-8.23%	1.12%	5.33%	-7.58%	-3.11%	-4.78%	-0.32%	-4.86%	-0.27%
O/H Sub-Trans.	0.89%	1.13%	2.33%	2.41%	1.43%	1.44%	-0.40%	0.44%	1.86%	1.21%	1.51%	-1.30%	0.02%	0.43%	0.09%
O/H Distrib.	0.16%	1.20%	0.92%	1.10%	1.21%	0.98%	0.92%	0.65%	0.92%	0.71%	0.20%	1.39%	0.35%	0.74%	1.51%
U/G Sub-Trans.	3.13%	2.02%	1.14%	3.48%	3.45%	4.34%	4.65%	5.31%	-2.68%	2.88%	2.58%	-1.46%	-0.62%	4.15%	-0.50%
U/G Distrib.	5.73%	2.15%	5.69%	4.52%	3.73%	3.64%	3.38%	3.33%	3.24%	2.83%	3.00%	2.69%	2.68%	2.84%	3.20%
Transformer	4.87%	3.66%	3.93%	3.69%	2.45%	2.87%	2.53%	2.77%	1.80%	1.69%	0.40%	1.27%	1.11%	1.20%	1.08%

Table 2.4 Distribution industry output and input percentage point contributions to annual TFP change, 2006–2021

Year	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
Energy	0.11%	0.15%	0.05%	0.06%	-0.19%	-0.15%	-0.28%	-0.18%	0.11%	0.06%	0.00%	-0.06%	0.07%	-0.19%	-0.03%
RMD	1.33%	1.52%	1.61%	0.49%	0.37%	0.07%	0.00%	0.47%	0.02%	0.02%	0.21%	0.10%	0.17%	0.23%	-0.01%
Customer No.	0.31%	0.29%	0.33%	0.28%	0.27%	0.26%	0.25%	0.24%	0.28%	0.30%	0.34%	0.33%	0.34%	0.26%	0.24%
Circuit Length	-0.34%	-0.02%	0.44%	0.32%	0.27%	0.27%	-0.05%	0.19%	0.21%	0.18%	0.18%	0.12%	0.19%	0.18%	0.17%
CMOS	2.04%	0.03%	-2.35%	1.67%	0.25%	0.45%	0.00%	-0.21%	-0.07%	-0.29%	1.16%	-0.59%	-1.30%	-0.31%	1.89%
Opex	0.07%	-5.18%	0.39%	-1.56%	-2.17%	-3.27%	3.10%	-0.52%	-1.99%	2.89%	1.17%	1.73%	0.11%	1.82%	0.12%
O/H Sub-Trans.	-0.05%	-0.06%	-0.10%	-0.12%	-0.07%	-0.07%	0.02%	-0.02%	-0.09%	-0.06%	-0.08%	0.06%	0.00%	-0.02%	0.00%
O/H Distrib.	-0.03%	-0.18%	-0.14%	-0.15%	-0.20%	-0.15%	-0.14%	-0.10%	-0.14%	-0.12%	-0.04%	-0.22%	-0.06%	-0.12%	-0.22%
U/G Sub-Trans.	-0.07%	-0.05%	-0.01%	-0.08%	-0.07%	-0.10%	-0.11%	-0.12%	0.05%	-0.07%	-0.07%	0.03%	0.02%	-0.09%	0.01%
U/G Distrib.	-0.72%	-0.21%	-0.66%	-0.46%	-0.45%	-0.43%	-0.39%	-0.37%	-0.37%	-0.34%	-0.37%	-0.26%	-0.31%	-0.31%	-0.32%
Transformer	-1.29%	-1.10%	-1.05%	-1.03%	-0.71%	-0.84%	-0.75%	-0.80%	-0.49%	-0.49%	-0.14%	-0.33%	-0.33%	-0.29%	-0.34%
TFP change	1.38%	-4.81%	-1.49%	-0.55%	-2.70%	-3.95%	1.65%	-1.43%	-2.48%	2.08%	2.36%	0.92%	-1.10%	1.15%	1.51%

3 DNSP Efficiency Results

This chapter presents summary MTFP and MPFP results for each DNSP followed by an update of the econometric opex cost function models in Economic Insights (2014; 2015a; 2015b; 2020a).

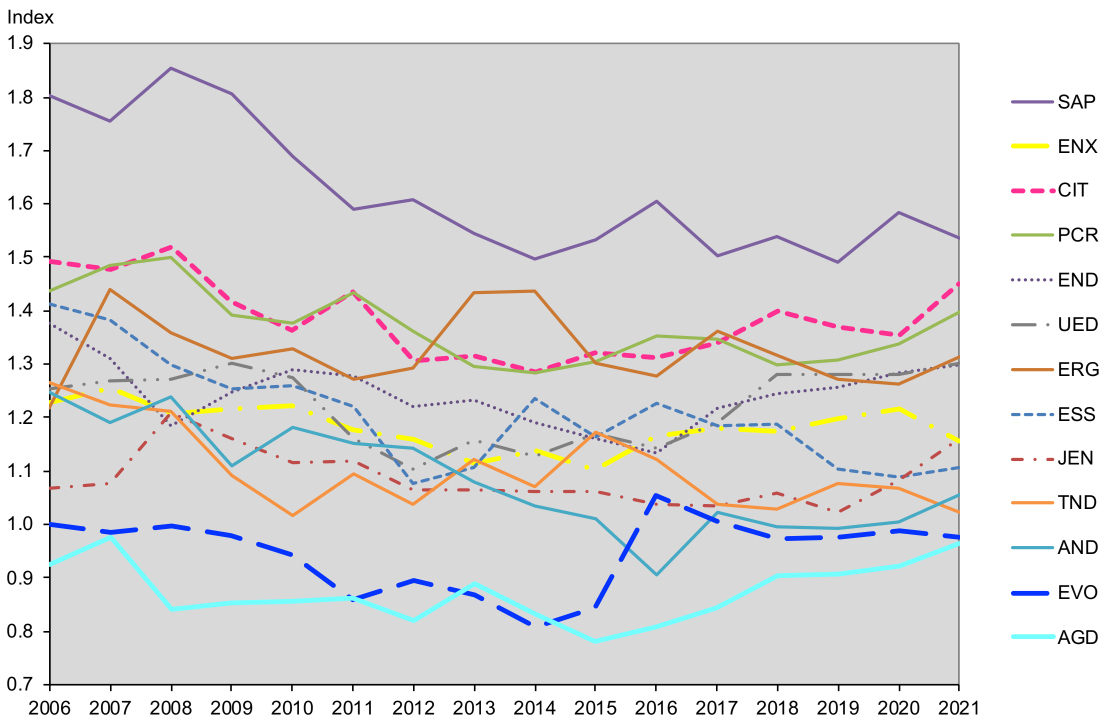
3.1 DNSP multilateral total and partial factor productivity indexes

As outlined in chapter 1, MTFP and MPFP indexes can allow comparisons of productivity levels as well as productivity growth to be made when a panel of DNSPs is included in the index analysis. The following two subsections examine MTFP and MPFP indexes in turn.

3.1.1 Multilateral TFP Indexes

Updated DNSP MTFP indexes are presented in Figure 3.1 and Table 3.1. For convenience, index results are presented relative to EVO in 2006 having a value of one. The results are invariant to which observation is used as the base.

Figure 3.1 DNSP multilateral total factor productivity indexes, 2006–2021



In 2006 the average MTFP index (relative to EVO in 2006) was 1.29, and it reduced to 1.21 in 2021, reflecting the average industry decrease in TFP over the intervening period. There was also a narrowing on MTFP scores, in that the difference between the highest and lowest MTFP indexes decreased from 0.88 in 2006 to 0.57 in 2021. Comparing MTFP levels in 2021:

- SAP has the highest MTFP level followed by CIT and PCR. AGD ranks lowest in terms of MTFP followed by EVO and TND;
- The DNSPs with above-average MTFP indexes were SAP (with an MTFP index of 1.54), CIT (1.45), PCR (1.40), ERG (1.31), UED (1.30) and END (1.30);
- Those with below-average MTFP indexes were (from smallest to largest) AGD (0.96), EVO (0.98), TND (1.02), AND (1.06), ESS (1.11), ENX (1.16) and JEN (1.16).

Table 3.1 DNSP multilateral total factor productivity indexes, 2006–2021

Year	EVO	AGD	CIT	END	ENX	ERG	ESS
2006	1.000	0.925	1.492	1.378	1.229	1.219	1.414
2007	0.985	0.977	1.477	1.311	1.255	1.440	1.383
2008	0.996	0.842	1.520	1.186	1.208	1.359	1.299
2009	0.978	0.853	1.418	1.247	1.215	1.312	1.255
2010	0.942	0.856	1.362	1.290	1.222	1.329	1.260
2011	0.859	0.861	1.436	1.278	1.176	1.272	1.220
2012	0.896	0.821	1.306	1.221	1.160	1.292	1.078
2013	0.869	0.888	1.317	1.234	1.114	1.433	1.107
2014	0.809	0.834	1.287	1.191	1.139	1.438	1.235
2015	0.843	0.781	1.321	1.160	1.102	1.302	1.163
2016	1.054	0.808	1.312	1.134	1.166	1.279	1.228
2017	1.007	0.846	1.338	1.218	1.180	1.363	1.186
2018	0.974	0.904	1.400	1.244	1.175	1.318	1.188
2019	0.976	0.908	1.370	1.257	1.200	1.271	1.102
2020	0.989	0.923	1.355	1.283	1.216	1.262	1.088
2021	0.976	0.964	1.451	1.299	1.157	1.312	1.106

Year	JEN	PCR	SAP	AND	TND	UED	AVG
2006	1.069	1.436	1.802	1.246	1.267	1.253	1.287
2007	1.077	1.486	1.755	1.192	1.224	1.268	1.295
2008	1.208	1.501	1.855	1.237	1.212	1.273	1.284
2009	1.161	1.392	1.807	1.110	1.092	1.302	1.242
2010	1.117	1.376	1.690	1.182	1.018	1.276	1.225
2011	1.118	1.433	1.590	1.152	1.095	1.162	1.204
2012	1.066	1.363	1.608	1.142	1.039	1.103	1.161
2013	1.063	1.296	1.545	1.081	1.121	1.157	1.171
2014	1.062	1.284	1.496	1.036	1.069	1.129	1.155
2015	1.063	1.304	1.534	1.010	1.172	1.171	1.148
2016	1.037	1.353	1.604	0.907	1.122	1.144	1.165
2017	1.035	1.348	1.502	1.024	1.037	1.191	1.175
2018	1.058	1.299	1.539	0.996	1.030	1.281	1.185
2019	1.022	1.307	1.491	0.993	1.076	1.282	1.174
2020	1.081	1.338	1.585	1.004	1.068	1.282	1.190
2021	1.162	1.397	1.535	1.057	1.024	1.303	1.211

Of the DNSPs with above-average MTFP in 2021, most increased their productivity from 2020 to 2021, SAP's MTFP decreased, whereas there were strong increases for CIT, PCR and ERG, and smaller increases for UED and END. Among the DNSPs with below-average MTFP in 2021, those which increased their MTFP substantially in 2021 were JEN, AND, and AGD, whilst ESS had a smaller increase. The remaining DNSPs, ENX, TND and EVO, had decreased MTFP in 2021.

Comparing the rankings of MTFP levels in 2021 to those in 2006, ERG had the largest increase in its ranking from 10th in 2006 to 4th in 2021. JEN had the second largest increase from 11th to 7th. Other increases in ranking included UED, from 7th to 5th; ENX from 9th to 8th. DNSPs with the largest decreases in rankings between 2006 and 2021 were ESS, from 4th to 9th and TND from 6th to 11th. The ranking of AND decreased from 8th to 10th and the ranking of END decreased from 5th to 6th.

Comparing the rankings of MTFP levels in 2021 to those in 2020, ERG and JEN had the largest increases in their rankings, from 6th to 4th, and from 9th to 7th respectively. AND also increased its ranking from 11th to 10th. On the other hand, the DNSPs whose ranking decreased were END from 4th to 6th, ENX from 7th to 8th, ESS from 8th to 9th and TND from 10th to 11th.

3.1.2 Multilateral PFP Indexes

MTFP levels are an amalgam of Opex MPFP and Capital MPFP levels. Updated Opex MPFP indexes are presented in Figure 3.2 and Table 3.2 while updated Capital MPFP indexes are presented in Figure 3.3 and Table 3.3.

From Figure 3.2 we see that Opex MPFP levels for most DNSPs decreased in the period from 2006 to 2012, but this trend was mostly reversed in the period 2012 to 2014, and since that time Opex MPFP has increased. From Figure 3.2 and Table 3.2 we see that six DNSPs increased Opex MPFP levels in 2021 by 5 per cent or more over 2020; namely JEN (35.4 per cent), CIT (32.0 per cent), ERG (13.3 per cent), AGD (9.0 per cent), AND (8.2 per cent), and UED (5.0 per cent). Smaller increases were achieved by PCR (4.9 per cent) and ESS (2.6 per cent). The Opex MPFP levels of five DNSPs decreased in 2021, including ENX (–13.8 per cent), TND (–8.8 per cent), SAP (–2.6 per cent), END (–2.1 per cent) and EVO (–1.8 per cent).[8]

PCR ranked highest in terms of Opex MPFP levels in 2021 followed by CIT, SAP and END. EVO ranked lowest in terms of Opex MPFP levels in 2021, followed by AND, ENX and AGD. Compared to 2020, JEN and ERG improved their Opex MPFP ranking by two places in 2021 (from 11th to 9th, and 9th to 7th respectively). CIT increased from 3rd to 2nd place whilst UED improved from 6th to 5th place. TND and SAP decreased their Opex MPFP ranking by

[8] As explained in Appendix A (section A1.4), annual growth rates are calculated using the log-difference method. Growth rates for Victorian DNSPs transitioning from calendar year to financial year reporting are annualised.

one place in 2021, but the most substantial reduction in Opex PFP ranking was ENX, which decreased by four places to become 11th ranked in 2021.

Figure 3.2 DNSP multilateral opex partial factor productivity indexes, 2006–2021

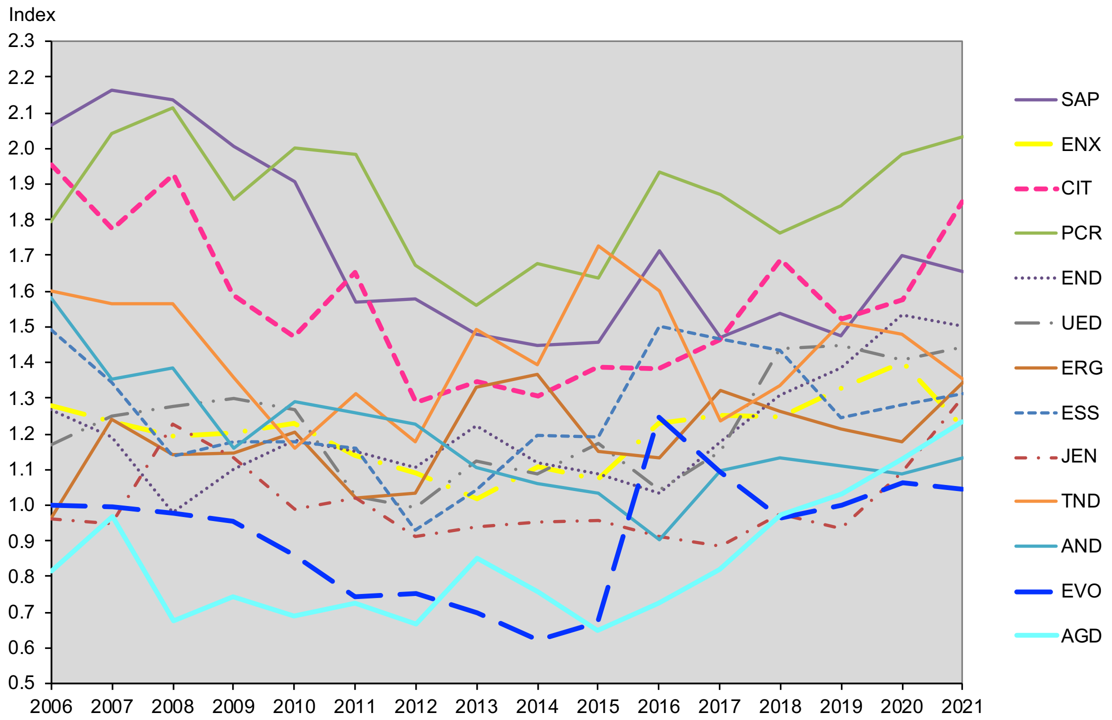


Table 3.2 DNSP multilateral opex partial factor productivity indexes, 2006–2021

Year	EVO	AGD	CIT	END	ENX	ERG	ESS
2006	1.000	0.814	1.955	1.268	1.277	0.960	1.491
2007	0.994	0.967	1.773	1.191	1.235	1.242	1.343
2008	0.977	0.678	1.926	0.978	1.192	1.140	1.139
2009	0.955	0.743	1.592	1.102	1.204	1.147	1.176
2010	0.861	0.690	1.473	1.181	1.230	1.204	1.176
2011	0.744	0.724	1.652	1.149	1.138	1.020	1.160
2012	0.751	0.666	1.290	1.104	1.091	1.034	0.932
2013	0.697	0.852	1.348	1.221	1.018	1.329	1.041
2014	0.621	0.756	1.308	1.119	1.106	1.368	1.197
2015	0.672	0.650	1.387	1.089	1.071	1.152	1.191
2016	1.247	0.724	1.381	1.032	1.231	1.134	1.502
2017	1.096	0.819	1.465	1.177	1.254	1.322	1.467
2018	0.964	0.973	1.687	1.308	1.248	1.264	1.433
2019	1.001	1.030	1.522	1.383	1.329	1.212	1.243
2020	1.064	1.130	1.575	1.534	1.402	1.176	1.279
2021	1.044	1.236	1.849	1.502	1.222	1.344	1.313

Table 3.2 (cont.)

Year	JEN	PCR	SAP	AND	TND	UED	AVG
2006	0.963	1.793	2.063	1.582	1.601	1.170	1.380
2007	0.948	2.042	2.163	1.355	1.565	1.248	1.390
2008	1.226	2.115	2.137	1.384	1.565	1.275	1.364
2009	1.135	1.858	2.006	1.159	1.359	1.301	1.287
2010	0.990	2.001	1.906	1.292	1.160	1.266	1.264
2011	1.021	1.986	1.569	1.261	1.311	1.027	1.212
2012	0.912	1.674	1.578	1.229	1.178	0.992	1.110
2013	0.937	1.559	1.481	1.104	1.491	1.123	1.169
2014	0.954	1.677	1.449	1.061	1.393	1.089	1.161
2015	0.958	1.638	1.456	1.032	1.729	1.174	1.169
2016	0.913	1.932	1.713	0.903	1.603	1.045	1.258
2017	0.887	1.869	1.470	1.098	1.238	1.151	1.255
2018	0.976	1.762	1.537	1.133	1.337	1.440	1.312
2019	0.934	1.842	1.474	1.110	1.510	1.449	1.311
2020	1.094	1.986	1.701	1.087	1.477	1.408	1.378
2021	1.306	2.034	1.656	1.132	1.354	1.444	1.418

Turning to Capital MPFP, we can see from Figure 3.3 and Table 3.3 that there has generally been a declining trend in capital MPFP levels – a steadier trend and without the reversal seen in Opex MTFP movements. The steadier nature of the trend is to be expected given the largely sunk and long-lived nature of DNSP capital assets.

In 2021, eight DNSPs improved their Capital MPFP levels, including AND (10.3 per cent), PCR (6.1 per cent), CIT (4.4 per cent), END (2.9 per cent), AGD (2.5 per cent), ESS (1.5 per cent), JEN (1.4 per cent) and UED (1.3 per cent). The five DNSPs with reductions in capital MPFP levels in 2021 were: SAP (–3.6 per cent), TND (–3.0 per cent), ERG (–1.4 per cent), EVO (–1.1 per cent), and ENX (–0.4 per cent).

The highest ranked DNSPs in terms of capital productivity in 2021 were SAP followed by CIT, ERG and UED (in that order), while TND ranked lowest followed by AGD, EVO, and ESS. Comparing rankings in 2021 with 2006, six DNSPs increased their Capital PFP ranking by two places: CIT from 4th to 2nd, UED from 6th to 4th, ENX from 8th to 6th, JEN from 9th to 7th, AND from 11th to 9th, and EVO from 13th to 11th. The DNSPs with substantial decreases in Capital MPFP ranking were ESS (5 places from 5th to 10th), END (3 places from 2nd to 5th), and TND (3 places from 10th to 13th).

Figure 3.3 DNSP multilateral capital partial factor productivity indexes, 2006–2021

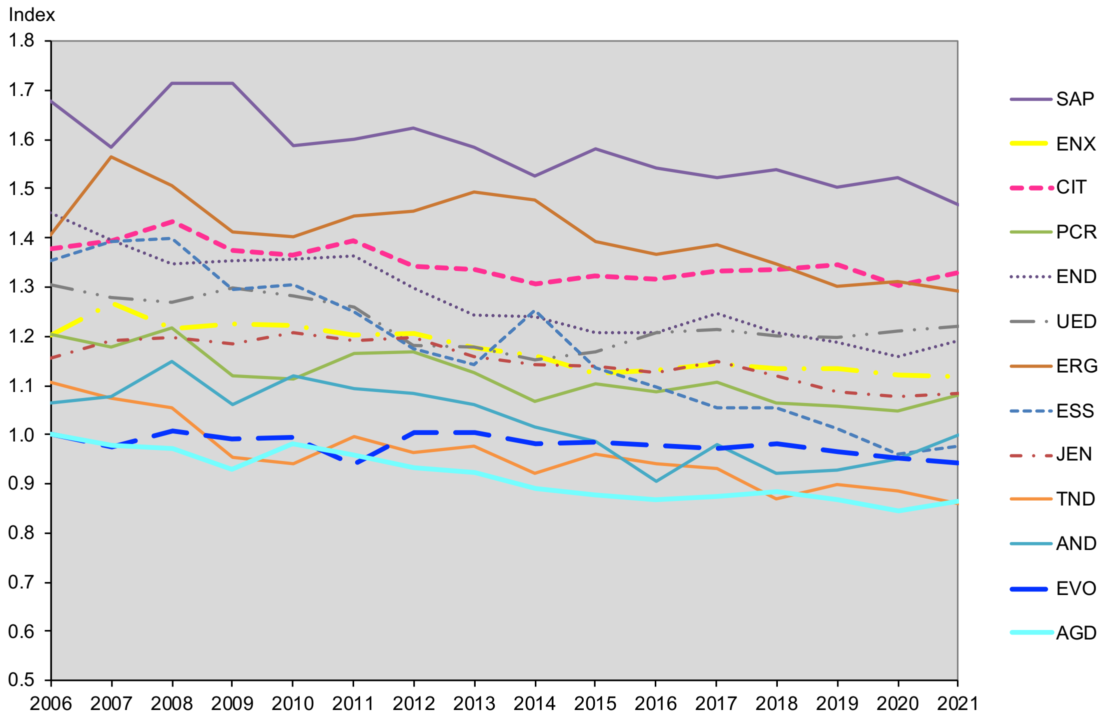


Table 3.3 DNSP multilateral capital partial factor productivity indexes, 2006–2021

Year	EVO	AGD	CIT	END	ENX	ERG	ESS
2006	1.000	1.001	1.377	1.451	1.204	1.404	1.353
2007	0.976	0.979	1.393	1.396	1.267	1.564	1.394
2008	1.008	0.972	1.433	1.348	1.215	1.508	1.400
2009	0.992	0.931	1.374	1.352	1.225	1.412	1.294
2010	0.996	0.981	1.365	1.358	1.221	1.403	1.305
2011	0.939	0.959	1.394	1.363	1.202	1.443	1.250
2012	1.005	0.933	1.342	1.299	1.205	1.455	1.174
2013	1.004	0.924	1.334	1.244	1.178	1.492	1.141
2014	0.983	0.889	1.307	1.241	1.159	1.477	1.251
2015	0.983	0.876	1.322	1.208	1.124	1.393	1.134
2016	0.978	0.868	1.317	1.206	1.132	1.368	1.096
2017	0.970	0.874	1.333	1.245	1.144	1.385	1.056
2018	0.983	0.883	1.336	1.206	1.135	1.347	1.056
2019	0.965	0.866	1.346	1.189	1.135	1.303	1.012
2020	0.952	0.844	1.302	1.159	1.122	1.310	0.962
2021	0.942	0.866	1.331	1.192	1.118	1.292	0.976

Table 3.3 (cont.)

Year	JEN	PCR	SAP	AND	TND	UED	AVG
2006	1.157	1.205	1.679	1.064	1.107	1.306	1.254
2007	1.191	1.179	1.585	1.076	1.075	1.278	1.258
2008	1.199	1.217	1.714	1.149	1.053	1.270	1.268
2009	1.183	1.120	1.715	1.062	0.955	1.299	1.224
2010	1.209	1.112	1.587	1.119	0.941	1.281	1.221
2011	1.192	1.166	1.601	1.094	0.995	1.261	1.220
2012	1.196	1.168	1.624	1.085	0.963	1.183	1.203
2013	1.159	1.126	1.585	1.061	0.977	1.177	1.185
2014	1.141	1.067	1.526	1.016	0.920	1.152	1.164
2015	1.141	1.104	1.581	0.988	0.961	1.167	1.153
2016	1.125	1.088	1.543	0.904	0.939	1.206	1.136
2017	1.149	1.106	1.521	0.981	0.930	1.215	1.147
2018	1.118	1.064	1.541	0.921	0.868	1.200	1.128
2019	1.089	1.057	1.502	0.927	0.899	1.197	1.114
2020	1.077	1.048	1.522	0.950	0.885	1.212	1.103
2021	1.085	1.080	1.468	1.000	0.859	1.219	1.110

3.2 Econometric opex cost function efficiency scores

While the Opex MPFP analysis presented in the preceding section has the advantage of producing robust results even with small datasets, it is a deterministic method that does not facilitate the calculation of confidence intervals. We thus also include econometric operating cost functions, which do facilitate this and potentially allows the direct inclusion of adjustment for operating environment factors. In this section we update the models in Economic Insights (2020a) to include data for 2020-21 for the Australian and New Zealand DNSPs and 2020 data for the Ontario DNSPs.[9]

The econometric cost function models produce average opex efficiency scores for the period over which the models are estimated. Four three-output opex cost function models are estimated for this report:

- a least squares econometrics model using the Cobb–Douglas functional form (LSECD),
- a least squares econometrics model using the more flexible translog functional form (LSETLG),[10]
- a stochastic frontier analysis model using the Cobb–Douglas functional form (SFACD), and

[9] Throughout this section and appendix C, when a sample is described as 2006 to 2021, it includes Ontario data for 2005 to 2020; and a sample described as 2012 to 2021 includes Ontario data for 2011 to 2020.

[10] The two least-squares models are estimated with panel-corrected standard errors.

- a stochastic frontier analysis model using the translog functional form (SFATLG).

We present the monotonicity performance and the average opex efficiency scores for two periods – 2006 to 2021 and 2012 to 2021 – in this section. The corresponding regression results are presented in Appendix C.

3.2.1 Monotonicity performance

Satisfying the property of monotonicity is an important requirement for estimated cost functions. This property requires that an increase in output can only be achieved with an increase in cost, holding other things constant. Cobb-Douglas models assume constant output elasticities and if the estimated output coefficients are greater than zero then monotonicity is satisfied. For translog models, we need to check not only the sign of the estimated first-order coefficient for each output (which is the output's elasticity at the mean of the sample used for normalisation), but also the estimated output elasticity for each observation as the models assume varying output elasticities. In previous benchmarking studies the SFATLG and LSETLG models have produced some monotonicity violations (2019, 2020a, 2021). The practice has been to calculate average efficiency scores for each DNSP after excluding either the SFATLG or LSETLG models (or both) if those models have an excessive number of monotonicity violations, representing more than half their number of observations for that DNSP. Further, if a model has monotonicity violations for the great majority of Australian DNSPs, then it will be disregarded altogether when calculating the average efficiency scores.

In this study, information on monotonicity violations for each model and for the longer and shorter sample periods is presented in Appendix C. The average efficiency scores for each DNSP in Table 3.4 are calculated after excluding either the SFATLG or LSETLG models (or both) if those models have violations for more than half their number of observations for that DNSP. However, as seen in Table 3.6 for the shorter period from 2012 to 2021, if a model has monotonicity violations for the great majority of DNSPs, then it will be disregarded altogether when calculating the average efficiency scores.

For the models applied to the full data sample from 2006 to 2021 (see Tables C.7 and C.8 of Appendix C) neither the LSETLG nor the SFATLG model have monotonicity violations for any of the Australian DNSPs. Hence, neither of these models is excluded for any Australian DNSP, and the average of efficiency score estimates from all four econometric models can be used.

For the models applied to the shorter sample period from 2012 to 2021 (see Tables C.15 and C.16 of Appendix C), the SFATLG model has monotonicity violations in 63.8 per cent of the observations on Australian DNSPs, and the LSETLG model has monotonicity violations in 42.3 per cent of Australian DNSP observations. In this shorter period, the SFATLG model has monotonicity violations for more than half of the observations for nine of the 13 Australian DNSPs, and it is not included in the average efficiency scores for the 2012 to 2021 period shown in Table 3.6. The LSETLG model has monotonicity violations for more than half of the observations for five Australian DNSPs. For these five DNSPs, the LSETLG model is not included in the average efficiency scores for the 2012 to 2021 period shown in Table 3.6.

3.2.2 Summary results for the sample period 2006-2021

Opex efficiency scores for each of the 13 National Electricity Market (NEM) DNSPs across the 16-year period 2006 to 2021 for the four opex cost function models and, for comparison, opex MPFP are presented in Figure 3.4 and Table 3.4. Average opex efficiency scores across the five economic benchmarking methods, and average opex efficiency scores across the four econometric models only, are presented in Figure 3.5. The opex efficiency scores in Figures 3.4 and Table 3.4, related to the full sample period and using the average of five methods, indicate:

- PCR and CIT have the highest average efficiency scores (0.99 and 0.90 respectively);
- Three other DNSPs have above-average efficiency, and can be regarded as part of the top performing group in terms of opex efficiency: SAP (0.81), TND (0.77) and UED (0.74);
- The sample average opex efficiency score is 0.69, and DNSPs with opex efficiency close to average are AND (0.68) and ESS (0.66);
- Several DNSPs are below-average but not the lowest in terms of opex efficiency. These include JEN (0.62), ERG (0.61), END (0.61) and ENX (0.60);
- The two DNSPs with lowest opex efficiency are AGD and EVO (with average opex efficiency scores of 0.45 and 0.48 respectively).

These rankings are similar to those in Economic Insights (2021). The overall average efficiency scores are also similar between models. The average efficiency score of the SFACD and the SFATLG models is 0.69, whereas from the LSECD and LSETLG models, the average efficiency scores are 0.70 and 0.66, respectively.

We can also compare the average of the econometric efficiency score estimates with an estimate obtained from the relative Opex PFP measures from the index analysis (taking the highest Opex PFP as equal to 1). The average relative Opex PFP is 0.69, similar to the econometric analysis. Although these measures are highly correlated, there are some notable differences. JEN's opex efficiency as measured by the average of the four econometric models is close to the average (at 0.64), whereas it is well below average when the opex PFP measure is used (at 0.54). Similarly, UED's efficiency score in the average of the econometric models is 0.76, compared to 0.66 relative opex PFP. Conversely, END, ENX and ERG have higher comparative efficiency when the opex PFP measures is used, than when the econometric estimates are used. The Opex MPFP model includes an additional two outputs – energy and reliability – but excludes the impact of undergrounding. This is one reason why differences between the measures are to be expected.

Figure 3.4 DNSP opex cost efficiency scores, 2006–2021

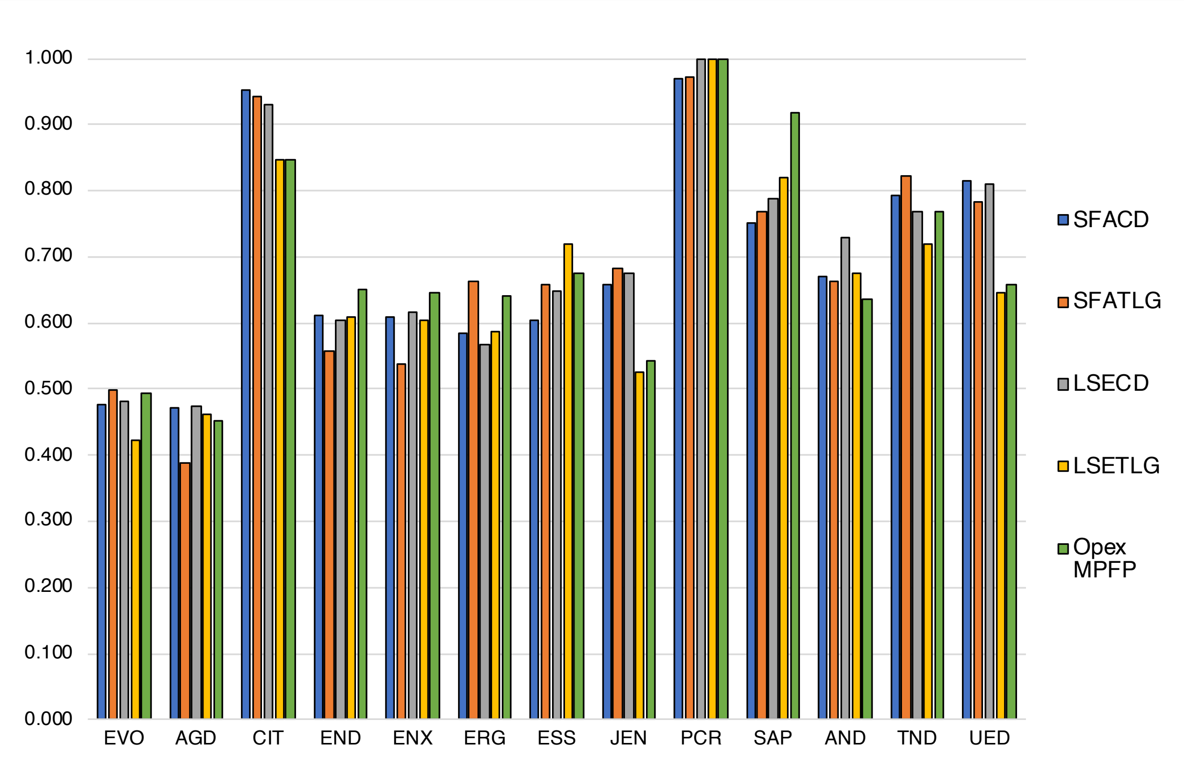


Table 3.4 DNSP average opex cost efficiency scores, 2006–2021

DNSP	*SFACD* (1)	*SFATLG* (2)	*LSECD* (3)	*LSETLG* (4)	*Opex MPFP* (5)	*Average of* (1)–(5)	*Average of* (1)–(4)
EVO	0.477	0.499	0.480	0.422	0.493	0.474	0.470
AGD	0.471	0.387	0.475	0.461	0.452	0.449	0.448
CIT	0.952	0.943	0.930	0.846	0.846	0.903	0.918
END	0.611	0.557	0.605	0.608	0.650	0.606	0.595
ENX	0.609	0.538	0.616	0.604	0.647	0.603	0.592
ERG	0.584	0.664	0.567	0.587	0.640	0.608	0.601
ESS	0.604	0.658	0.647	0.720	0.675	0.661	0.657
JEN	0.657	0.683	0.674	0.526	0.543	0.616	0.635
PCR	0.969	0.973	1.000	1.000	1.000	0.988	0.985
SAP	0.751	0.768	0.789	0.819	0.919	0.809	0.782
AND	0.670	0.663	0.728	0.675	0.636	0.674	0.684
TND	0.793	0.821	0.769	0.718	0.768	0.774	0.775
UED	0.816	0.783	0.811	0.646	0.659	0.743	0.764

Compared to the results in the 2021 report, ERG's average efficiency score has improved by more than one percentage point, whereas the average efficiency scores of ENX, SAP and UED deteriorated by more than one percentage point.

Figure 3.5 shows the average efficiency scores when the average is calculated for the four econometric models together with the opex PFP-based score, and when the average is calculated only for the four econometric models. The results are broadly similar whichever of these two averaging approaches is used.

Figure 3.5 DNSP opex cost efficiency scores, 2006–2021, average of models

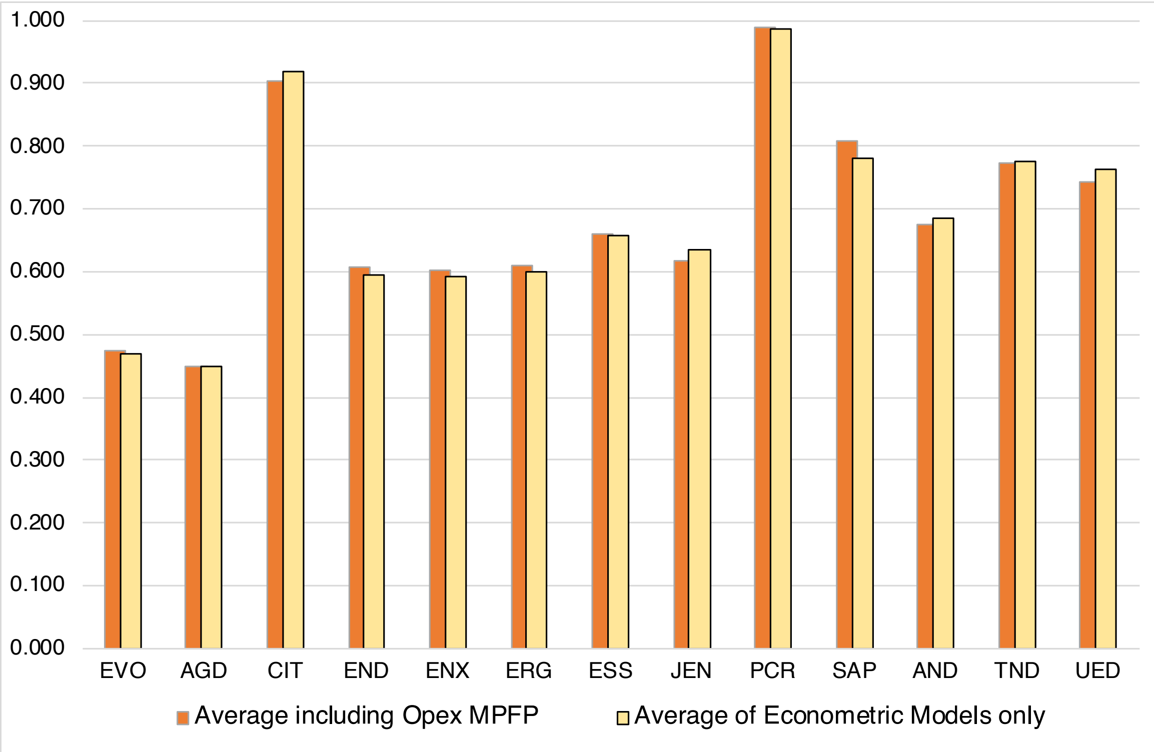


Table 3.5 presents a summary of the cost-output elasticities estimated for the four econometric models. For the Cobb-Douglas specifications (SFACD and LSECD) the cost-output elasticities are restricted to be the same for all observations. For the translog specifications (SFATLG and LSETLG) the cost-output elasticities vary with different levels of the outputs and hence vary across all observations in the sample.

Table 3.5 Average DNSP output elasticities by country and overall, 2006–2021

Sub-sample	*Customer numbers*	*Circuit length*	*RMD*	*Customer numbers*	*Circuit length*	*RMD*
	SFACD model			*LSECD model*		
All	0.420	0.105	0.449	0.594	0.153	0.228
	SFATLG model			*LSETLG model*		
Australia	0.336	0.170	0.391	0.343	0.252	0.445
New Zealand	0.451	0.060	0.545	0.663	0.208	0.060
Ontario	0.519	0.061	0.379	0.340	0.109	0.491
Full sample	0.464	0.082	0.428	0.432	0.165	0.360

Table 3.5 shows averages of these elasticities by country and over the full sample (i.e. including overseas DNSPs). The average cost-output elasticities for the translog model, when taken over the whole sample, are broadly similar to those estimated using the Cobb-Douglas specification. The cost-output elasticities for the Australian sub-sample, in the translog models, tend to smaller for the customer numbers output and larger for circuit length, compared to the average for the full sample. For example:

- in the SFATLG model, the customer numbers elasticity is 0.34 for Australian DNSPs, and 0.46 for the whole sample; and in the LSETLG model, the customer numbers elasticity is 0.34 for Australian DNSPs, and 0.43 for the whole sample;
- the circuit length elasticity for Australian DNSPs in the SFATLG model is 0.17, compared to 0.08 for the whole sample; and in the LSETLG model, the circuit length elasticity is 0.25 for Australian DNSPs compared to 0.17 for the whole sample.

Figure 3.6 compares the average efficiency scores using the four econometric models against the average efficiency scores obtained by averaging only the two Cobb-Douglas models, SFACD and LSECD. This shows that whether the average of four econometric models is used, or whether the average of only the Cobb-Douglas models is used, the resulting efficiency scores are broadly similar.

3.2.3 Summary results for the sample period 2012-2021

We turn now to the opex efficiency scores based on the more recent period, 2012 to 2021. Opex efficiency scores are presented in Figure 3.7 and Table 3.6 for each of the 13 NEM DNSPs, averaged over the 10-year period, from the four opex cost function models and opex MPFP. Opex efficiency scores averaged across four economic benchmarking models (two CD models, the LSETLG and relative opex PFP) for the 10-year period are presented in Figure 3.8 and Table 3.6. For five of the DNSPs the average efficiency score is calculated excluding the LSETLG model.

Figure 3.6 DNSP opex cost efficiency scores, 2006–2021, average of four econometric models compared to the average of CD models

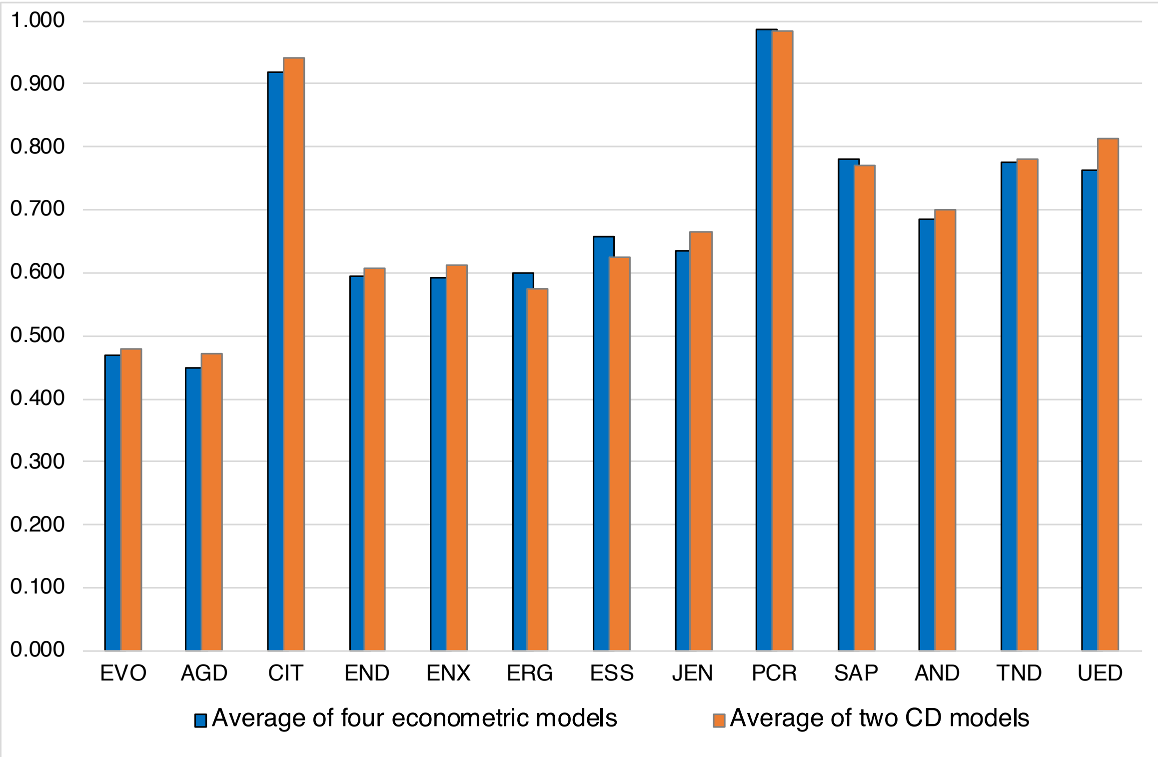
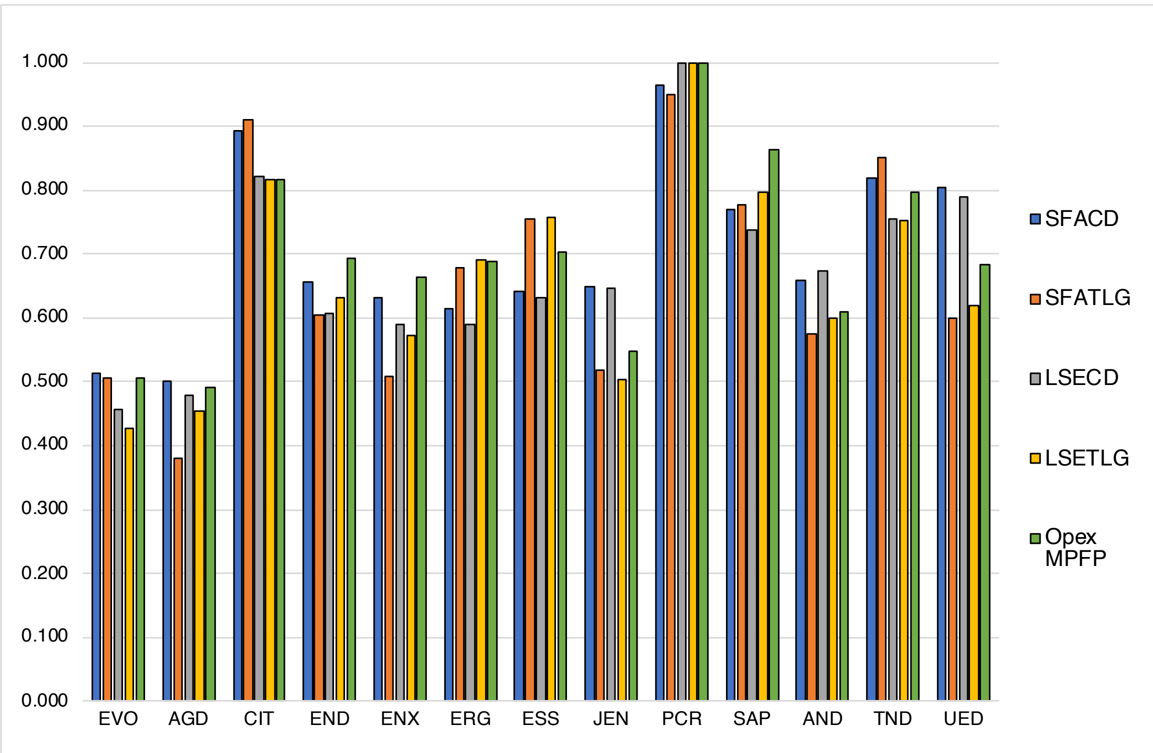


Figure 3.7 DNSP opex cost efficiency scores, 2012–2021



From Figures 3.7 and Table 3.6 we see that the rankings are reasonably similar to the full sample period. We discuss the average of the two CD models, the LSETLG and the opex PFP model, although for five DNSPs the average is taken over the two CD models and the opex PFP model. Again, PCR and CIT are the two with highest opex efficiency measures. PCR's opex efficiency is 0.99 and CIT's is 0.84, the latter being lower than for the full period (0.90). The next highest ranked in terms of opex efficiency are TND, SAP and ESS. The latter's opex efficiency of 0.76 is significantly higher than for the full period (0.66), whereas UED's opex efficiency of 0.68 is significantly lower than for the full period (0.74). The two lowest ranked DNSPs in terms of opex efficiency are AGD and EVO, the same as for the full sample; and their efficiency scores are slightly higher than for the full period.

The average efficiency score for the Australian DNSPs (using the averages shown in the second last column of Table 3.6) for the in the period from 2012 to 2021 is 0.69, which is the same as the average for the full period (0.69).

Turning to the comparison between the models in terms of average scores for the post-2012 period, the SFACD and SFATLG models have average efficiency scores of 0.70 and 0.66 respectively; the LSECD and LSETLG models have average efficiency scores of 0.68 and 0.66 respectively.

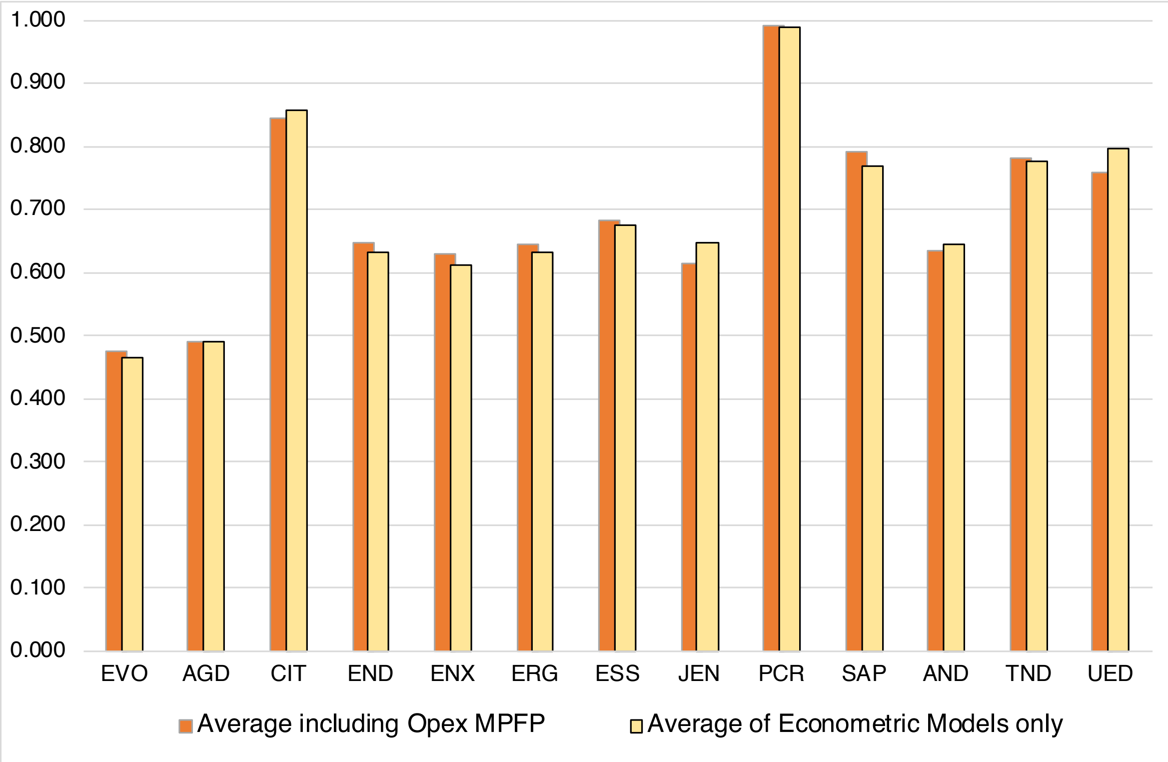
Table 3.6 DNSP average opex cost efficiency scores, 2012–2021

DNSP	*SFACD* (1)	*SFATLG* (2)	*LSECD* (3)	*LSETLG* (4)	*Opex MPFP* (5)	*Average of* (1), (3) – (5)	*Average of* (1) (3) & (4)
EVO	0.514	0.507	0.457	0.427	0.506	0.476	0.466
AGD	0.502	0.380	0.479	0.454	0.492	0.491*	0.490*
CIT	0.893	0.910	0.821	0.817	0.817	0.844*	0.857*
END	0.656	0.604	0.607	0.631	0.693	0.647	0.632
ENX	0.632	0.509	0.591	0.572	0.665	0.629*	0.612*
ERG	0.615	0.678	0.590	0.690	0.688	0.646	0.632
ESS	0.640	0.755	0.631	0.757	0.702	0.683	0.676
JEN	0.650	0.518	0.646	0.504	0.548	0.615*	0.648*
PCR	0.965	0.949	1.000	1.000	1.000	0.991	0.988
SAP	0.769	0.777	0.738	0.798	0.864	0.792	0.768
AND	0.660	0.574	0.674	0.599	0.608	0.635	0.644
TND	0.820	0.851	0.754	0.754	0.798	0.781	0.776
UED	0.804	0.599	0.791	0.620	0.684	0.760*	0.798*

Note: * Excludes LSETLG.

Figure 3.8 shows, for the shorter sample period, the average efficiency scores when the average is calculated for the two CD and the LSETLG econometric models plus the opex PFP-based score, and when the average is calculated only for the same econometric models. Again, the results are broadly similar whichever of these two averaging approaches is used.

Figure 3.8 DNSP opex cost efficiency scores, 2012–2021, average of models



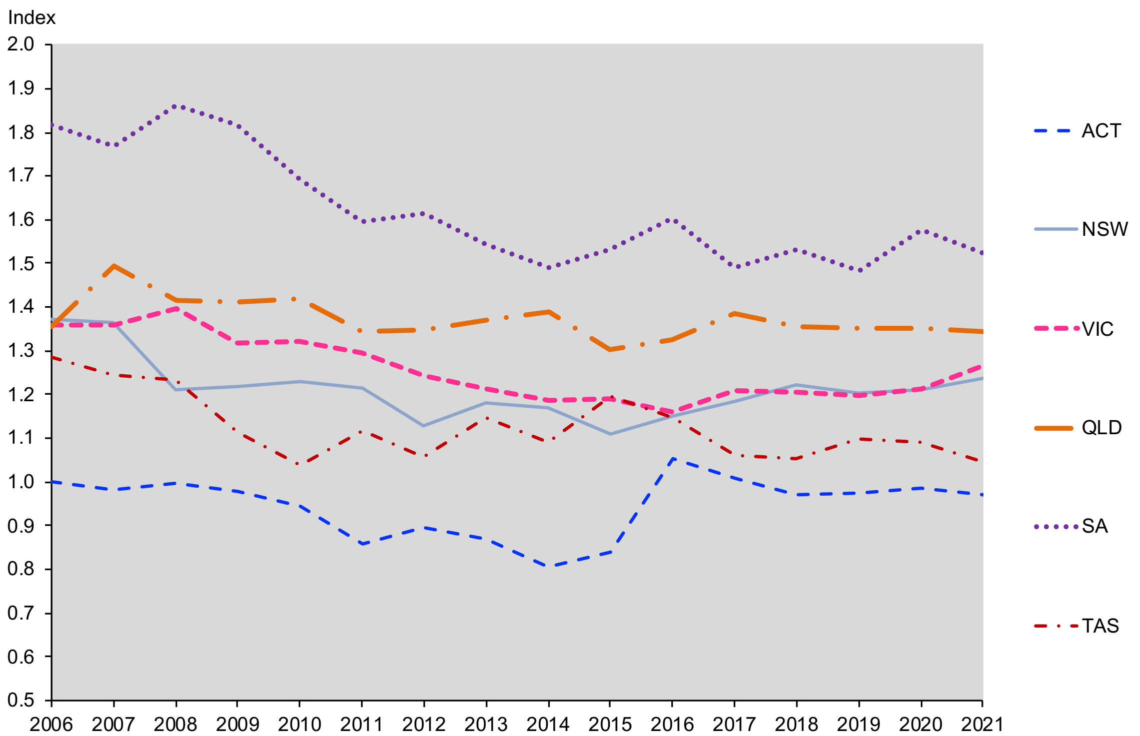
4 State–level Distribution Productivity Results

In this section we present MTFP and Opex MPFP results for each of the NEM jurisdictions before analysing outputs, inputs and drivers of productivity change for each jurisdiction.

4.1 MTFP and Opex MPFP indexes

The multifactor total factor productivity method can be used to calculate the comparative levels of TFP for electricity distribution in each state. Figure 4.1 and Table 4.1 show the MTFP of electricity distribution in each state and territory of the NEM for which RIN data is collected.

Figure 4.1 State–level DNSP multilateral TFP indexes, 2006–2021



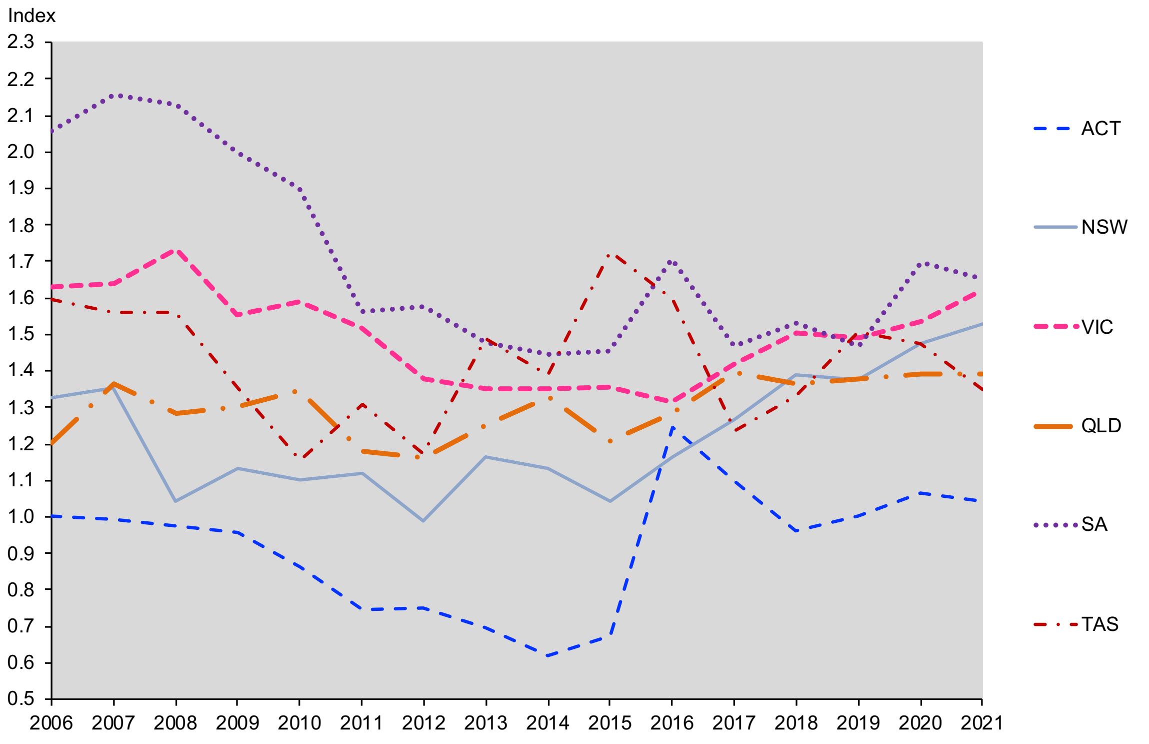
In 2021, South Australia (SA) had the highest MTFP level by a relatively wide margin followed by Queensland (QLD) being in second place. New South Wales (NSW) and Victoria (VIC) had similar levels of MTFP which were close to the average for the NEM states. Tasmania (TAS) was in fifth place in 2021, with the ACT having the lowest MTFP level.

VIC had the largest MTFP increase in 2021, by 8.6 per cent, followed by NSW, with an MTFP increase of 2.3 per cent in 2021. The remaining states all had reduced MTFP in 2021 compared to 2020. For TAS, SA, the Australian Capital Territory (ACT) and QLD the MTFP change in 2021 was –4.3 per cent, –3.4 per cent, –1.4 per cent and –0.5 per cent respectively.

Table 4.1 State–level DNSP multilateral TFP indexes, 2006–2021

Year	ACT	NSW	VIC	QLD	SA	TAS
2006	1.000	1.371	1.361	1.356	1.817	1.288
2007	0.983	1.365	1.361	1.496	1.766	1.244
2008	0.998	1.210	1.396	1.417	1.864	1.232
2009	0.979	1.220	1.319	1.410	1.818	1.114
2010	0.945	1.229	1.321	1.420	1.694	1.038
2011	0.858	1.214	1.295	1.345	1.594	1.119
2012	0.895	1.128	1.241	1.346	1.613	1.058
2013	0.868	1.181	1.213	1.372	1.545	1.148
2014	0.807	1.169	1.186	1.389	1.492	1.090
2015	0.840	1.111	1.191	1.304	1.531	1.197
2016	1.054	1.150	1.160	1.326	1.602	1.148
2017	1.007	1.185	1.210	1.384	1.491	1.060
2018	0.972	1.224	1.206	1.357	1.530	1.055
2019	0.974	1.202	1.199	1.351	1.483	1.100
2020	0.986	1.210	1.211	1.352	1.578	1.091
2021	0.973	1.238	1.264	1.345	1.525	1.045

Figure 4.2 State-level DNSP multilateral Opex PFP indexes, 2006–2021



Opex MPFP levels by State are shown in Figure 4.2 and Table 4.2. In 2021, SA had the highest Opex MTFP level, slightly ahead of VIC. The states with average Opex MTFP levels were NSW, QLD and TAS, whereas the ACT had much lower level of Opex MTFP in 2021 than the other states.

In 2021 VIC's Opex MPFP grew by a large 11.1 per cent compared to 2020. NSW's Opex MTFP increased by 3.7 per cent in 2021, and QLD's remained unchanged. TAS, which had the highest Opex MTFP level in 2019 (marginally), was 5th highest in 2021, after a decrease in 2020 and a large decrease of 8.8 per cent in 2021. Other Opex MTFP decreases in 2021 included the ACT (–1.9 per cent) and SA (–2.6 per cent).

Table 4.2 State–level DNSP multilateral Opex PFP indexes, 2006–2021

Year	ACT	NSW	VIC	QLD	SA	TAS
2006	1.000	1.327	1.632	1.205	2.058	1.598
2007	0.994	1.355	1.637	1.364	2.156	1.560
2008	0.977	1.043	1.732	1.281	2.132	1.560
2009	0.955	1.133	1.552	1.300	2.001	1.354
2010	0.861	1.103	1.588	1.345	1.900	1.156
2011	0.744	1.119	1.517	1.180	1.565	1.308
2012	0.751	0.989	1.377	1.161	1.575	1.174
2013	0.697	1.165	1.349	1.254	1.477	1.488
2014	0.621	1.131	1.351	1.330	1.445	1.388
2015	0.672	1.043	1.354	1.207	1.453	1.725
2016	1.246	1.165	1.317	1.284	1.708	1.598
2017	1.096	1.266	1.418	1.396	1.466	1.235
2018	0.964	1.390	1.505	1.363	1.533	1.333
2019	1.001	1.374	1.491	1.380	1.470	1.506
2020	1.063	1.475	1.535	1.393	1.697	1.473
2021	1.044	1.530	1.623	1.393	1.652	1.349

4.2 Outputs, inputs and productivity change

This section presents output, input and MTFP indexes calculated for States and Territories separately (i.e. without grouping data for the purpose of calculating comparative productivity levels).

4.2.1 Australian Capital Territory (ACT)

The ACT is the smallest of the NEM jurisdictions and is served by one DNSP, Evoenergy. In 2021 ACT delivered 2,851 GWh to 212,505 customers over 4,813 circuit kilometres of lines and cables.

ACT productivity performance

The ACT's total output, total input and TFP indexes are presented in Figure 4.3 and Table 4.3. Over the 16-year period 2006 to 2021, ACT's average annual rate TFP change was –0.1 per cent. Between 2006 and 2012, TFP levels fell at an average annual rate of 2.0 per cent (more than 10 per cent in total). Then from 2012 to 2021, the ACT's TFP increased at an average annual rate of 1.1 per cent, almost fully restoring the 2006 level of TFP. In 2021, the ACT's TFP *decreased* by 0.9 per cent.

Figure 4.3 ACT output, input and TFP indexes, 2006–2021

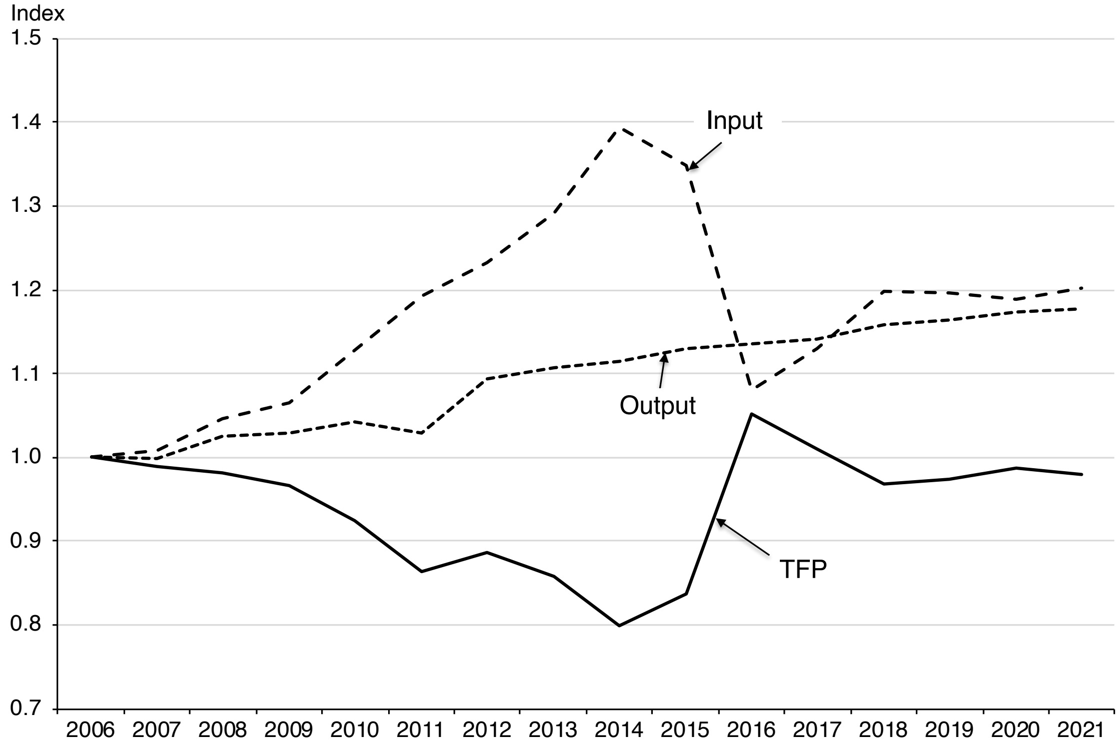


Table 4.3 ACT output, input, TFP and PFP indexes, 2006–2021

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	0.998	1.008	0.990	1.002	0.980
2008	1.026	1.046	0.981	0.967	0.990
2009	1.029	1.065	0.966	0.951	0.974
2010	1.043	1.127	0.925	0.854	0.972
2011	1.029	1.192	0.864	0.757	0.941
2012	1.093	1.232	0.888	0.752	0.991
2013	1.107	1.291	0.857	0.696	0.987
2014	1.114	1.393	0.800	0.618	0.971
2015	1.129	1.349	0.837	0.673	0.976
2016	1.136	1.080	1.052	1.249	0.968
2017	1.140	1.130	1.009	1.104	0.965
2018	1.159	1.198	0.967	0.963	0.971
2019	1.164	1.195	0.973	1.006	0.956
2020	1.174	1.188	0.988	1.068	0.945
2021	1.178	1.203	0.979	1.053	0.939
Growth Rate 2006-2021	1.1%	1.2%	-0.1%	0.3%	-0.4%
Growth Rate 2006-2012	1.5%	3.5%	-2.0%	-4.7%	-0.1%
Growth Rate 2012-2021	0.8%	-0.3%	1.1%	3.7%	-0.6%
Growth Rate 2021	0.3%	1.2%	-0.9%	-1.4%	-0.6%

Total output increased reasonably steadily over the period 2006 to 2021 at an average annual rate of 1.1 per cent, similar to the industry average rate of 1.0 per cent seen in chapter 3. Total input use increased at an average rate of 3.5 per cent per year up to 2012, a similar rate to the industry average rate (3.7 per cent) in this period. Input use *decreased* at an average annual rate of 0.3 per cent between 2012 and 2021, again similar to the industry for which there was no change in inputs over the same period. The indexes in Table 4.3 show that swings in opex usage, and hence opex PFP, have been the main driver of the changes in the ACT's TFP trends.

ACT output and input quantity changes

We graph the quantity indexes for the ACT's five individual outputs in Figure 4.4 and for its six individual inputs in Figure 4.5, respectively. From Figure 4.4 we see that:

- The customer numbers output increased steadily over the period and was 37.5 per cent higher in 2021 than it was in 2006;
- Energy throughput increased slightly over the period 2006 to 2021, and in 2021 was 3.4 per cent higher than in 2006;
- The ACT's maximum demand did not exceed its 2006 level until 2012 and there was a further increase in ratcheted maximum demand (RMD) in 2015, so that in 2021, RMD was 14.9 per cent higher than in 2006;
- The ACT's circuit length output grew much more over the 16-year period than occurred for the industry overall and by 2021 was 17.8 per cent higher than it was in 2006 compared to an increase of 5.2 per cent for the industry;
- Total customer minutes off-supply (CMOS) levels in the ACT are the lowest of the 13 DNSPs in the NEM and for this reason CMOS receives only a negative 3.7 per cent of total revenue weight on average in ACT's total output.[11] In 2021, CMOS for the ACT was 48.5 per cent higher than in 2006, after a 10.7 per cent increase in 2021.

Turning to the input side, we see from ACT's six individual inputs and total input shown in Figure 4.5 that the quantity of opex increased rapidly between 2009 and 2014, being approximately 80 per cent higher in 2014 than it was in 2006. It then fell sharply in 2015 and 2016 (a combined decrease of almost 50 per cent) following the AER's price determination for ActewAGL (now Evoenergy), before increasing by over 20 per cent up to 2018 and falling again up to 2020. By 2021, opex was 11.8 per cent higher than in 2006.

[11] The weight of CMOS in the output index depends on both the value of customer reliability (VCR), which varies between DNSPs, and the quantity of CMOS, which also varies. Their product relative to total revenue determines the weight.

Figure 4.4 ACT output quantity indexes, 2006–2021

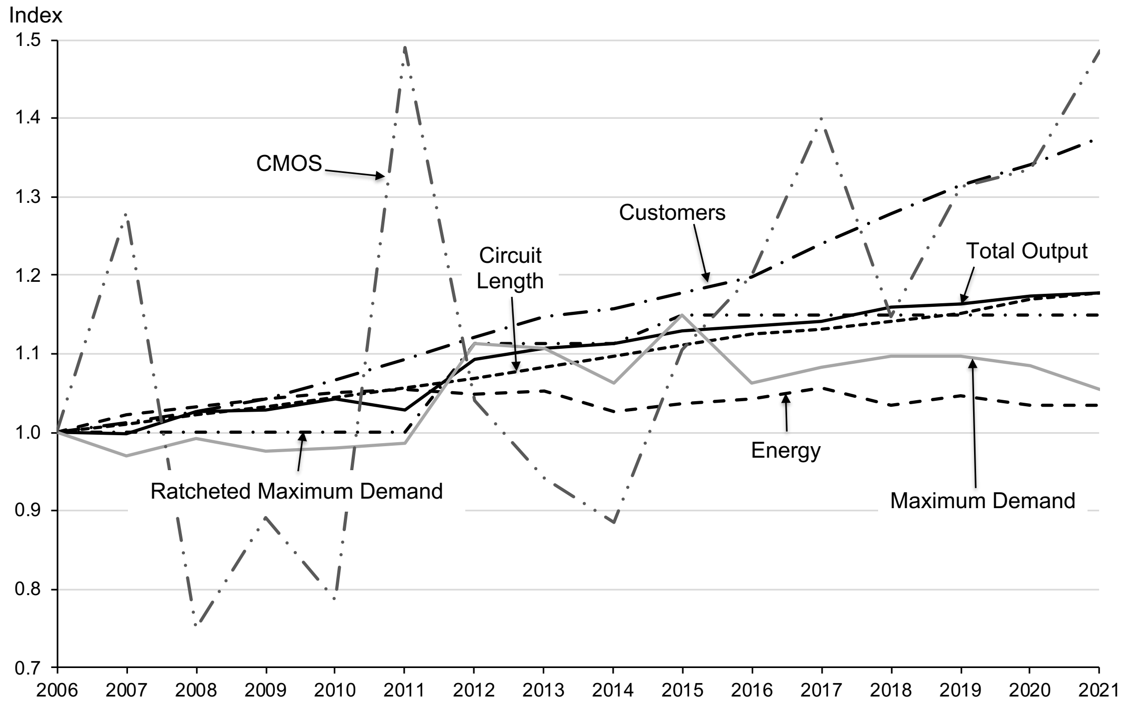
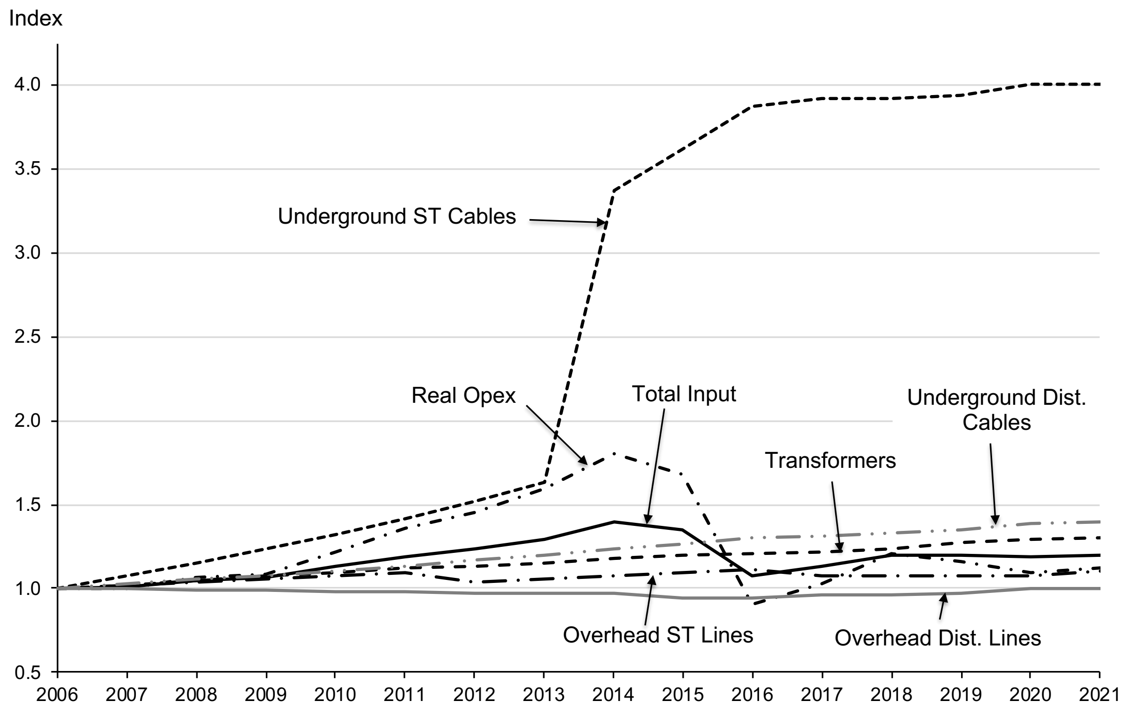


Figure 4.5 ACT input quantity indexes, 2006–2021



Opex has the largest average share in ACT's total costs at 38.8 per cent and so is an important driver of its total input quantity index. Except for underground sub-transmission cables, the ACT's other input component quantities increased at more modest and steady rates over the period. Although underground sub-transmission cables in 2021 were four times their level in 2006 – due to a doubling of line length and MVA capacity rating in 2014 – the total length is only 9 kilometres and this input has a negligible share in total cost. The quantity of transformer inputs, which have an average share of 26.8 per cent in ACT's total cost, increased by 30.6 per cent over the 16-year period.

ACT output and input contributions to TFP change

Table 4.4 decomposes the ACT's TFP change into its constituent output and input contributions for the whole 16-year period, for the periods up to and after 2012, and for 2021. ACT's drivers of TFP change over the whole 16-year period show the following patterns. Customer numbers, circuit length and RMD outputs contributed the most to TFP growth – a combined contribution of 1.2 percentage points per year (which compares favourably into the industry average of 0.9 percentage points). CMOS was a small negative contributor to TFP growth for the ACT (–0.1 percentage points) rather than a small positive contributor for the industry (0.2 percentage points).

Among the inputs' contributions to TFP growth for ACT from 2006 to 2021:

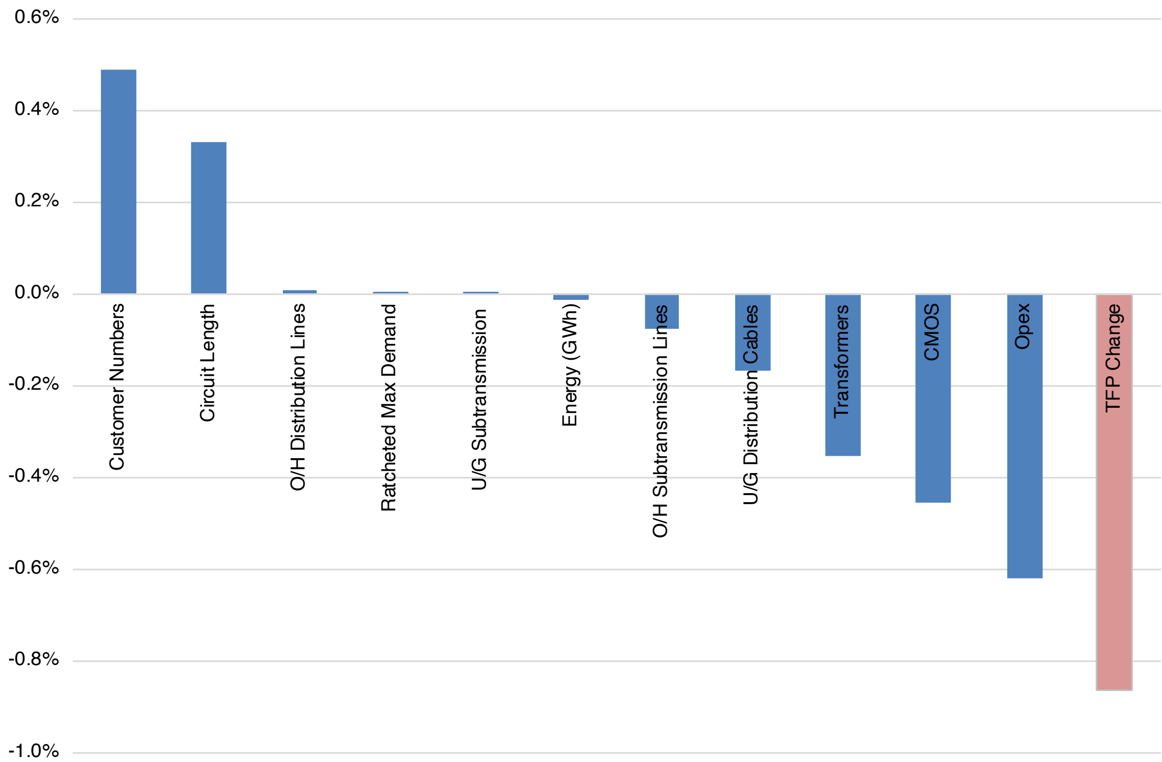
- Transformer input use contributes –0.5 percentage points (compared to –0.7 for the industry);
- Opex usage contributes –0.3 percentage points (compared to –0.2 for the industry);
- The four inputs for overhead and underground subtransmission and distribution lines together contributed –0.5 percentage points (compared to –0.6 for the industry).

Table 4.4 ACT output and input percentage point contributions to average annual TFP change: various periods

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2020 to 2021*
Energy (GWh)	0.02%	0.07%	-0.01%	-0.01%
Ratcheted Max Demand	0.32%	0.63%	0.12%	0.00%
Customer Numbers	0.41%	0.37%	0.44%	0.49%
Circuit Length	0.45%	0.46%	0.44%	0.33%
CMOS	-0.11%	-0.03%	-0.16%	-0.46%
Opex	-0.29%	-2.47%	1.15%	-0.62%
O/H Subtransmission Lines	-0.02%	-0.02%	-0.02%	-0.08%
O/H Distribution Lines	0.00%	0.05%	-0.03%	0.01%
U/G Subtransmission Cables	-0.01%	-0.01%	-0.01%	0.00%
U/G Distribution Cables	-0.43%	-0.53%	-0.36%	-0.17%
Transformers	-0.48%	-0.51%	-0.47%	-0.35%
TFP Change	-0.14%	-1.99%	1.09%	-0.86%

Figure 4.6 shows the contributions to TFP growth in 2021. An increase in opex usage in 2021 contributed –0.6 percentage points, and an increase in CMOS also contributed –0.5 percentage points, to the ACT's TFP change of –0.9 per cent that year. Growth of circuit length and customer numbers in 2021 together contributed 0.8 percentage points to TFP growth while growth in transformer capacity and underground distribution cables together contributed –0.5 percentage points.

Figure 4.6 ACT output and input percentage point contributions to TFP change, 2021



4.2.2 New South Wales (NSW)

NSW is the largest of the NEM jurisdictions and is served by three DNSPs: Ausgrid (AGD), Endeavour Energy (END) and Essential Energy (ESS). In 2021 the three NSW DNSPs delivered 53,613 GWh to 3.78 million customers over 274,514 circuit kilometres of lines and cables.

NSW DNSP productivity performance

NSW's total output, total input and TFP indexes are presented in Figure 4.7 and Table 4.5. Opex and capital PFP indexes are also presented in Table 4.5. Over the 16-year period 2006 to 2021, the NSW DNSPs' TFP *decreased* at an average annual rate of 0.6 per cent. Although total output increased by an average annual rate of 0.7 per cent, total input use increased faster, at a rate of 1.3 per cent.

Figure 4.7 NSW DNSP output, input and TFP indexes, 2006–2021

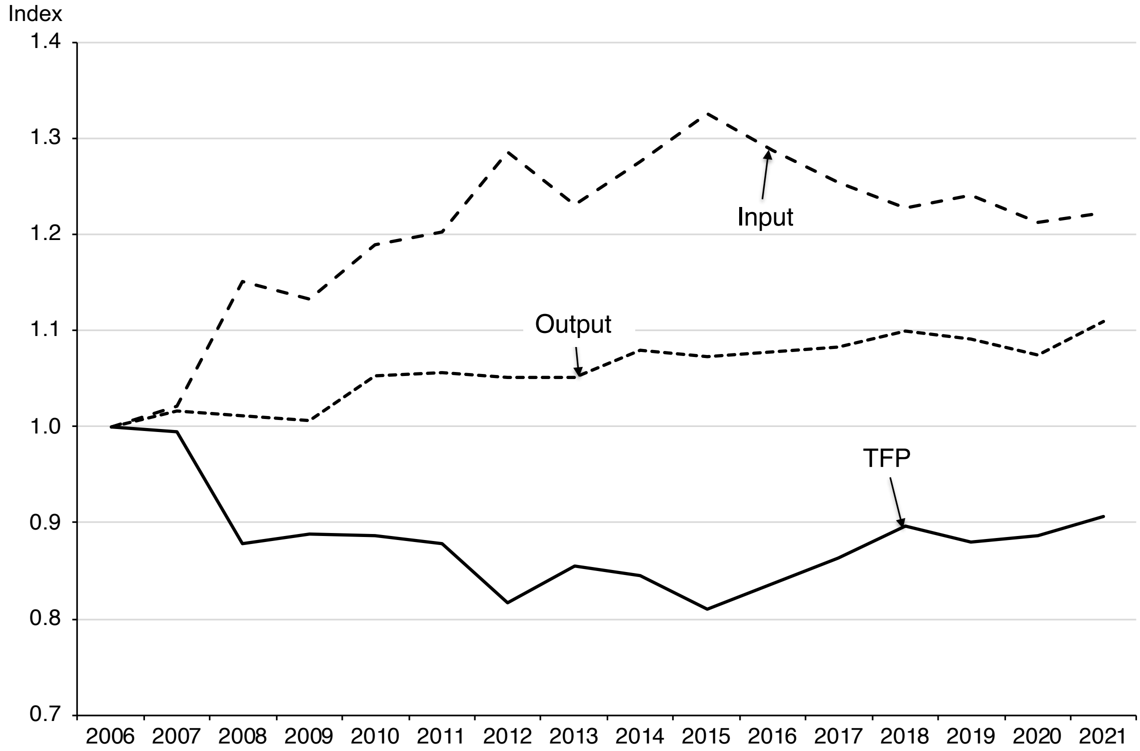


Table 4.5 NSW DNSP output, input, TFP and PFP indexes, 2006–2021

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	1.017	1.021	0.995	1.021	0.979
2008	1.010	1.152	0.877	0.786	0.949
2009	1.007	1.133	0.888	0.853	0.913
2010	1.053	1.189	0.886	0.830	0.919
2011	1.056	1.202	0.878	0.842	0.898
2012	1.050	1.285	0.817	0.743	0.866
2013	1.052	1.230	0.855	0.876	0.840
2014	1.079	1.276	0.846	0.850	0.841
2015	1.072	1.325	0.809	0.784	0.824
2016	1.078	1.288	0.837	0.877	0.812
2017	1.082	1.254	0.863	0.952	0.813
2018	1.099	1.227	0.896	1.046	0.816
2019	1.091	1.240	0.880	1.034	0.799
2020	1.074	1.212	0.887	1.110	0.774
2021	1.109	1.222	0.907	1.152	0.786
Growth Rate 2006-2021	0.7%	1.3%	-0.6%	0.9%	-1.6%
Growth Rate 2006-2012	0.8%	4.2%	-3.4%	-4.9%	-2.4%
Growth Rate 2012-2021	0.6%	-0.6%	1.2%	4.9%	-1.1%
Growth Rate 2021	3.1%	0.9%	2.3%	3.7%	1.6%

From 2006 and 2012, input use increased at an average rate of 4.2 per cent, which was followed by a moderate *reduction* of 0.6 per cent per annum in input use from 2012 to 2021. This shift in the trend of input use was the main determinant of the turnaround in the TFP trend in NSW from –3.4 per cent per annum between 2006 and 2012, to a positive TFP growth of 1.2 per cent per year from 2012 to 2021. The PFP indexes in Table 4.5 also demonstrate that reduced opex usage was the main driver of the improved TFP performance after 2012.

NSW DNSP output and input quantity changes

Quantity indexes for the NSW DNSPs' five individual outputs are plotted in Figure 4.8 and for the six individual inputs in Figure 4.9. From Figure 4.8 we see that NSW's output components showed a broadly similar pattern of change to the industry as a whole. From 2006 to 2021 the outputs of NSW DNSPs showed the following trends:

- Customer numbers increased steadily over the period and were 18.2 per cent higher in 2021 than it was in 2006;
- Energy throughput peaked in 2008 and has fallen since then. In 2021 it was 9.6 per cent below 2006;
- RMD increased from 2006 until 2019, and has since been flat. In 2021 it was 12.7 per cent higher than in 2006 (less than the increase for the industry as a whole);
- Circuit length output grew by 1.4 per cent in total over the whole 16-year period (compared to an increase of 5.2 per cent for the industry);
- Customer minutes off-supply (CMOS) was broadly similar to the industry as a whole, having *decreased* by 13.0 per cent between 2006 and 2021. CMOS had an average weight of –14.3 per cent of NSW total revenue over the 16-year period.

Among the inputs, we see from NSW's six individual inputs and total input in Figure 4.9 that:

- The quantity of NSW's opex generally increased up to 2015 and decreased after that. Opex input increased at an average annual rate of 5.8 per cent from 2006 to 2012 and *decreased* at an average annual rate of 4.3 per cent from 2012 to 2021. In 2021, NSW opex input was 3.7 per cent below its 2006 level (compared to 8.7 per cent for the industry);
- NSW's underground distribution cables and transformers inputs also increased strongly in the sub-period to 2012 and continued to increase but at a lower rate over the period from 2012 to 2021. By 2021, these two inputs exceeded their 2006 levels by 58.3 per cent and 40.6 per cent respectively (broadly similar to 68.6 per cent and 42.2 per cent respectively for the industry);

Figure 4.8 NSW output quantity indexes, 2006–2021

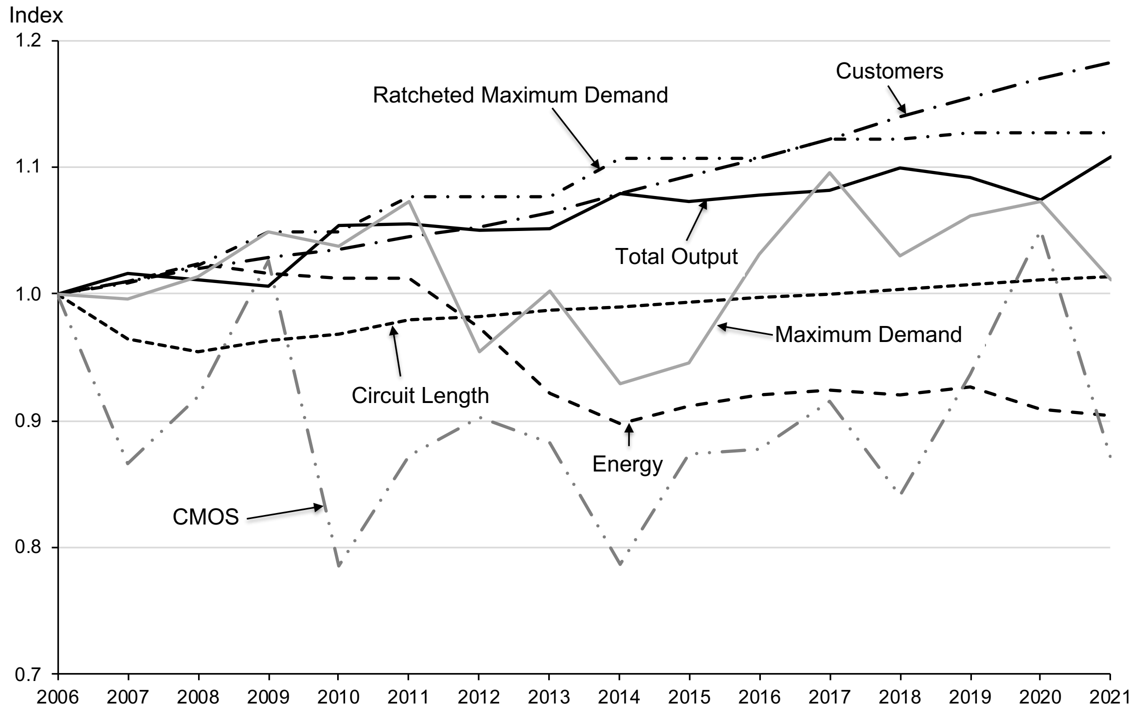
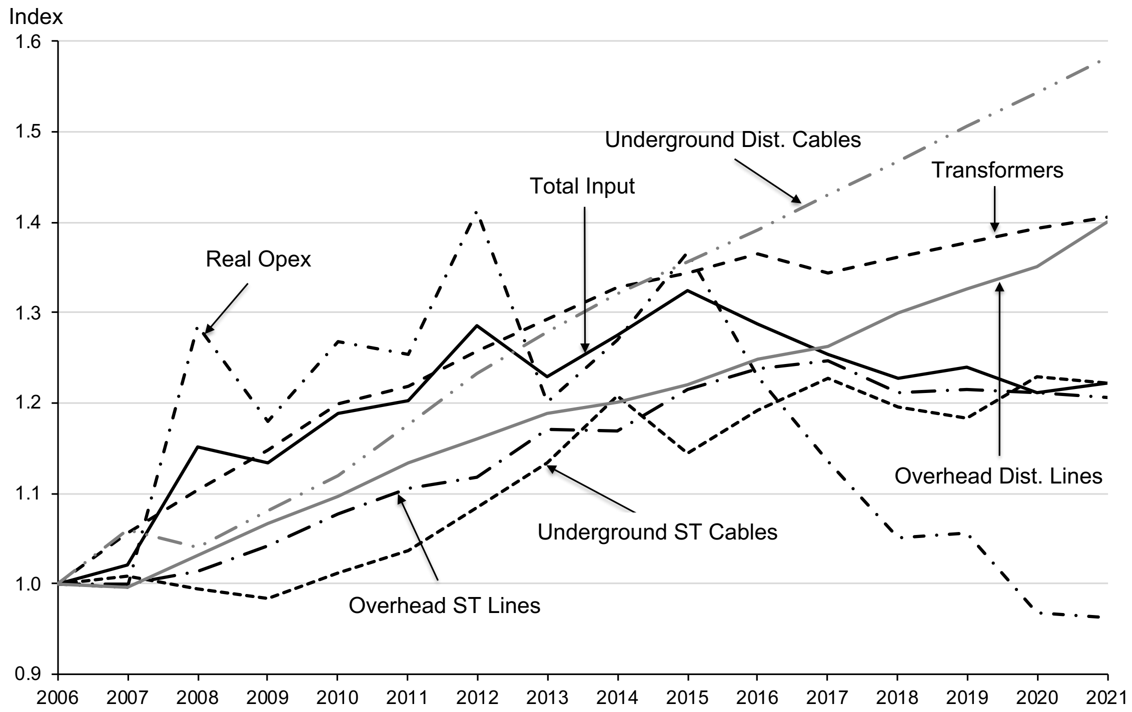


Figure 4.9 NSW DNSP input quantity indexes, 2006–2021



- Overhead distribution lines and overhead subtransmission lines inputs for NSW also increased strongly over the period from 2006 to 2012, and had slower growth after that. By 2021, these two inputs exceeded their 2006 levels by 40.0 per cent and 20.6 per cent respectively (compared to 13.6 per cent and 14.4 per cent respectively for the whole industry);
- NSW's underground subtransmission cables input in 2021 was 22.1 per cent above its 2006 level (compared to 37.6 per cent for the industry).

NSW output and input contributions to TFP change

Table 4.6 decomposes NSW's TFP change into its constituent output and input contributions for the whole 16-year period, for the periods up to and after 2012, and for 2021. NSW's drivers of TFP change for the 16-year period are broadly similar to the industry as a whole except that the major outputs (customer numbers, RMD and circuit length) contribute somewhat less due to their weaker growth in NSW, and opex makes a marginally positive contribution in NSW. Together, customer numbers, RMD and circuit length contribute 0.6 percentage points to TFP growth in NSW, compared to a 0.9 percentage points contribution of these three inputs to industry-wide TFP growth.

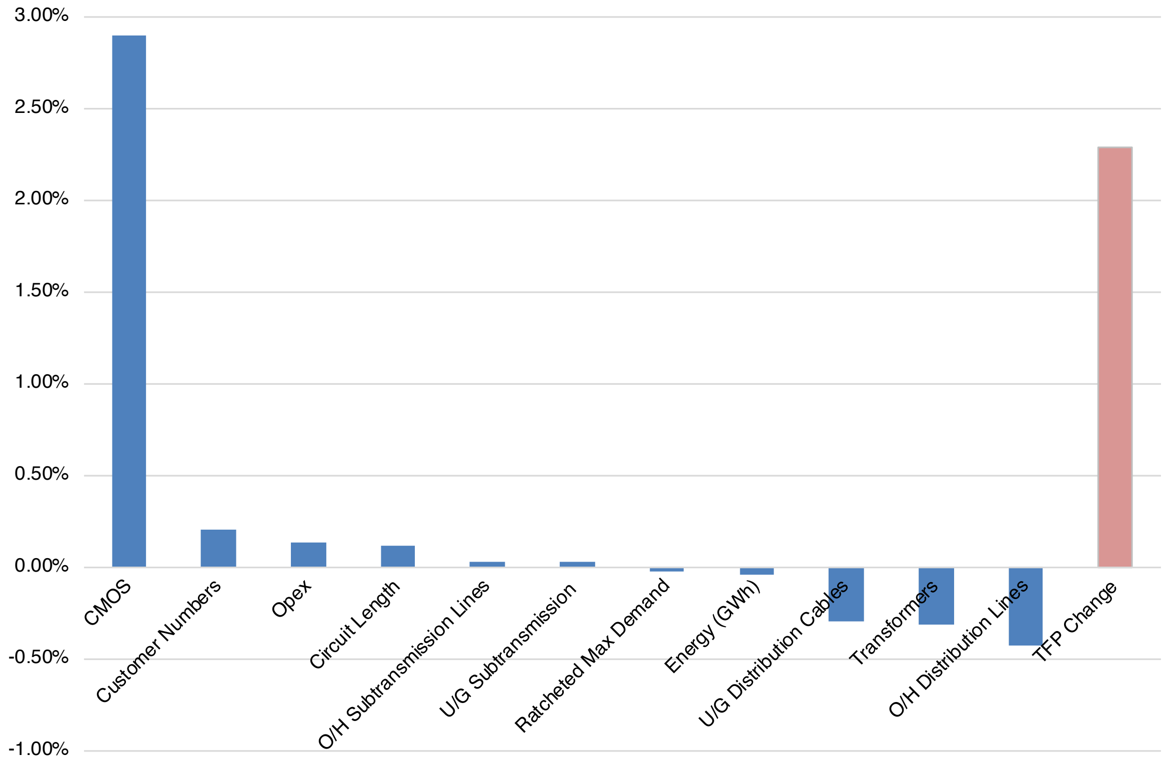
Opex has a marginal positive contribution of less than 0.1 percentage points to TFP growth in NSW over the period from 2006 to 2021 due to its decreased use as an input, whereas for the industry as a whole it contributed –0.2 percentage points to TFP growth (see Table 2.2). The other inputs, namely overhead and underground subtransmission and distribution lines, and transformers, all made broadly similar contributions to TFP growth in NSW compared to the industry overall.

Table 4.6 NSW output and input percentage point contributions to average annual TFP change: various periods

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2020 to 2021*
Energy (GWh)	-0.07%	-0.05%	-0.08%	-0.04%
Ratcheted Max Demand	0.31%	0.49%	0.20%	-0.02%
Customer Numbers	0.24%	0.19%	0.27%	0.20%
Circuit Length	0.04%	-0.13%	0.16%	0.12%
CMOS	0.16%	0.31%	0.06%	2.90%
Opex	0.06%	-2.26%	1.61%	0.14%
O/H Subtransmission Lines	-0.06%	-0.09%	-0.04%	0.03%
O/H Distribution Lines	-0.26%	-0.26%	-0.26%	-0.43%
U/G Subtransmission Cables	-0.04%	-0.04%	-0.05%	0.03%
U/G Distribution Cables	-0.36%	-0.39%	-0.33%	-0.30%
Transformers	-0.67%	-1.13%	-0.37%	-0.32%
TFP Change	-0.65%	-3.36%	1.16%	2.29%

Figure 4.10 shows the decomposition of TFP change of 2.3 per cent in 2021. The major positive contribution in 2021 came from increased reliability (i.e., a reduction in CMOS), which contributed 2.9 percentage points. The major negative effects on TFP came from increases in overhead distribution lines, underground distribution cables and transformers which together contributed –1.1 percentage points. The contributions of all the other outputs and inputs in 2021 are individually small, and on balance positive.

Figure 4.10 NSW output and input percentage point contributions to TFP change, 2021



4.2.3 Victoria (VIC)

VIC is the second largest of the NEM jurisdictions (by customer numbers) and is served by five DNSPs: AusNet Services Distribution (AND), CitiPower (CIT), Jemena Electricity Networks (JEN), Powercor (PCR) and United Energy (UED). In 2021 the Victorian DNSPs delivered 34,961 GWh to 3.08 million customers over 147,215 circuit kilometres of lines and cables.

Victorian DNSP productivity performance

Victoria's total output, total input and TFP indexes are presented in Figure 4.11 and Table 4.7. Opex and capital PFP indexes are also presented in Table 4.7. Over the 16-year period 2006 to 2021, the Victorian DNSPs' TFP *decreased* at an average annual rate of 0.5 per cent. Although total output increased by an average annual rate of 1.2 per cent, total input use increased faster, at a rate of 1.7 per cent.

Figure 4.11 VIC DNSP output, input and TFP indexes, 2006–2021

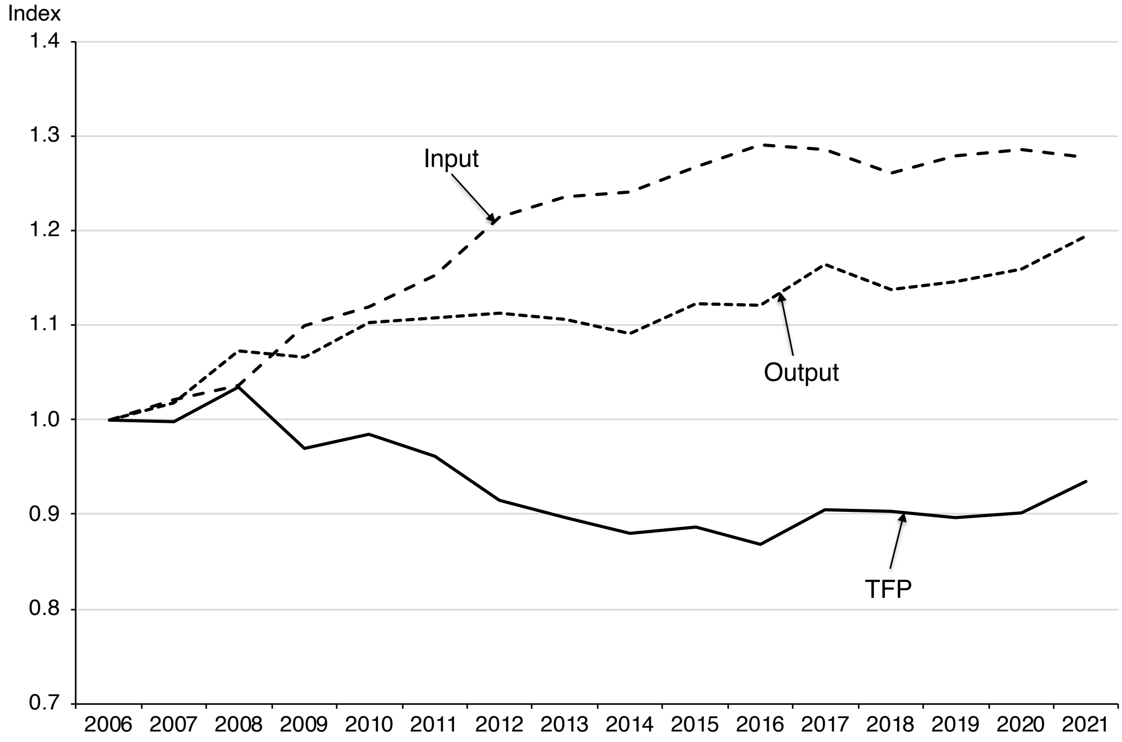


Table 4.7 VIC DNSP output, input and TFP and PFP indexes, 2006–2021

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index Opex*	*PFP Index Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	1.019	1.021	0.998	1.004	0.994
2008	1.073	1.037	1.035	1.059	1.022
2009	1.067	1.099	0.970	0.953	0.982
2010	1.103	1.119	0.985	0.972	0.994
2011	1.107	1.152	0.961	0.928	0.982
2012	1.112	1.215	0.916	0.843	0.967
2013	1.107	1.235	0.896	0.826	0.944
2014	1.091	1.241	0.879	0.828	0.914
2015	1.122	1.267	0.886	0.828	0.925
2016	1.121	1.290	0.869	0.806	0.910
2017	1.163	1.286	0.905	0.865	0.930
2018	1.138	1.260	0.903	0.921	0.893
2019	1.146	1.279	0.896	0.913	0.888
2020	1.160	1.286	0.902	0.939	0.881
2021	1.194	1.277	0.935	0.990	0.901
Growth Rate 2006-2021	1.2%	1.7%	-0.5%	-0.1%	-0.7%
Growth Rate 2006-2012	1.8%	3.2%	-1.5%	-2.9%	-0.6%
Growth Rate 2012-2021	0.8%	0.6%	0.2%	1.9%	-0.8%
Growth Rate 2021	5.8%	-1.3%	7.2%	10.7%	4.4%

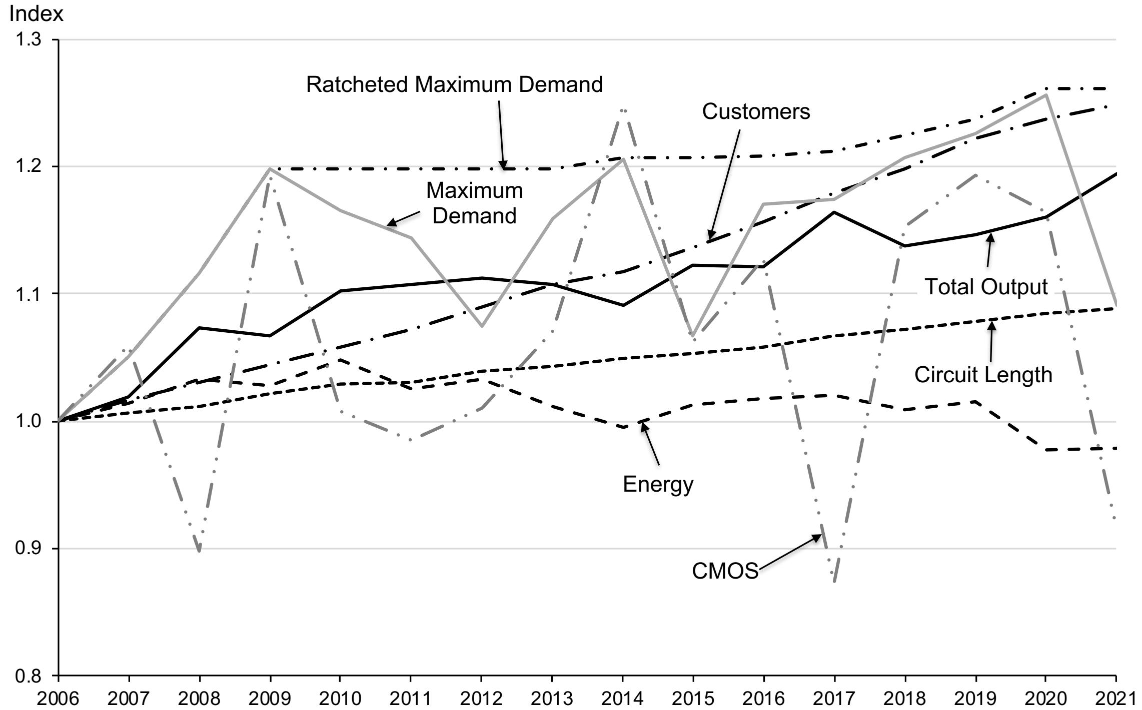
Victoria had slightly higher output growth and input growth, and a similar rate of TFP decline, compared to the industry as a whole. The TFP average annual change for Victorian DNSPs for the period up to 2012, at –1.5 per cent per annum, compares to a slightly positive rate of growth of 0.2 per cent per annum for the period 2012 to 2021. The PFP indexes in Table 5.7 confirm that better Opex PFP performance was the main driver of the improved TFP performance after 2012.

Victorian DNSP output and input quantity changes

The quantity indexes for the Victorian DNSPs' individual outputs are plotted in Figure 4.12, and the six individual inputs are plotted in Figure 4.13. From Figure 4.12 we see that:

- Customer numbers increased steadily over the period and were 24.8 per cent higher in 2021 than in 2006 (similar to the industry as a whole);
- Energy throughput peaked in 2010 and has fallen slowly since then. In 2021 it was 2.1 per cent below 2006 (a smaller decline than for the industry as a whole);
- VIC's RMD increased up to 2009, and again from 2014 onwards. By 2021, RMD was 26.1 per cent higher than in 2006 (more than the 18.1 per cent increase for the industry as a whole);
- VIC's circuit length output grew by 8.9 per cent in total over the whole 16-year period (compared to an increase of 5.2 per cent for the industry);

Figure 4.12 VIC output quantity indexes, 2006–2021



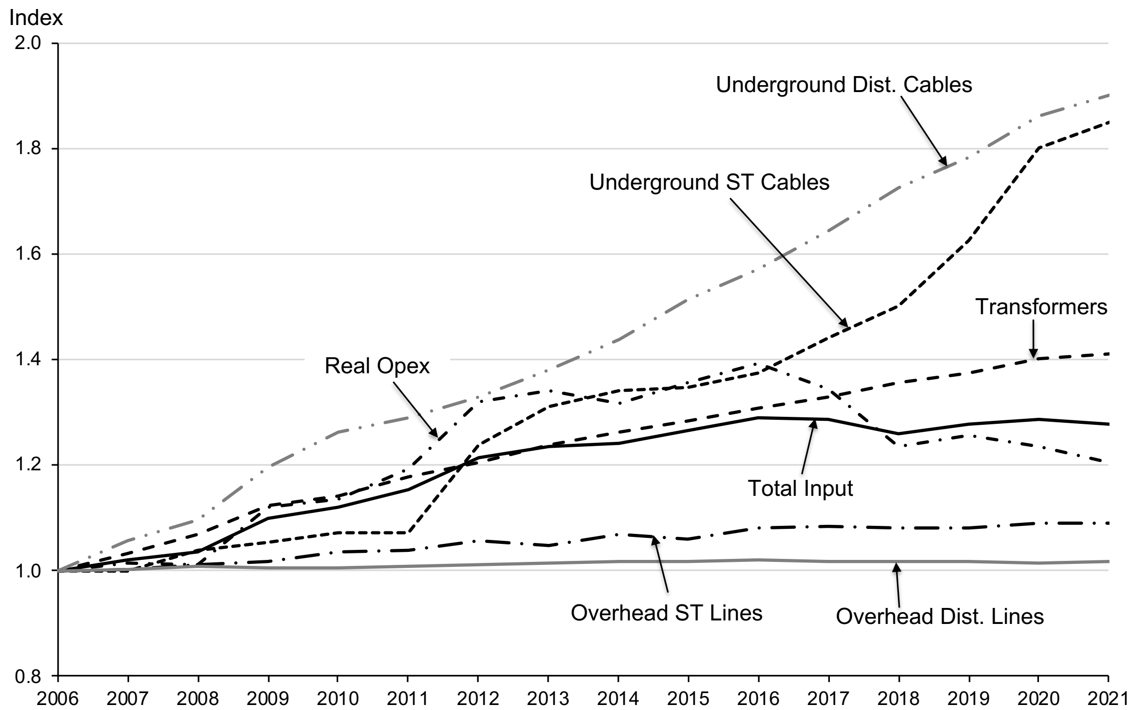
- VIC's total customer minutes off-supply (CMOS) *decreased* by 8.6 per cent in total between 2006 and 2021 (compared to an 11.4 per cent decrease for the industry over the same period). CMOS receives an average weight of –12.6 per cent of total revenue for Victoria.

In 2021, customers and circuit length increased by 1.8 per cent and 0.7 per cent respectively. CMOS *decreased* by 48.3 per cent, which contributed positively to total output growth. Energy output also increased in 2021, by 0.4 per cent, whilst RMD remained unchanged. VIC total outputs increased in 2021 by 5.8 per cent.

Victoria's six individual inputs and total input are shown Figure 4.13:

- VIC opex increased by 34.0 percent in total up to 2013, and remained at a similar level up to 2017, after which it declined, so that in 2021 opex was 20.6 percent above its 2006 level (compared to 8.7 per cent for the industry). Opex has the largest average share in VIC total costs at 38.5 per cent and so is an important driver of its total input quantity index;
- VIC's underground distribution and subtransmission cables increased at a much higher rate that for the industry overall. By 2021, these two inputs exceeded their 2006 levels by 89.9 per cent and 84.8 per cent respectively (compared to 68.6 and 37.6 per cent for the industry).

Figure 4.13 VIC DNSP input quantity indexes, 2006–2021



- Transformers inputs in VIC increased at a similar rate to the industry as a whole. By 2021, VIC transformer inputs exceeded their 2006 levels by 41.1 per cent;
- Overhead subtransmission and distribution lines in VIC increased much less than for the industry. By 2021, overhead subtransmission and distribution inputs exceeded their 2006 levels by 9.1 per cent and 1.6 per cent respectively (compared to 14.4 per cent and 13.6 per cent respectively for the whole industry).

Victorian output and input contributions to TFP change

Table 4.8 decomposes VIC's TFP change into its constituent output and input contributions for the 16-year period, for the periods up to and after 2012, and for 2021. Victoria's drivers of TFP change for the 2006 to 2021 period are broadly similar to the industry as a whole except that opex increases have made a greater negative contribution to TFP growth for VIC, at –0.4 per cent compared to –0.2 per cent for the industry. Transformer inputs made a smaller negative contribution to Victoria's TFP at –0.5 percentage points compared to –0.7 for the industry.

Consistent with the industry as a whole, the biggest source of change in TFP between the sub-periods 2006 to 2012 and 2012 to 2021 is in opex input use. Growth in use of opex inputs in the former period contributed –1.8 percentage points to VIC TFP growth, and reduction in opex inputs in the latter period contributed 0.5 percentage points to VIC TFP growth.

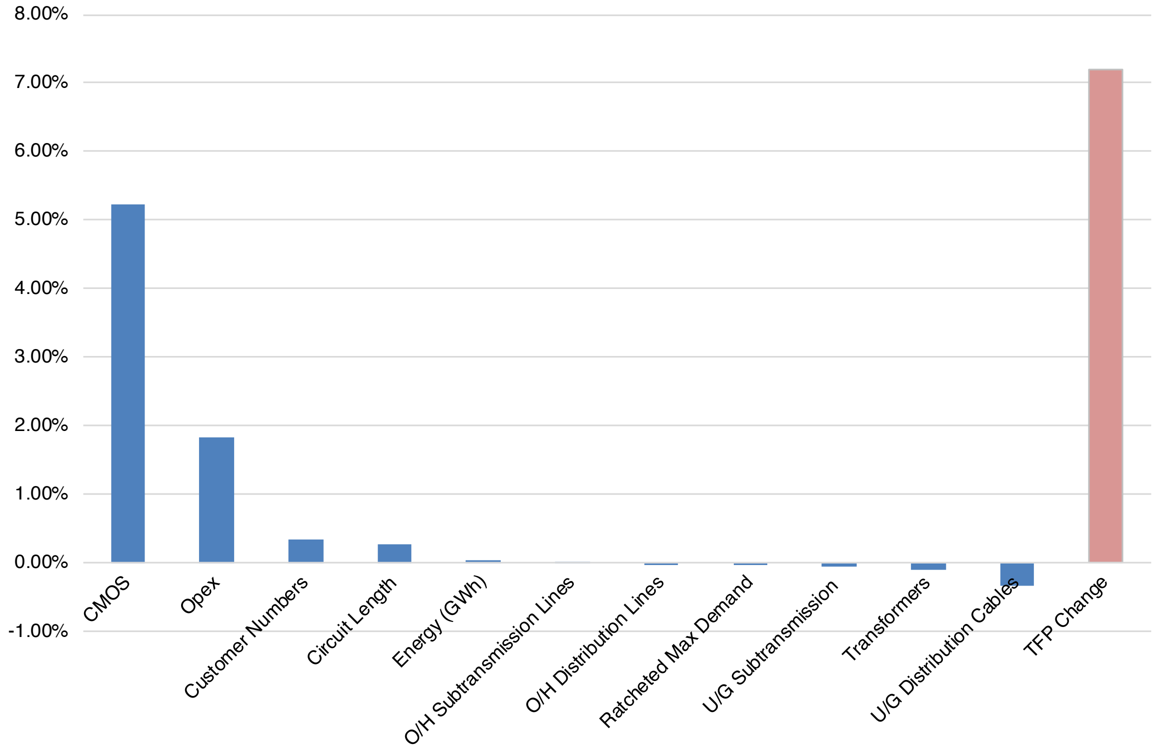
Table 4.8 VIC output and input percentage point contributions to average annual TFP change: various periods

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2020 to 2021*
Energy (GWh)	-0.01%	0.05%	-0.06%	0.04%
Ratcheted Max Demand	0.59%	1.16%	0.21%	-0.03%
Customer Numbers	0.32%	0.30%	0.33%	0.34%
Circuit Length	0.26%	0.28%	0.24%	0.26%
CMOS	0.23%	-0.03%	0.40%	5.24%
Opex	-0.43%	-1.82%	0.50%	1.84%
O/H Subtransmission Lines	-0.02%	-0.03%	-0.01%	0.01%
O/H Distribution Lines	-0.02%	-0.04%	-0.01%	-0.01%
U/G Subtransmission Cables	-0.05%	-0.04%	-0.06%	-0.05%
U/G Distribution Cables	-0.55%	-0.61%	-0.51%	-0.33%
Transformers	-0.51%	-0.69%	-0.39%	-0.11%
TFP Change	-0.21%	-1.47%	0.63%	7.19%

In Figure 4.14 we see that the largest single contribution to VIC TFP growth of 7.2 per cent in 2021 was improvement in reliability (i.e., reduction in CMOS), which contributed 5.2 percentage points. Among the outputs, the other contributors were customer numbers and circuit length outputs, which combined contributed 0.6 percentage points. On the input side, Opex savings was a major contributor to TFP growth, contributing 1.84 percentage points.

This was only partly offset by the negative contributions from underground distribution cables and transformer inputs which together contributed –0.4 percentage points.

Figure 4.14 VIC output and input percentage point contributions to TFP change, 2021



4.2.4 Queensland (QLD)

QLD is the third largest of the NEM jurisdictions in terms of customer numbers and the second largest in terms of circuit length. It is served by two DNSPs: Energex (ENX) and Ergon Energy (ERG). In 2021 the two Queensland DNSPs delivered 34,610 GWh to 2.30 million customers over 209,329 circuit kilometres of lines and cables.

Queensland DNSP productivity performance

QLD's total output, total input and TFP indexes are presented in Figure 4.15 and Table 4.9. Opex and capital PFP indexes are also presented in Table 4.9. Over the 16-year period 2006 to 2021, the average annual rate of TFP change of QLD DNSPs was zero per cent. QLD's total output increased by an average annual rate of 1.5 per cent over the same period, which is higher than the output growth rates in NSW and VIC (and higher than for the industry as a whole, which was 1.0 per cent over the same period). QLD's total input use increased at an average annual rate of 1.6 per cent (mid-way between the rate of growth in NSW and VIC, and similar to the average for the industry). QLD's zero TFP growth between 2006 and 2021 compares favourably to the industry average TFP *decline* (–0.5 per cent per year).

Figure 4.15 Qld DNSP output, input and TFP indexes, 2006–2021

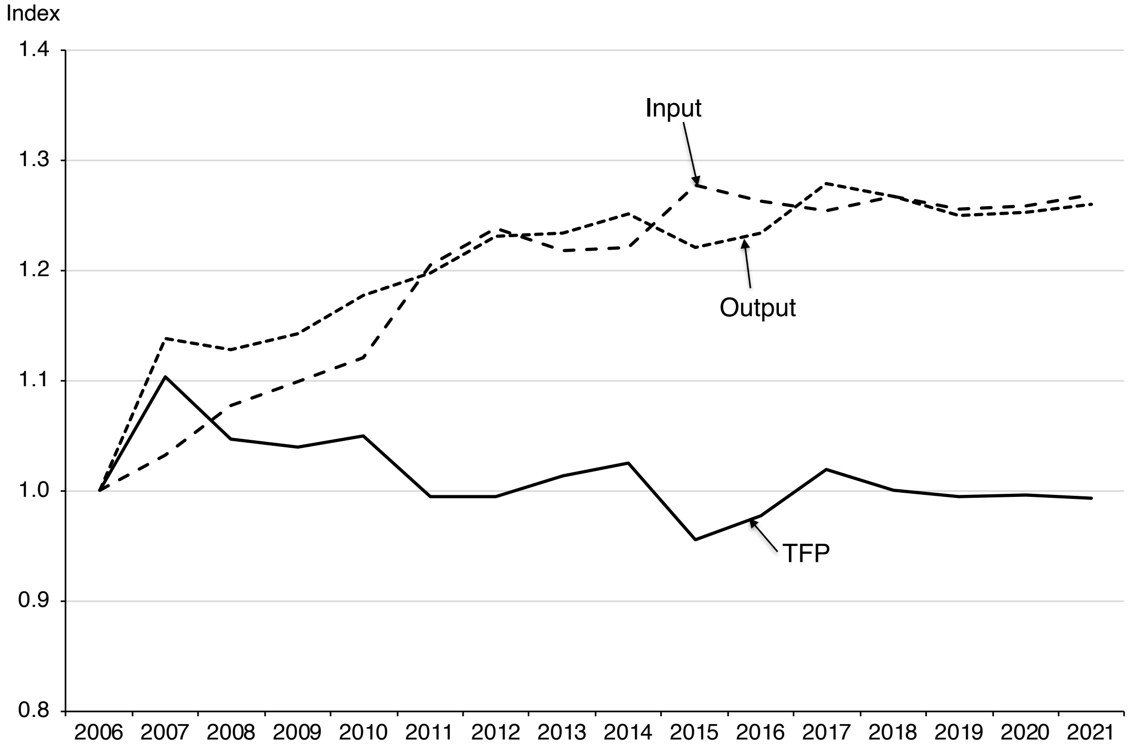


Table 4.9 Qld DNSP output, input, TFP and PFP indexes, 2006–2021

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	1.138	1.032	1.103	1.132	1.085
2008	1.128	1.077	1.047	1.062	1.040
2009	1.143	1.099	1.040	1.076	1.017
2010	1.176	1.121	1.049	1.113	1.013
2011	1.197	1.204	0.994	0.973	1.004
2012	1.231	1.239	0.994	0.958	1.008
2013	1.234	1.217	1.014	1.033	1.001
2014	1.251	1.220	1.025	1.095	0.986
2015	1.221	1.277	0.956	0.990	0.936
2016	1.233	1.263	0.976	1.056	0.933
2017	1.278	1.254	1.019	1.151	0.951
2018	1.266	1.266	1.000	1.123	0.934
2019	1.249	1.256	0.995	1.137	0.921
2020	1.253	1.258	0.996	1.148	0.916
2021	1.259	1.268	0.993	1.150	0.911
Growth Rate 2006-2021	1.5%	1.6%	0.0%	0.9%	-0.6%
Growth Rate 2006-2012	3.5%	3.6%	-0.1%	-0.7%	0.1%
Growth Rate 2012-2021	0.3%	0.3%	0.0%	2.0%	-1.1%
Growth Rate 2021	0.5%	0.8%	-0.3%	0.2%	-0.6%

Comparing the period before 2012 to that after 2012, it can be seen that TFP change of QLD DNSPs averaged –0.1 per cent per annum from 2006 to 2012, and was zero after 2012. The PFP indexes in Table 4.9 show that deterioration in Opex PFP was a major influence on TFP growth before 2012, and improvement in Opex PFP together with deterioration of capital PFP, influenced TFP growth after 2012.

Queensland DNSP output and input quantity changes

Quantity indexes for the Queensland DNSPs' individual outputs are plotted in Figure 4.16, and their six individual inputs are plotted in Figure 4.17. From Figure 4.16 we see that QLD's output components showed a generally similar pattern of change to the industry as a whole except that there was more growth in outputs for Queensland over the period.

- Energy throughput showed less of a downturn after 2010 than for some other states and the industry overall, likely reflecting the effects of the mining boom. In 2021 it was 1.5 per cent above 2006 (compared to 4.8 per cent *below* 2006 for the industry as a whole);
- Customer numbers increased steadily over the period and were 25.4 per cent higher in 2021 than it was in 2006;
- QLD's RMD increased mainly in the period up to 2010, thereafter having only an incremental increase in 2020. By 2021 it was 22.0 per cent higher than in 2006 (slightly higher than the 18.1 per cent for the industry as a whole);
- QLD's circuit length output grew by 7.3 per cent in total over the whole 16-year period (slightly above the increase of 5.2 per cent for the industry);
- Total customer minutes off-supply (CMOS) has generally followed a similar pattern to that of the industry although, despite a marked increase in 2015, it has declined more overall. In total it *decreased* by 19.2 per cent between 2006 and 2021 (compared to an 11.4 per cent decrease for the industry over the same period).

The circuit length and RMD outputs together receive an average weight of 86.5 per cent of total revenue in forming the total output index for QLD, but in Figure 4.16 the total output index often lies above these two output indexes and also above the customer numbers output index. This is due to the CMOS index which enters the formation of total output as a negative output (i.e. the reduction in CMOS over the period makes a positive contribution to total output). In Queensland CMOS receives an average weight of –18.6 per cent of total revenue in forming the total output index.

From Figure 4.17, showing QLD's six individual inputs and total input, it can be seen when comparing to Figure 2.3 that the quantity of Queensland's underground distribution and sub-transmission cables and transformers inputs have increased more than for the industry as a whole (see Figure 2.4). The increase in underground cables starts from a small base and reflects Queensland's higher rate of customer numbers growth.

Figure 4.16 Qld output quantity indexes, 2006–2021

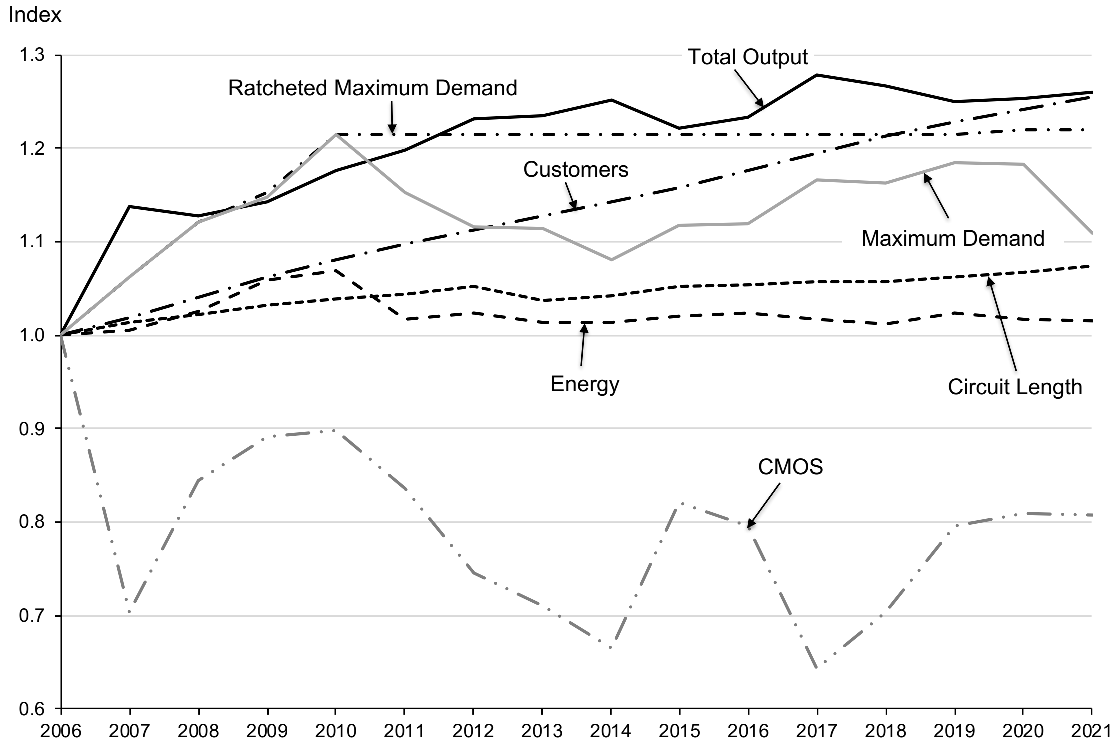
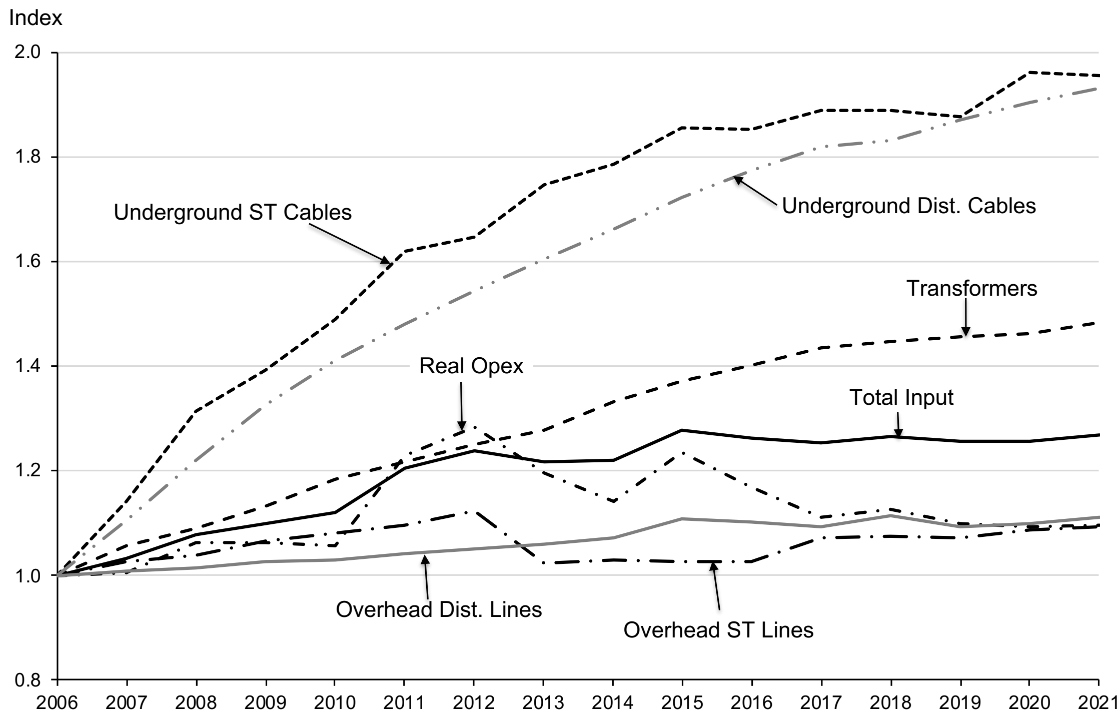


Figure 4.17 Qld DNSP input quantity indexes, 2006–2021



Opex in QLD increased at a similar rate to the industry average, and overhead lines increased somewhat less than for the industry. QLD opex increased by 28.5 per cent in total up to 2012 (which was less than the corresponding increase for the industry of 36.4 per cent). It declined afterward, so that in 2021 opex was 9.5 percent above its 2006 level (similar to the industry average). Opex has the largest average share in QLD's total costs at 36.2 per cent and so is an important driver of its total input quantity index. Among the other inputs:

- Transformers inputs in QLD increased by 48.3 per cent between 2006 and 2021 (compared to 42.2 per cent for the industry over the same period);
- Overhead subtransmission and distribution lines in QLD increased by 9.2 per cent and 11.1 per cent, respectively, in total between 2006 and 2021 (compared to 14.4 per cent and 13.6 per cent respectively for the whole industry).

Queensland output and input contributions to TFP change

Table 4.10 decomposes QLD's TFP change into the contributions of individual outputs and inputs for the whole 16-year period, for the periods up to and after 2012, and for 2021. QLD's drivers of TFP change for the period 2006 to 2021 are broadly similar to the industry as a whole except that RMD and CMOS make slightly larger positive contributions of 0.6 and 0.4 percentage points respectively (compared to 0.4 and 0.2 respectively for the industry). With regard to the contributions of other outputs and inputs:

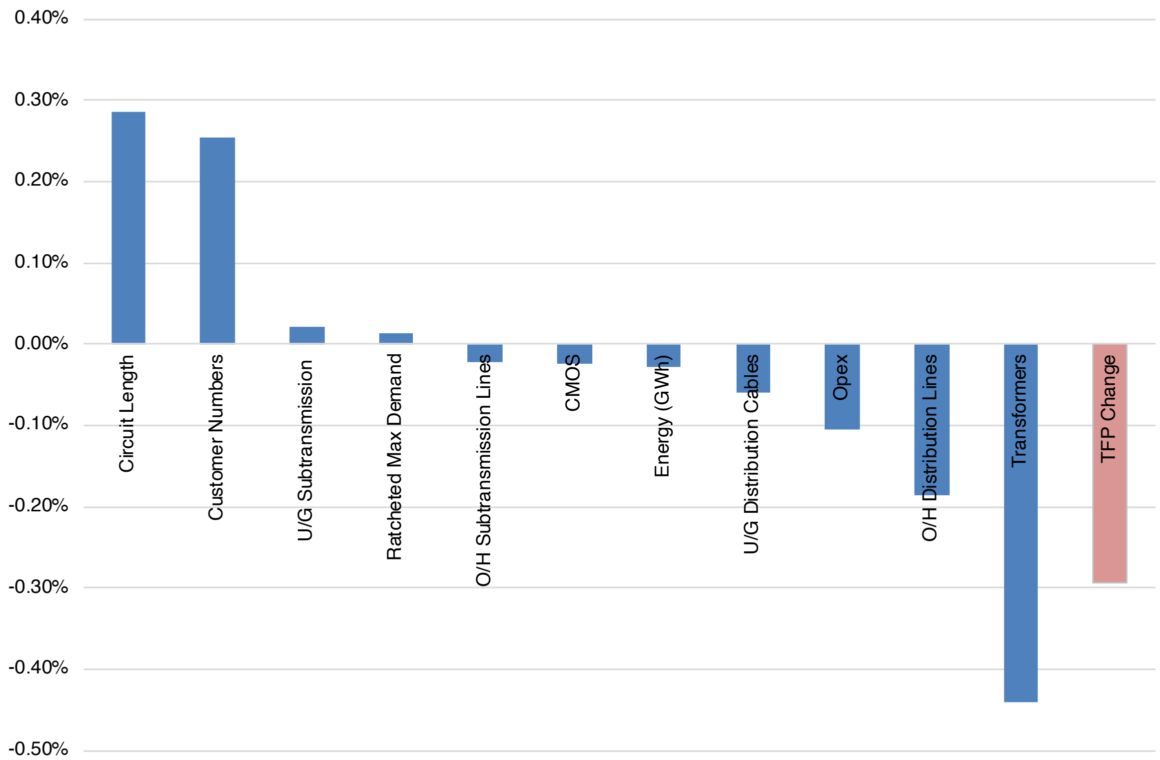
- Customers and circuit length outputs together contributed 0.6 percentage points to QLD's average TFP growth for the period 2006 to 2021 (compared to 0.4 for the whole industry);
- Opex input contributed –0.2 percentage points to QLD's TFP rate of growth, the same as for the industry;
- Overhead and underground sub-transmission and distribution lines together contributed –0.6 percentage points to QLD TFP growth (similar to the industry);
- Transformers input contributed –0.8 percentage points to QLD's TFP rate of growth (compared to –0.7 for the industry).

Figure 4.18 shows the contributions of individual outputs and inputs to QLD's TFP growth in 2021 of –0.3 per cent. Among outputs, positive contributions were made by customer numbers and circuit length. Among inputs, opex made a small negative contribution, while whilst increases in overhead distribution lines and transformer inputs made the largest negative contributions to TFP growth.

Table 4.10 Qld output and input percentage point contributions to average annual TFP change: various periods

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2020 to 2021*
Energy (GWh)	0.01%	0.04%	-0.01%	-0.03%
Ratcheted Max Demand	0.56%	1.37%	0.02%	0.01%
Customer Numbers	0.34%	0.42%	0.29%	0.25%
Circuit Length	0.23%	0.41%	0.11%	0.29%
CMOS	0.39%	1.22%	-0.16%	-0.02%
Opex	-0.23%	-1.48%	0.61%	-0.11%
O/H Subtransmission Lines	-0.04%	-0.13%	0.03%	-0.02%
O/H Distribution Lines	-0.12%	-0.14%	-0.11%	-0.19%
U/G Subtransmission Cables	-0.11%	-0.19%	-0.05%	0.02%
U/G Distribution Cables	-0.31%	-0.52%	-0.18%	-0.06%
Transformers	-0.78%	-1.09%	-0.57%	-0.44%
TFP Change	-0.05%	-0.10%	-0.01%	-0.29%

Figure 4.18 Qld output and input percentage point contributions to TFP change, 2021



4.2.5 South Australia (SA)

SA is the fourth largest NEM jurisdiction (by customer numbers) and is served by one DNSP, SA Power Networks (SAP). In 2021 it delivered 9,666 GWh to 920,841 customers over 89,608 circuit kilometres of lines and cables.

SA DNSP productivity performance

SA's total output, total input and TFP indexes are presented in Figure 4.19 and Table 4.11. Opex and capital PFP indexes are also presented in Table 4.11. Over the 16-year period 2006 to 2021, the SA DNSP's TFP *decreased* at an average annual rate of 1.3 per cent. Although total output increased by an average annual rate of 0.8 per cent, total input use increased faster, at a rate of 2.1 per cent. SA thus had slightly lower output growth and higher input growth compared to the industry as whole, and hence a larger rate of decrease in TFP.

Input use increased at a faster rate in the period 2006 to 2012 at an annual rate of 3.9 per cent and increased more slowly from 2012 to 2021 at an annual average rate of 0.8 per cent. This pattern is similar to that for the industry as a whole, except the growth of inputs after 2012 differs from the static level of inputs for the industry. Although the rate of output growth was also lower after 2012 (0.1 per cent per year compared to an average rate of 1.8 per cent before 2012), the flattening of the input index led to a slower decline in TFP after 2012. Whereas SA's average annual TFP growth rate before 2012 was –2.2 per cent, from 2012 to 2021 it averaged –0.7 per cent.

Figure 4.19 SA DNSP output, input and total factor productivity indexes, 2006–2021

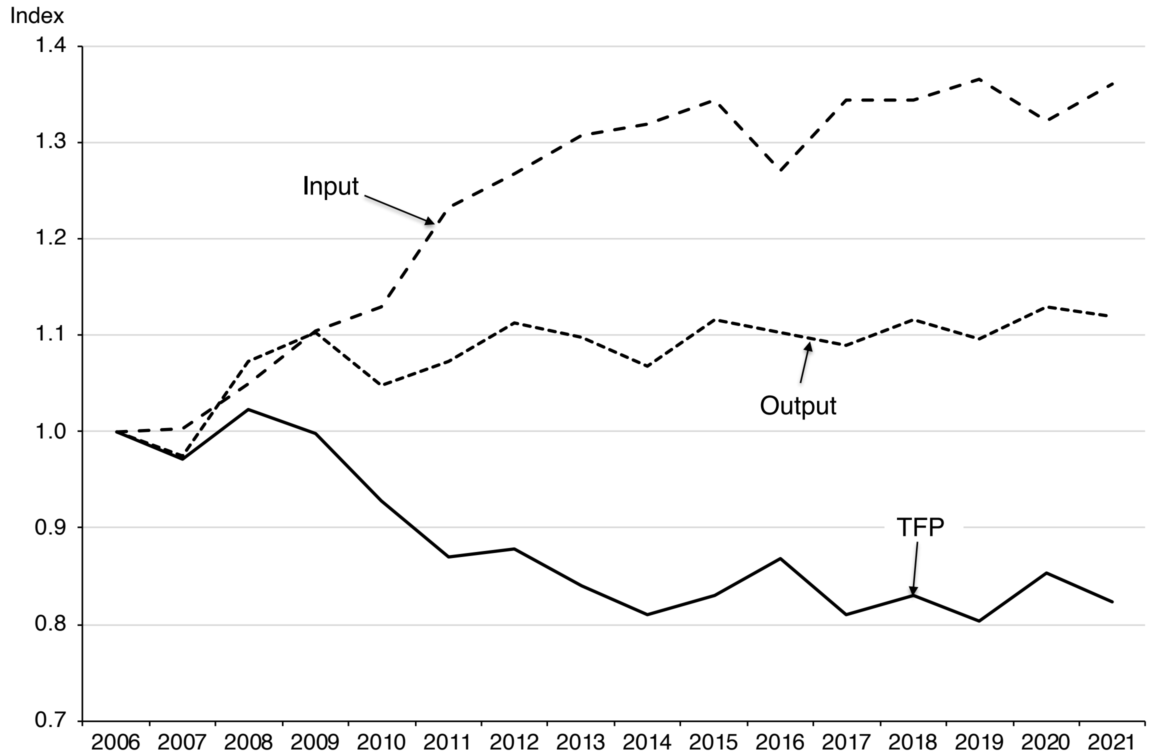


Table 4.11 SA DNSP output, input, TFP and PFP indexes, 2006–2021

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	0.974	1.003	0.971	1.049	0.940
2008	1.073	1.049	1.023	1.036	1.013
2009	1.102	1.105	0.997	0.972	1.011
2010	1.048	1.128	0.929	0.924	0.931
2011	1.073	1.232	0.871	0.759	0.935
2012	1.112	1.266	0.879	0.761	0.944
2013	1.098	1.307	0.840	0.714	0.917
2014	1.068	1.319	0.810	0.698	0.879
2015	1.116	1.343	0.831	0.701	0.907
2016	1.103	1.270	0.869	0.827	0.888
2017	1.089	1.344	0.810	0.708	0.868
2018	1.115	1.343	0.830	0.741	0.880
2019	1.097	1.365	0.804	0.710	0.857
2020	1.128	1.321	0.854	0.820	0.869
2021	1.120	1.360	0.823	0.798	0.833
Growth Rate 2006-2021	0.8%	2.1%	-1.3%	-1.5%	-1.2%
Growth Rate 2006-2012	1.8%	3.9%	-2.2%	-4.5%	-1.0%
Growth Rate 2012-2021	0.1%	0.8%	-0.7%	0.5%	-1.4%
Growth Rate 2021	-0.8%	2.9%	-3.7%	-2.7%	-4.2%

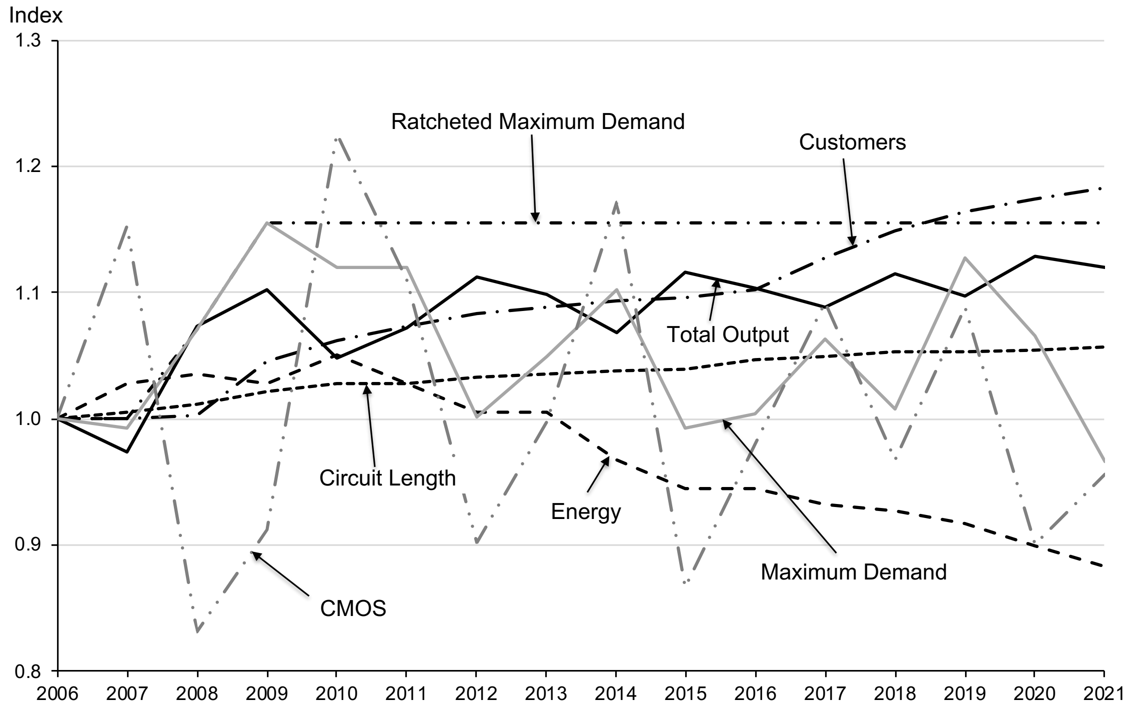
SA DNSP output and input quantity changes

Quantity indexes for SA's individual outputs are graphed in Figure 4.20 and for its six individual inputs in Figure 4.21. From Figure 4.20 we see that:

- SA customer numbers increased steadily over the period and were 18.2 per cent higher in 2021 than in 2006 (compared to 22.0 per cent for the industry as a whole);
- Like several other jurisdictions, energy throughput in SA peaked in 2010 and has fallen slowly since then. In 2021 it was 11.8 per cent below 2006; a much larger decrease than that for the industry as a whole over the same period (–4.8 per cent);
- SA's maximum demand peaked in 2009 and has not exceeded that level since. RMD had therefore been constant since 2009 at 15.5 per cent above the 2006 level. This is comparable to the increase in RMD of 18.1 per cent for the industry between 2006 and 2021;
- SA's circuit length output grew by 5.6 per cent in total over the 16-year period (a similar rate as that for the industry);
- SA's CMOS *decreased* by 4.4 per cent in total between 2006 and 2021, thus making a smaller contribution to output growth than for the industry (where CMOS *decreased* by

11.4 per cent over the same period). CMOS receives an average weight of –16.7 per cent of total revenue for SA.

Figure 4.20 SA output quantity indexes, 2006–2021



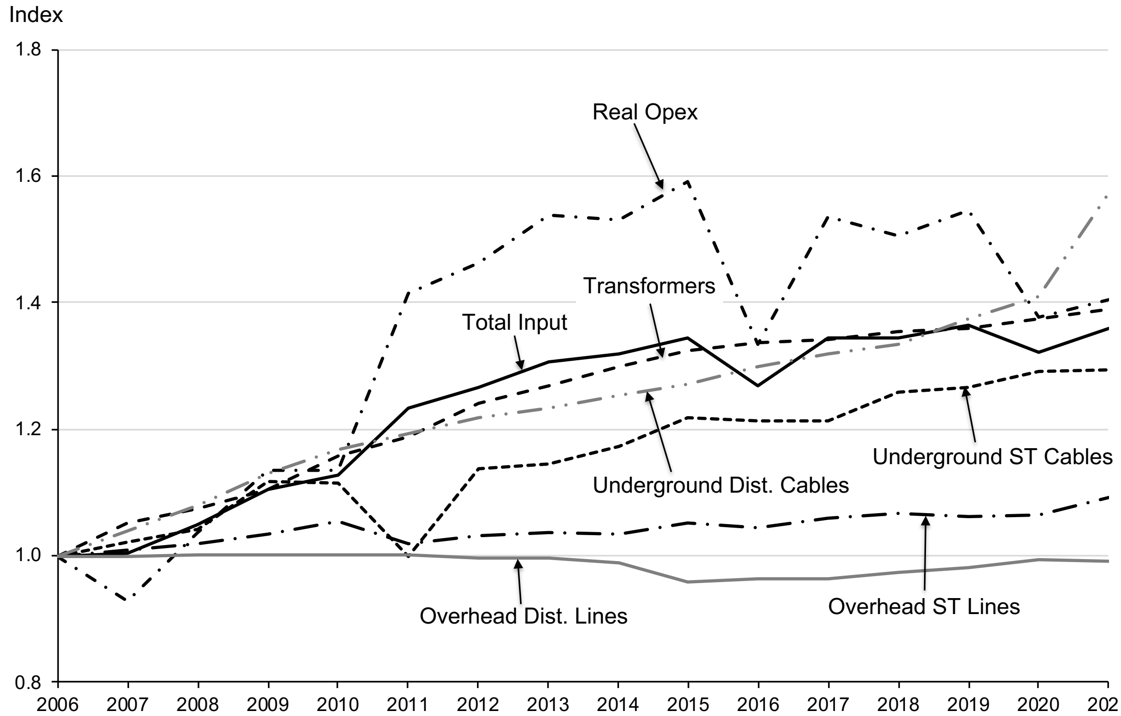
Since the circuit length and RMD outputs receive a combined average weight of around 85.1 per cent of total revenue in forming the total output index for SA, we see in Figure 4.20 that the total output index lies between these output indexes in most years. The total output index for SA increased by 12.0 per cent between 2006 and 2021 (less than the increase for the industry of 16.0 per cent over the same period).

Turning to Figure 4.21, which shows the SA DNSP input indexes, it can be seen that SA's total input index increased by 36.0 per cent in total between 2006 and 2021, which is higher than the corresponding increase of 25.2 per cent for industry. In regard to the six individual input indexes for SA shown Figure 4.21:

- SA's opex input increased by 40.4 per cent over the 16-year period, which is much greater than for the industry (an increase of 8.7 per cent over the same period). This outcome was driven by an especially strong increase in SA's opex input between 2006 and 2012 of 46.1 per cent. After 2012 there was no significant decrease from this level until 2020. Opex has the largest average share in SA's total costs at 35.0 per cent and so is an important driver of its total input quantity index;

- Underground distribution and subtransmission cables in SA increased by 57.2 per cent and 29.4 per cent respectively over the 16-year period to 2021 (compared to 68.6 and 37.6 per cent for the industry);
- Transformers inputs in SA increased at a similar rate to the industry as a whole, exceeding their 2006 levels by 39.0 per cent by 2021 (compared to 42.2 per cent for the industry);
- SA's overhead subtransmission increased between 2006 and 2021 by 9.2 per cent and its overhead distribution lines *decreased* by 0.8 per cent (compared to increases of 14.4 per cent and 13.6 per cent respectively for the whole industry).

Figure 4.21 SA DNSP input quantity indexes, 2006–2021



SA output and input contributions to TFP change

In Table 4.12, SA's TFP change is decomposed into the contributions of the individual outputs and inputs for the whole 16-year period, for the periods up to and after 2012, and for 2021. SA's drivers of TFP change for the 16-year period to 2021 are broadly similar to the industry with the main exception of opex input, which has a much larger negative contribution than the industry. For SA, opex input contributed –0.8 percentage points to the average TFP growth rate of –1.3 per cent from 2006 to 2021 (compared to a negative contribution of opex –0.2 to the industry average TFP growth rate of –0.5 per cent for the same period). Other contributions to SA's average TFP growth rate over the 16 years to 2021 include:

- Customers, RMD and circuit length outputs together contributed 0.8 percentage points (compared to 0.9 for the industry);
- Overhead and underground sub-transmission and distribution lines together contributed –0.6 percentage points (the same as for the industry);
- Transformers input contributed –0.7 percentage points (similar to the industry); and
- CMOS contributed close to zero percentage points (compared to 0.2 for the industry).

Table 4.12 SA output and input percentage point contributions to average annual TFP change: various periods

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2020 to 2021*
Energy (GWh)	-0.08%	0.01%	-0.14%	-0.19%
Ratcheted Max Demand	0.38%	0.96%	0.00%	0.00%
Customer Numbers	0.24%	0.30%	0.20%	0.15%
Circuit Length	0.17%	0.26%	0.11%	0.10%
CMOS	0.04%	0.26%	-0.10%	-0.83%
Opex	-0.75%	-2.10%	0.14%	-0.71%
O/H Subtransmission Lines	-0.01%	-0.01%	-0.01%	-0.04%
O/H Distribution Lines	0.01%	0.01%	0.01%	0.03%
U/G Subtransmission Cables	-0.01%	-0.01%	0.00%	0.00%
U/G Distribution Cables	-0.55%	-0.68%	-0.46%	-1.75%
Transformers	-0.74%	-1.14%	-0.47%	-0.42%
TFP Change	-1.30%	-2.16%	-0.72%	-3.66%

Figure 4.22 SA output and input percentage point contributions to TFP change, 2021

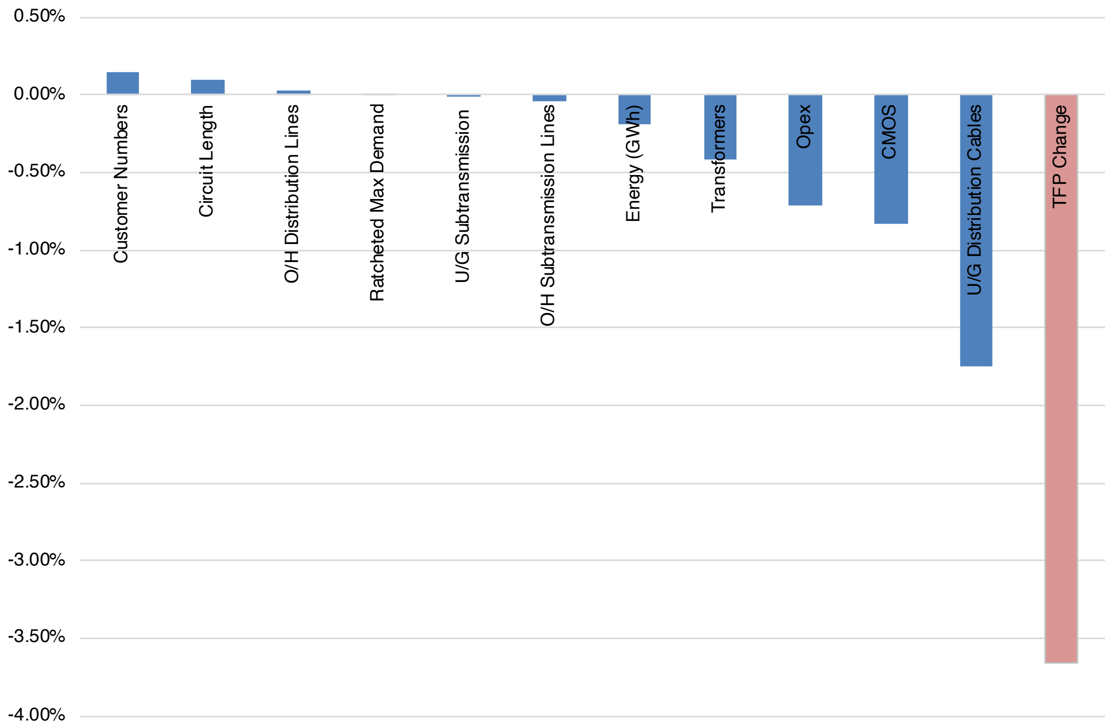


Figure 4.22 shows the percentage point contributions of individual outputs and inputs to SA's TFP growth in 2021. SA's large TFP *decrease* of 3.6 per cent in 2021 was driven by a significant decrease in reliability (i.e., increase in CMOS) and increases in several inputs. The increase in CMOS contributed –0.8 percentage points to TFP growth in 2021. An increase in opex contributed –0.7 percentage points, and increases in underground distribution cables and transformer inputs contributed –1.8 and –0.4 percentage points to TFP growth respectively.

4.2.6 Tasmania (TAS)

TAS is the second smallest of the NEM jurisdictions (by customer numbers) and is served by one DNSP, TasNetworks Distribution (TND). In 2021 it delivered 4,483 GWh to 297,656 customers over 22,657 circuit kilometres of lines and cables.[12]

Tasmanian DNSP productivity performance

Tasmania's total output, total input and TFP indexes are presented in Figure 4.23 and Table 4.13. Opex and capital PFP indexes are also presented in Table 4.13. Over the 16-year period 2006 to 2021, the Tasmanian DNSP's TFP *decreased* at an average annual rate of 1.2 per cent. Total output has increased at only 0.2 per cent per annum on average. Total input use, on the other hand, increased at an average annual rate of 1.4 per cent over the 16-yeasr period. Input use increased at a faster rate of 3.4 per cent between 2006 and 2012, and at a rate of 0.1 per cent per year from 2012 to 2021. Output increased at an average annual rate of 0.3 per cent from 2006 to 2012, and on average increased by 0.1 per cent per annum thereafter. The net effect of these trends was that TFP *decreased* at an average rate of 3.1 per cent up to 2012 and increased at an average rate of 0.1 per cent from 2012 to 2021.

Tasmanian DNSP output and input quantity changes

Quantity indexes for the Tasmanian DNSP's individual outputs are shown in Figure 4.24 and its six individual inputs in Figure 4.25. TAS outputs had the following trends:

- Customer numbers were 18.8 per cent higher in 2021 than in 2006 (compared to 22.0 per cent for the industry as a whole);
- Energy throughput peaked in 2009 and decreased each year through to 2014 before recovering somewhat in later years. It was 0.8 per cent higher in 2021 than in 2006 (compared to 4.8 per cent lower for industry as a whole);

[12] As previously indicated in Economic Insights (2015b, 4), TND is something of an outlier in terms of system structure in that it has by far the most 'downstream' boundary with transmission. It consequently has far less sub-transmission capacity than other Australian DNSPs. While this gives it an advantage in terms of a lower quantity of subtransmission inputs (and hence it should have a high MPFP of these lines), these inputs also receive a very low weight in forming the total input quantity (and hence it receives little benefit for its higher productivity in this area when forming the MTFP measure). For example, TND has an overhead subtransmission lines MPFP several times higher than that of any other DNSP but, whereas subtransmission lines account for around 25 per cent of the total AUC of overhead lines for the industry as a whole, they account for only 1.5 per cent of TND's overhead lines AUC.

Figure 4.23 TAS DNSP output, input and TFP indexes, 2006–2021

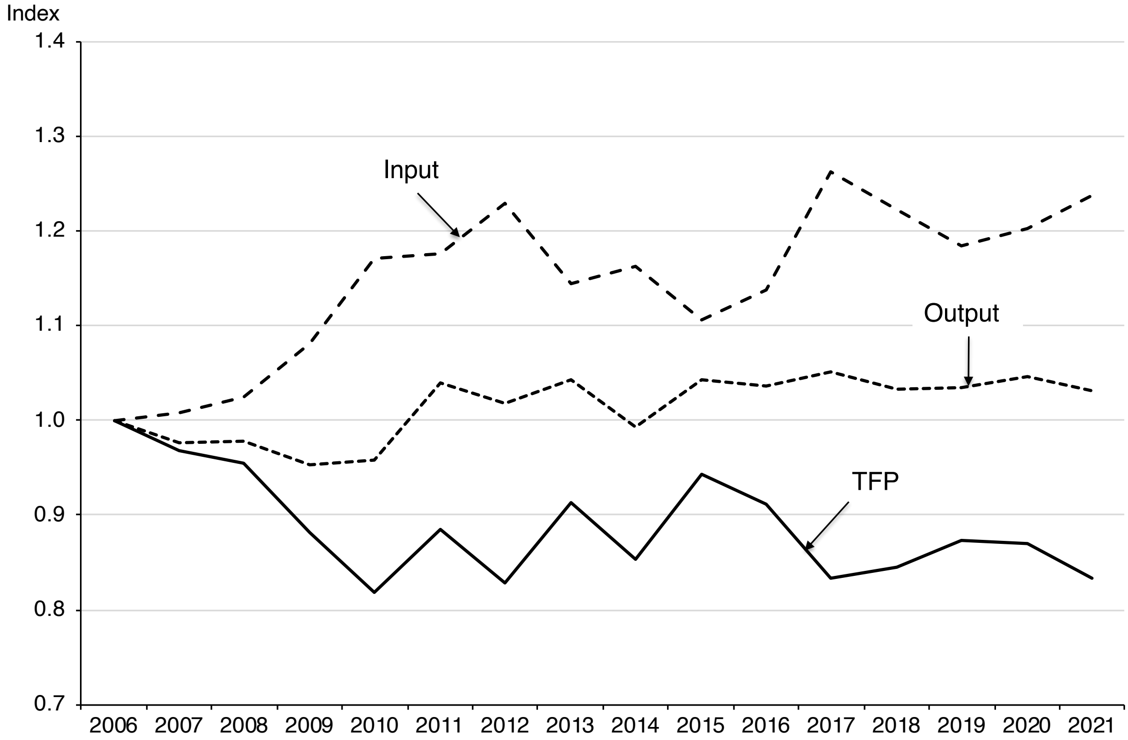


Table 4.13 TAS DNSP output, input, TFP and PFP indexes, 2006–2021

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index Opex*	*PFP Index Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	0.977	1.008	0.969	0.979	0.964
2008	0.979	1.025	0.955	0.971	0.946
2009	0.952	1.080	0.881	0.846	0.903
2010	0.958	1.171	0.818	0.719	0.880
2011	1.040	1.176	0.884	0.810	0.926
2012	1.017	1.228	0.828	0.726	0.892
2013	1.043	1.143	0.912	0.918	0.910
2014	0.993	1.162	0.854	0.856	0.853
2015	1.044	1.106	0.944	1.064	0.889
2016	1.036	1.137	0.911	0.985	0.877
2017	1.052	1.262	0.834	0.761	0.879
2018	1.032	1.223	0.844	0.826	0.855
2019	1.034	1.184	0.874	0.935	0.843
2020	1.046	1.203	0.870	0.914	0.846
2021	1.030	1.237	0.833	0.839	0.829
Growth Rate 2006-2021	0.2%	1.4%	-1.2%	-1.2%	-1.3%
Growth Rate 2006-2012	0.3%	3.4%	-3.1%	-5.3%	-1.9%
Growth Rate 2012-2021	0.1%	0.1%	0.1%	1.6%	-0.8%
Growth Rate 2021	-1.5%	2.9%	-4.4%	-8.6%	-2.0%

- TAS's maximum demand increased up to 2008 and has not reached that level since, so that RMD has been constant from 2008 to 2021 at 8.6 per cent higher than in 2006 (compared to the 18.1 per cent increase for the industry as a whole). TAS's circuit length output grew by 6.8 per cent in total over the 16-year period to 2021 (compared to an increase of 5.2 per cent for the industry);
- CMOS increased by 45.1 per cent in total between 2006 and 2021 (compared to a decrease of 11.4 per cent for the industry over the same period). This represents a significant deterioration in reliability performance compared to 2006. CMOS receives an average weight of –18.3 per cent of total revenue for Tasmania.

TAS's output index increased by 3.0 per cent from 2006 to 2021, compared to 16.0 per cent for the industry as a whole. CMOS had an important influence on this because it enters the total output index as a negative output (i.e. the large increase in CMOS over the period makes a substantial negative contribution to total output).

Figure 4.24 TAS output quantity indexes, 2006–2021

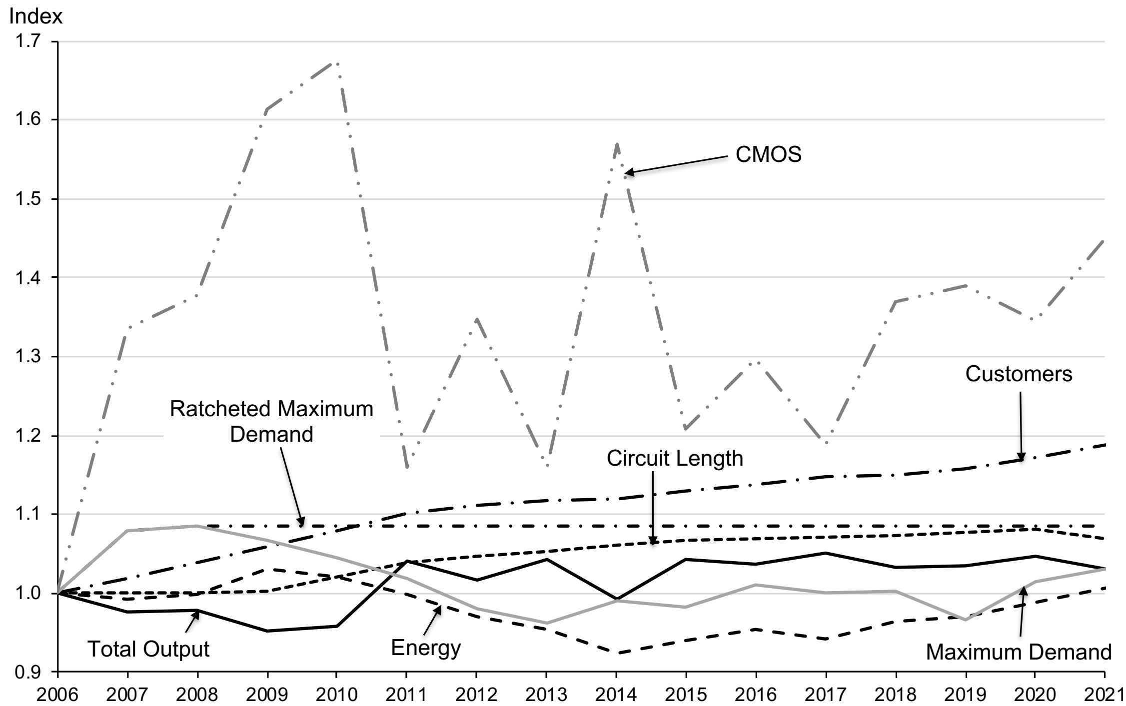


Figure 4.25 plots TAS's six individual inputs and the total input index:

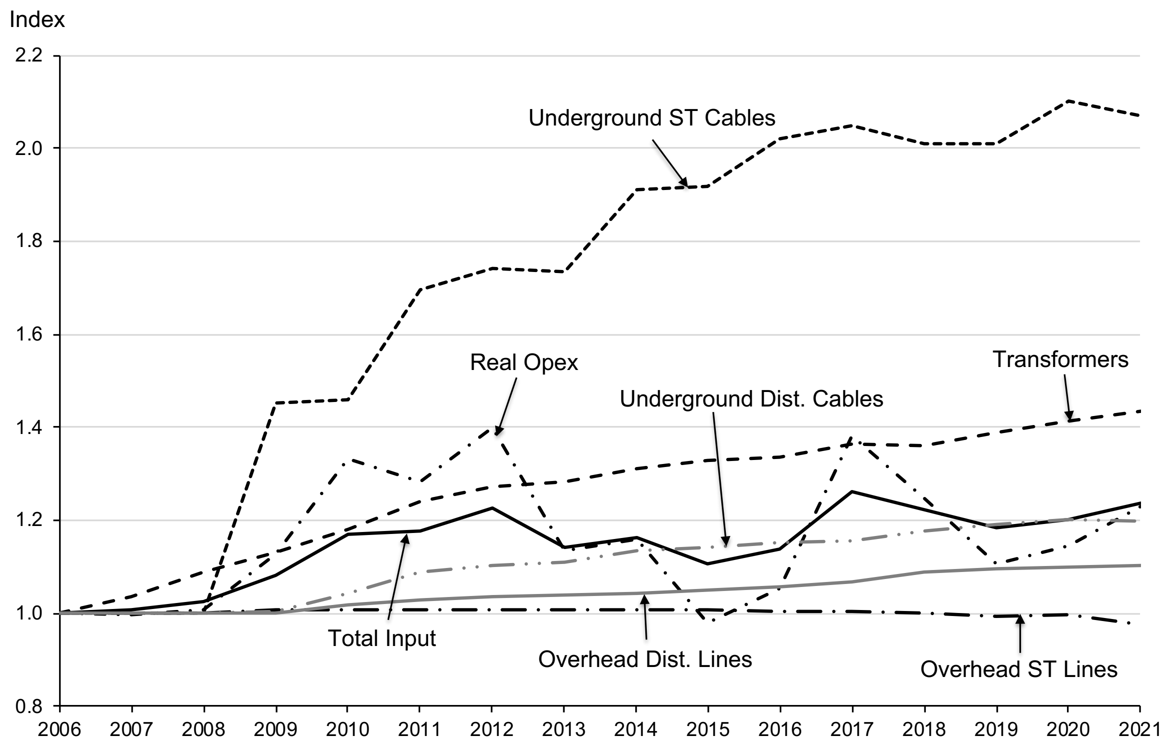
- Opex input increased by 22.9 per cent from 2006 to 2021. A substantial increase occurred in the period up to 2012 (at an average annual rate of 5.6 per cent, or 40.0 per cent in total), with a net decrease in the period from 2012 to 2021. However, this trend was partially reversed in 2021, with opex input increasing by 7.1 per cent. The increase of opex over the whole 16-year period is higher than that for the industry. As noted in

Economic Insights (2018), part of this increase was to address bushfire and other risks. Opex has the largest average share in Tasmania's total costs at 35.3 per cent and so is an important driver of total input quantity;

- Transformers inputs in TAS increased at a similar rate to the industry as a whole; by 2021 exceeding the 2006 level by 43.3 percent (compared to 42.2 per cent for the industry);
- TAS's underground distribution cables inputs increased by 19.9 per cent in total over the 16 years to 2021 (compared to 68.6 per cent for the industry). TAS's underground subtransmission cables more than doubled over the 16-year period, off a low base;
- Overhead subtransmission and distribution lines in TAS were in 2021, –2.3 per cent and 10.2 per cent from 2006, respectively (compared to 14.4 per cent and 13.6 per cent respectively for the whole industry).

From Figure 4.25 we see the TAS total input quantity index has generally been below the quantity indexes for opex and transformers and above the quantity index for overhead distribution and subtransmission lines. Total input quantity increased by 23.7 per cent over the 16 years to 2021, compared to 25.2 per cent for the industry overall.

Figure 4.25 TAS DNSP input quantity indexes, 2006–2021



Tasmanian output and input contributions to TFP change

Table 4.14 presents the decomposition of TAS's TFP change into its constituent outputs and inputs for the whole 16-year period, for the periods up to and after 2012, and for 2021. Tasmania's drivers of TFP change for the whole 16-year period show several differences to those for the industry as a whole. Among the outputs:

- RMD, customer numbers and circuit length together contributed 0.7 percentage points to TAS's average TFP change of –1.2 per cent from 2006 to 2021, compared to a 0.9 percentage points contribution of these outputs to the industry TFP change; and
- CMOS contributed –0.5 percentage points to average TAS TFP growth from 2006 to 2021, compared to 0.2 percentage points for the industry.

Among the inputs:

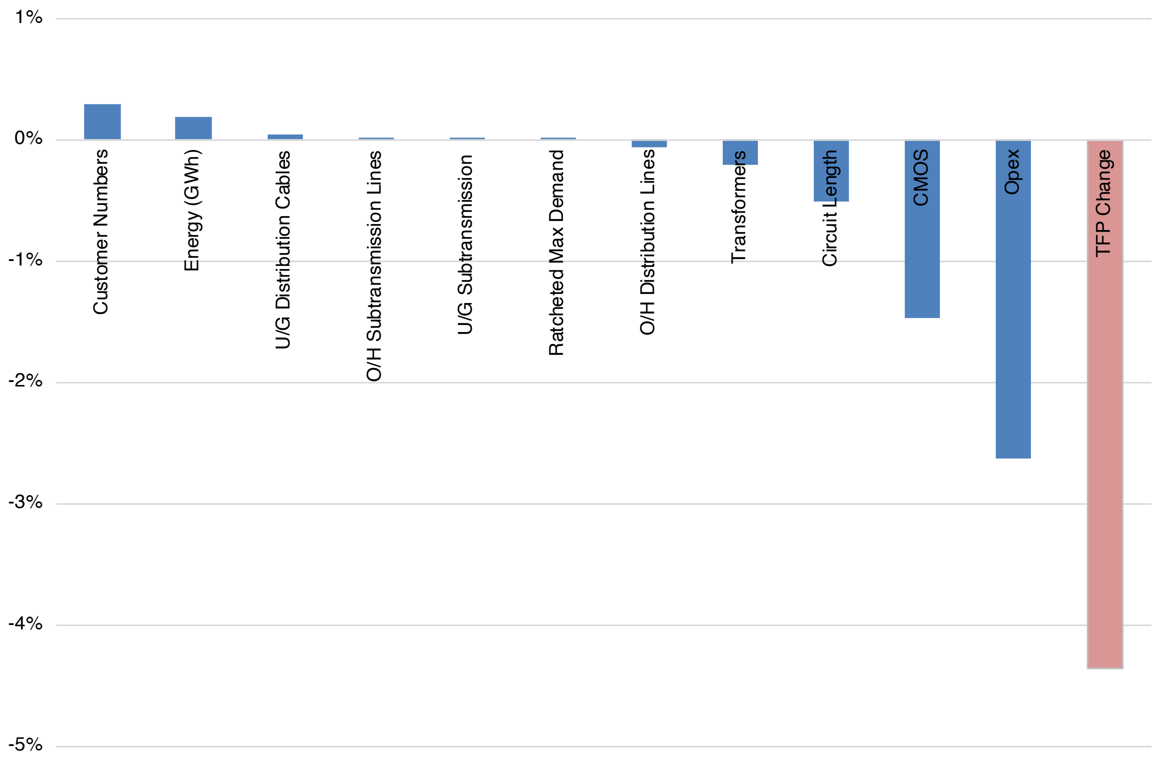
- Opex growth contributed –0.5 percentage points to TAS average TFP growth, compared to –0.2 percentage points for the industry.
- Overhead and underground distribution and subtransmission lines, taken together contributed –0.3 percentage points to TAS TFP change, compared to –0.6 percentage points for the industry. Transformers contributed –0.6 percentage points to TAS's TFP growth rate compared to –0.7 percentage points for the industry.

Figure 4.26 shows the contributions of individual inputs and outputs to TAS's TFP growth from 2020 to 2021 of –4.4 per cent. Deterioration in reliability contributed –1.5 percentage points to TFP growth and an increase in opex contributed –2.6 percentage points.

Table 4.14 TAS output and input percentage point contributions to average annual TFP change: various periods

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2020 to 2021*
Energy (GWh)	0.01%	-0.05%	0.04%	0.19%
Ratcheted Max Demand	0.22%	0.55%	0.00%	0.00%
Customer Numbers	0.25%	0.39%	0.16%	0.29%
Circuit Length	0.21%	0.36%	0.10%	-0.51%
CMOS	-0.49%	-0.97%	-0.16%	-1.47%
Opex	-0.49%	-2.02%	0.52%	-2.63%
O/H Subtransmission Lines	0.00%	0.00%	0.00%	0.01%
O/H Distribution Lines	-0.18%	-0.15%	-0.20%	-0.06%
U/G Subtransmission Cables	-0.02%	-0.03%	-0.01%	0.01%
U/G Distribution Cables	-0.14%	-0.19%	-0.10%	0.04%
Transformers	-0.59%	-1.03%	-0.30%	-0.21%
TFP Change	-1.22%	-3.14%	0.06%	-4.36%

Figure 4.26 TAS output and input percentage point contributions to TFP change, 2021



5 DNSP Outputs, Inputs and Productivity Change

This chapter presents indexes for outputs, inputs and productivity for the remaining 10 NEM DNSPs. Three of the NEM jurisdictions covered in the preceding section have only one DNSP so we have already covered the ACT's Evoenergy, South Australia's SA Power Networks and Tasmania's TasNetworks Distribution.

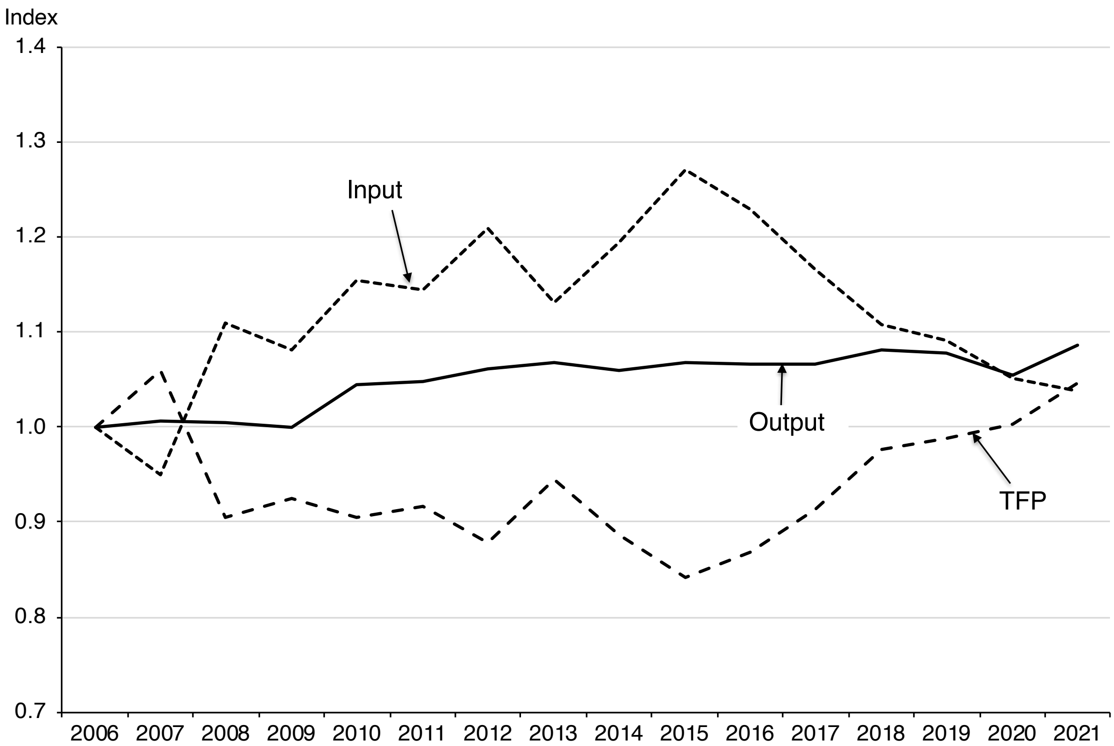
5.1 Ausgrid (AGD)

In 2021, AGD delivered 24,457 GWh to 1.77 million customers over 42,485 circuit kilometres of lines and cables. AGD distributes electricity to the eastern half of Sydney (including the Sydney CBD), the NSW Central Coast and the Hunter region across an area of 22,275 square kilometres. It is the largest of the three NSW DNSPs in terms of customer numbers and energy throughput.

5.1.1 AGD's productivity performance

AGD's total output, total input and TFP indexes are presented in Figure 5.1 and Table 5.1. Opex and capital PFP indexes are also presented in Table 5.1.

Figure 5.1 AGD output, input and total factor productivity indexes, 2006–2021



Over the 16-year period 2006 to 2021, AGD's TFP averaged an annual rate of change of 0.3 per cent. This can be compared to the industry's average annual change of –0.5 per cent over the same period. AGD's total output increased over the same period at an average annual rate of 0.6 per cent. This is lower than the industry average rate of growth in output of 1.0 per cent per annum. AGD's average annual rate of increase in input use of 0.3 per cent was much lower than the rate of increase in total input use for the industry (1.5 per cent per year).

Table 5.1 AGD output, input, TFP and PFP indexes, 2006–2021

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	1.006	0.949	1.060	1.188	0.982
2008	1.004	1.109	0.905	0.834	0.956
2009	0.999	1.082	0.924	0.917	0.926
2010	1.044	1.154	0.905	0.845	0.938
2011	1.048	1.144	0.916	0.888	0.925
2012	1.061	1.210	0.878	0.814	0.908
2013	1.068	1.131	0.944	1.037	0.890
2014	1.060	1.194	0.887	0.923	0.861
2015	1.068	1.270	0.841	0.793	0.863
2016	1.066	1.229	0.868	0.886	0.850
2017	1.066	1.166	0.914	1.002	0.862
2018	1.081	1.108	0.976	1.188	0.873
2019	1.077	1.090	0.988	1.260	0.865
2020	1.054	1.051	1.003	1.389	0.841
2021	1.086	1.038	1.046	1.511	0.862
Growth Rate 2006-2021	0.6%	0.3%	0.3%	2.8%	-1.0%
Growth Rate 2006-2012	1.0%	3.2%	-2.2%	-3.4%	-1.6%
Growth Rate 2012-2021	0.3%	-1.7%	2.0%	6.9%	-0.6%
Growth Rate 2021	3.0%	-1.2%	4.2%	8.4%	2.5%

Over the period from 2006 to 2012, AGD's TFP increased in some years but overall, it *decreased* at an average rate of 2.2 per cent per year. From 2012 to 2021, TFP increased in most years, and on average TFP increased at an annual rate of 2.0 per cent. The TFP increase in 2021 of 4.2 per cent is one of AGN's largest single year increases. During the first part of the sample period, up to 2012, AGD's output increased comparatively strongly at 1.0 per cent per annum, whereas in the later period after 2012, the rate of change of the output index was 0.3 per cent. The effect of changing output trends on TFP was swamped by the much larger movements in input index growth. From 2006 to 2012, the input index increased at an average annual rate of 3.2 per cent, whereas in the period after 2012 the input index fell, averaging an annual rate of –1.7 per cent. The high rate of input growth in the period up to 2012 resulted in a strong rate of decrease in TFP, and the reductions of the input index after 2012 resulted in positive TFP growth.

The PFP indexes in Table 5.1 show that the turnaround from negative to positive average annual rates of change of TFP after 2012 was associated with a reduced rate of decrease in Capital PFP, and a substantial turn-around in Opex PFP trends. The latter's large falls in the period up to 2012, were replaced by strong increases in the period after 2012.

5.1.2 AGD's output and input quantity changes

Figure 5.2 plots the quantity indexes for AGD's individual outputs and Figure 5.3 plots indexes for the six individual inputs. Regarding outputs, in Figure 5.2, we see:

- AGD's circuit length (the output component that receives the largest weight in forming the output index) has increased steadily and by 2021 was 9.7 per cent above the 2006 level (which is higher than the increase of 5.2 per cent, for the industry over the 16-year period).
- AGD's energy throughput decreased at a greater rate than for the industry. In 2021, AGD's energy throughput was 18.8 per cent below its 2006 level compared to the industry's throughput then being 4.8 per cent less than it was in 2006.
- RMD increased though to 2011, in total by 7.3 per cent, and remained constant thereafter. Although maximum demand reduced considerably after 2011, it increased after 2015 despite flat energy demand, but did not reach its 2011 level.
- AGD's customers increased by 14.7 per cent in total between 2006 and 2021, which is less than the increase in customers for the industry over the same period (22.0 per cent in total, or 1.3 per cent per year).
- CMOS in 2021 was 6.8 per cent lower than in 2006. This decrease is comparable to the decrease of 11.4 per cent for the industry over the same period.

With regard to input movements, in Figure 5.3:

- Over the 16-year period to 2021, opex input decreased in total by 28.1 per cent. This compares favourably to the total increase of 8.7 per cent for the industry over the same period.
- Overhead sub-transmission and distribution lines in 2021, compared to 2006, were 3.3 per cent lower and 5.0 per cent higher respectively (compared to 14.4 per cent and 13.6 per cent increases, respectively, for the industry over the same period).
- Underground sub-transmission and distribution cables were, in 2021, 6.8 and 33.9 per cent higher than in 2006 respectively (compared to increases of 37.6 per cent and 68.6 per cent respectively for the industry over the same period).
- AGD's quantity of transformers increased strongly over the period from 2006 to 2012, and more slowly in the period from 2012 to 2021. By 2021, transformer inputs were

36.1 per cent above the 2006 level, which is a smaller increase than the industry's 42.2 per cent.

Figure 5.2 AGD output quantity indexes, 2006–2021

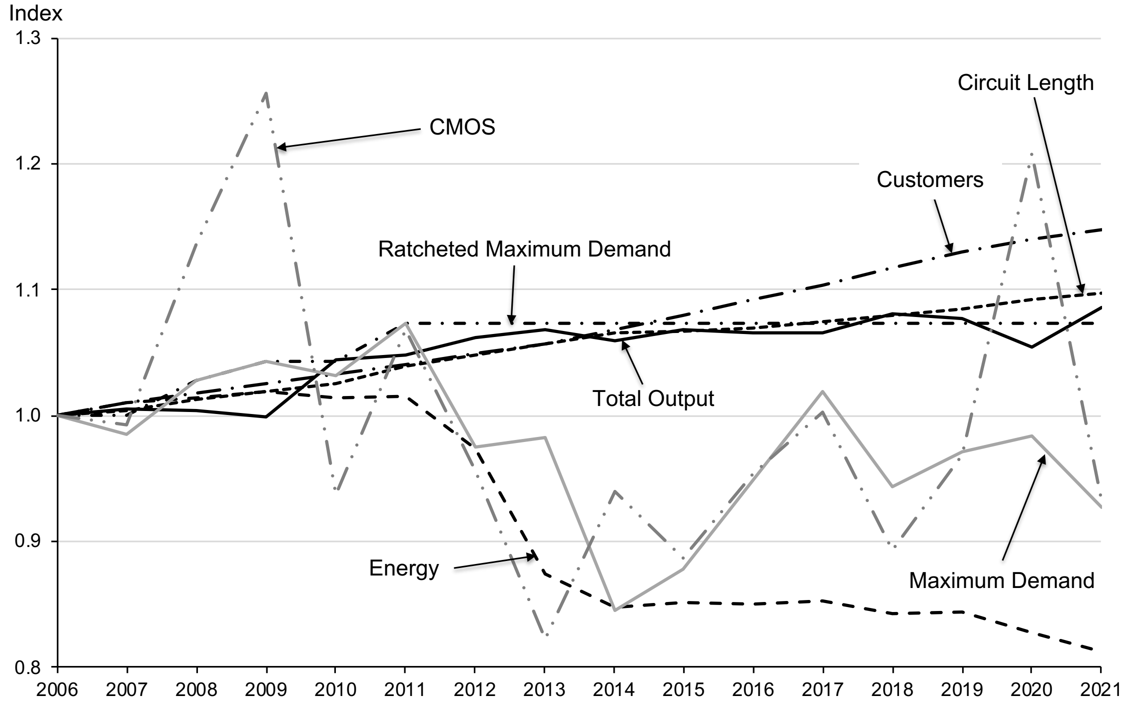
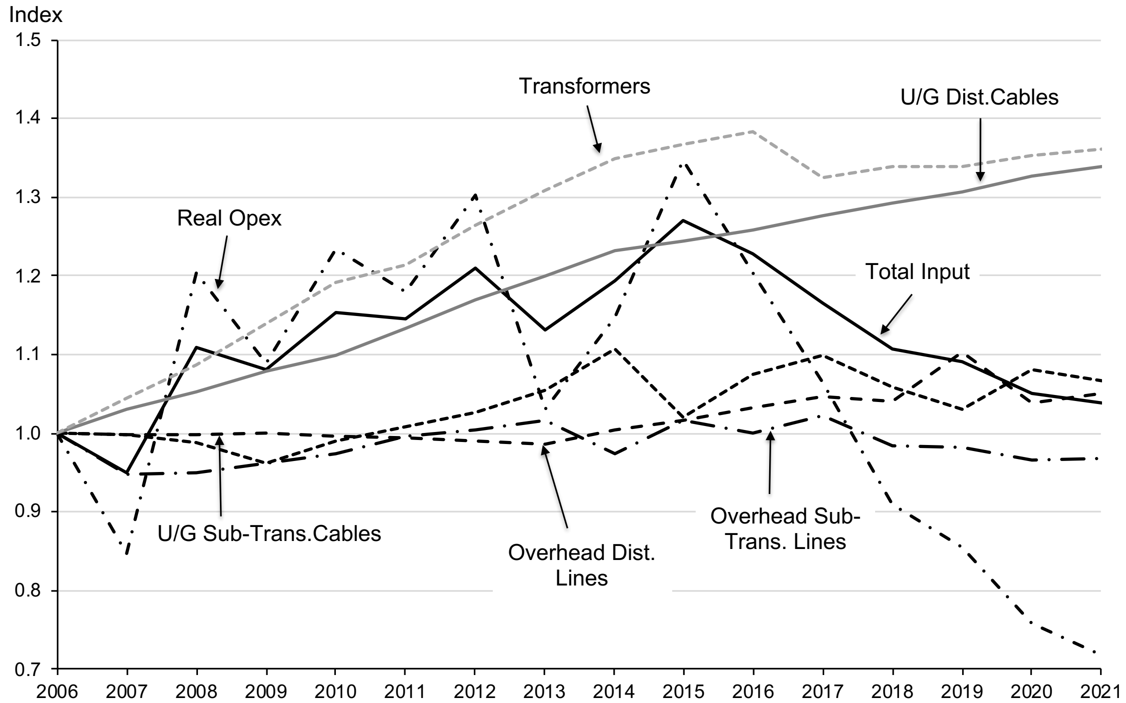


Figure 5.3 AGD input quantity indexes, 2006–2021



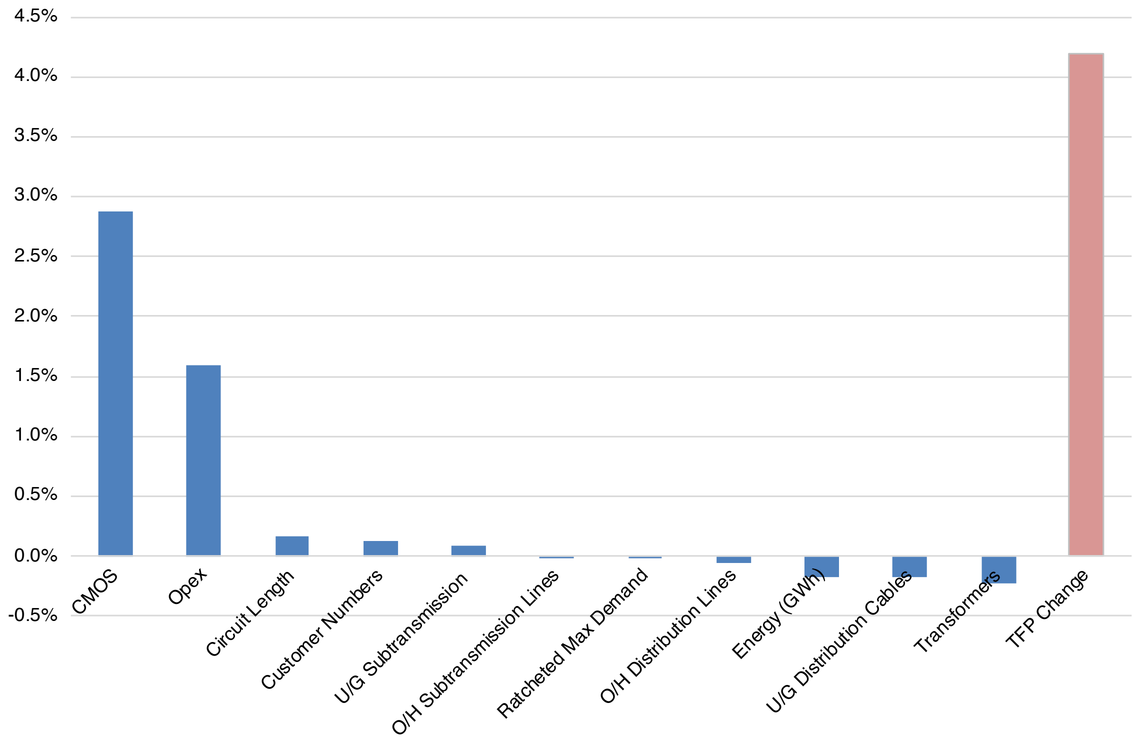
5.1.3 AGD's output and input contributions to TFP change

Table 5.2 shows the decomposition of AGD's rate of TFP change into the contributions of the individual outputs and inputs for the whole 16-year period, for the periods up to and after 2012, and for 2021. Figure 5.4 shows the contributions of outputs and inputs to AGD's rate of TFP change in 2021.

Table 5.2 AGD output and input percentage point contributions to average annual TFP change: various periods

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2020 to 2021*
Energy (GWh)	-0.13%	-0.05%	-0.19%	-0.17%
Ratcheted Max Demand	0.18%	0.44%	0.00%	-0.01%
Customer Numbers	0.19%	0.17%	0.20%	0.12%
Circuit Length	0.27%	0.35%	0.21%	0.17%
CMOS	0.05%	0.08%	0.03%	2.88%
Opex	0.71%	-1.62%	2.26%	1.59%
O/H Subtransmission Lines	0.01%	0.00%	0.02%	0.00%
O/H Distribution Lines	-0.02%	0.01%	-0.04%	-0.06%
U/G Subtransmission Cables	-0.03%	-0.02%	-0.03%	0.08%
U/G Distribution Cables	-0.28%	-0.35%	-0.24%	-0.18%
Transformers	-0.63%	-1.19%	-0.27%	-0.23%
TFP Change	0.30%	-2.18%	1.95%	4.19%

Figure 5.4 AGD output and input percentage point contributions to TFP change in 2021



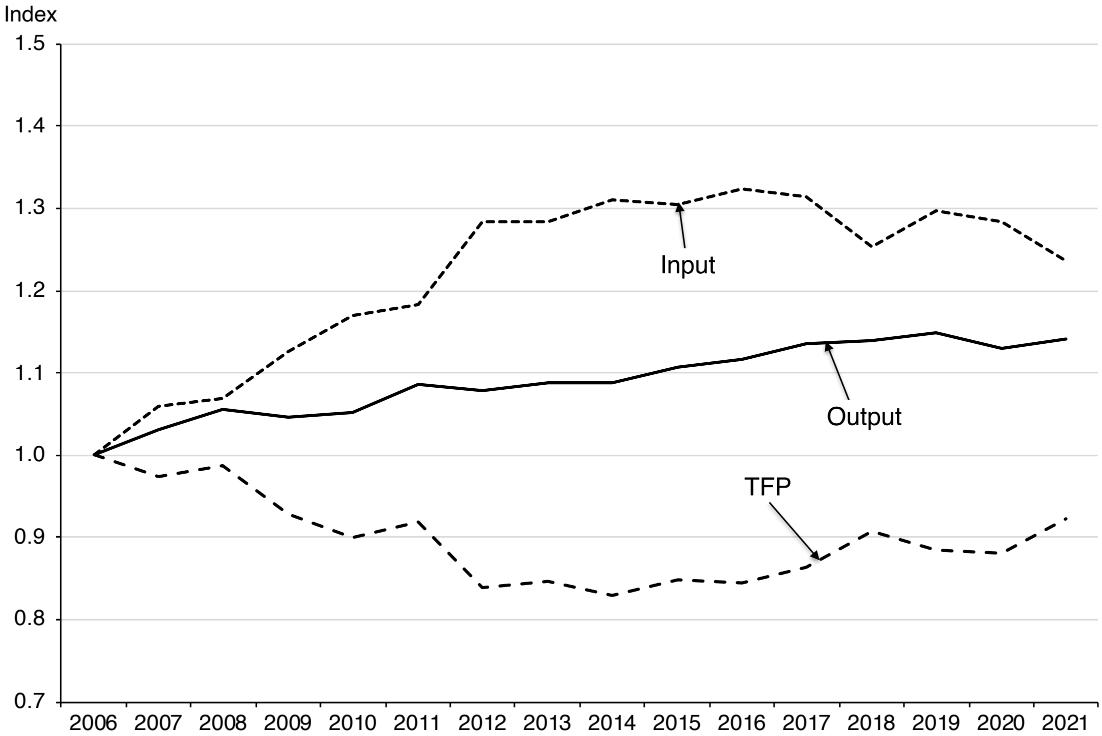
5.2 CitiPower (CIT)

In 2021, CIT delivered 5,124 GWh to 346,855 customers over 4,583 circuit kilometres of lines and cables. CIT is the smallest of the Victorian DNSPs (in terms of customer numbers) and covers central Melbourne, including the Melbourne CBD.

5.2.1 CIT's productivity performance

CIT's total output, total input and TFP indexes are presented in Figure 5.5 and Table 5.3. Opex and capital PFP indexes are also presented in Table 5.3.

Figure 5.5 CIT's output, input and TFP indexes, 2006–2021



Over the 16-year period 2006 to 2021, CIT's TFP *decreased* at an average annual rate of 0.6 per cent, which is similar to the industry's average annual TFP change of –0.5 per cent over the same period. CIT's total output increased over the 16-year period at an average annual rate of 0.9 per cent, which is similar to the industry (1.0 per cent per year). CIT's average annual rate of increase in input use of 1.5 per cent was the same as for the industry.

The decrease in TFP mostly occurred in the period from 2006 to 2012 and was associated with a large increase in input use, averaging a 4.2 per cent increase per year over this period. TFP *decreased* at average annual rate of 2.9 per cent over this period. Input use stabilised in the period 2012 to 2021, with an average annual rate of change of –0.4 per cent, and average TFP growth in this period was 1.1 per cent per annum.

Table 5.3 CIT's output, input, TFP and PFP indexes, 2006–2021

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	1.032	1.059	0.974	0.903	0.997
2008	1.057	1.070	0.988	0.972	0.994
2009	1.047	1.126	0.929	0.816	0.970
2010	1.053	1.169	0.901	0.756	0.954
2011	1.087	1.182	0.919	0.840	0.947
2012	1.078	1.284	0.839	0.661	0.916
2013	1.087	1.283	0.847	0.691	0.911
2014	1.087	1.310	0.830	0.675	0.893
2015	1.106	1.304	0.848	0.713	0.901
2016	1.116	1.323	0.844	0.708	0.897
2017	1.136	1.314	0.864	0.747	0.907
2018	1.138	1.254	0.908	0.866	0.921
2019	1.148	1.297	0.885	0.778	0.924
2020	1.130	1.283	0.881	0.813	0.903
2021	1.142	1.237	0.923	0.946	0.910
Growth Rate 2006-2021	0.9%	1.5%	-0.6%	-0.4%	-0.7%
Growth Rate 2006-2012	1.2%	4.2%	-2.9%	-6.9%	-1.5%
Growth Rate 2012-2021	0.7%	-0.4%	1.1%	4.2%	-0.1%
Growth Rate 2021	2.0%	-7.3%	9.2%	30.3%	1.3%

The PFP indexes in Table 5.3 show that:

- The PFP of capital inputs has *declined* at an average rate of 0.7 per cent per year from 2006 to 2021. The rate of decline was strongest in the period up to 2012 and was only marginal in the period after 2012.
- The PFP of opex input declined particularly strongly in the period up to 2012, at average annual rate of –6.9 per cent, whereas it increased at an average rate of 4.2 per cent per annum from 2012 to 2021.

5.2.2 CIT's output and input quantity changes

Figure 5.6 graphs the quantity indexes for CIT's individual outputs. Figure 5.7 graphs quantity indexes for its six individual inputs.

Regarding outputs in Figure 5.6:

- CIT's circuit length has increased steadily and by 2021 was 16.0 per cent above the 2006 level (higher than the increase of 5.2 per cent for the industry over the same period).

- CIT's energy throughput decreased over the 16-year period at a faster rate than for the industry, and in 2021, CIT's energy throughput was 14.2 per cent below its 2006 level (compared to a 4.8 per cent reduction for the industry).
- RMD increased from 2006 through to 2009 by 10.4 per cent in total and further increased from 2017 to 2020, despite the strong decline in energy throughput. By 2021 RMD was 17.5 per cent above its 2006 level which is similar to the industry as a whole (an 18.1 per cent increase over the same period).
- CIT's customers increased at an average rate of 1.1 per cent per annum from 2006 to 2021, or 17.6 per cent in total, which is slightly lower than the rate of customer growth for the industry over the same period.
- CMOS in 2021 was 4.8 per cent higher than in 2006. The compares unfavourably to the industry total change of –11.4 per cent over the same period.

Turning to inputs shown in Figure 5.7, we see:

- The quantity of CIT's opex increased at an average annual rate of 8.1 per cent (or 63.0 per cent in total) over the period from 2006 to 2012. Opex input subsequently declined over the period from 2012 to 2021, averaging –3.5 per cent per annum. In 2021, opex was 20.6 per cent above its 2006 level. This compares unfavourably to the total increase of 8.7 per cent for the industry over the same period.
- Overhead sub-transmission and distribution lines in 2021 were 1.9 per cent higher and 9.1 per cent *lower* respectively, than in 2006 (compared with increases of 14.4 per cent and 13.6 per cent respectively for the industry over the same period).
- Underground sub-transmission and distribution cables in 2021, were 87.5 and 25.9 per cent higher than in 2006 respectively (compared to increases of 37.6 per cent and 68.6 per cent respectively for the industry over the same period).
- CIT's quantity of transformers increased steadily over most of the 16-year period and by 2021, transformer inputs were 23.4 per cent above the 2006 level, a smaller increase than the industry's 42.2 per cent.

Figure 5.6 CIT's output quantity indexes, 2006–2021

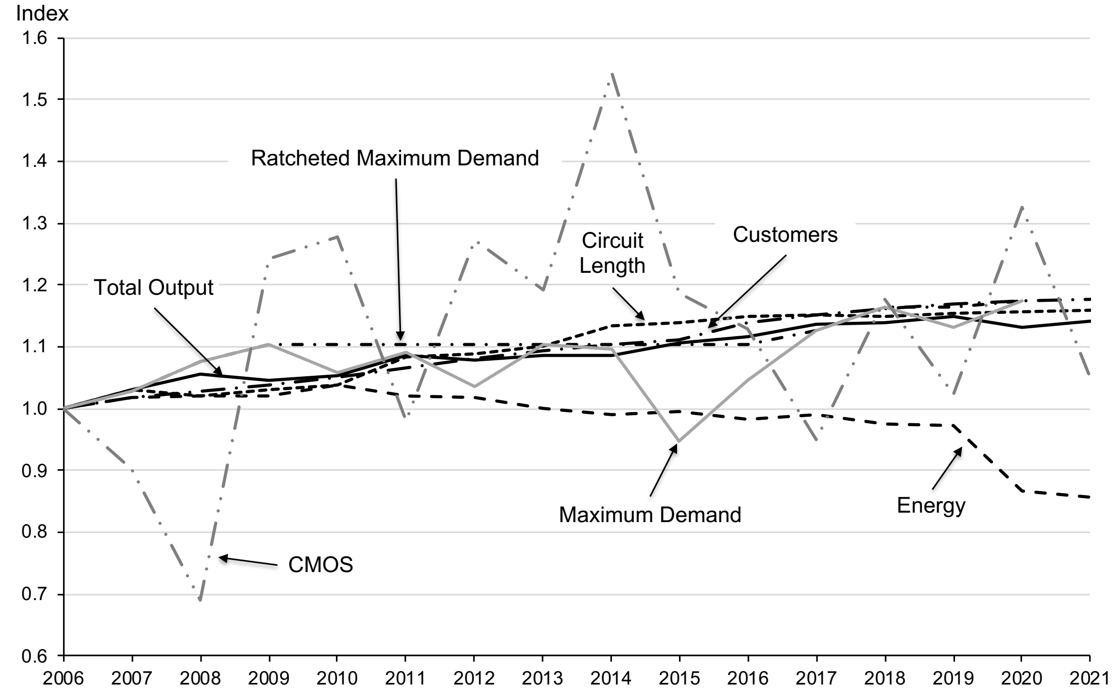
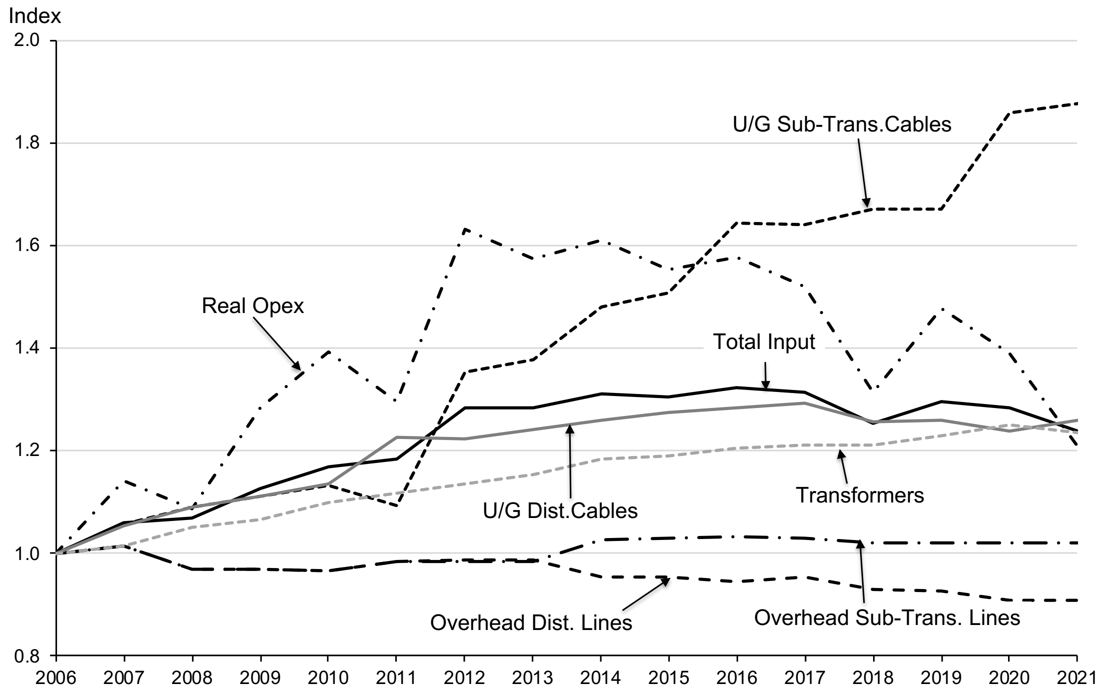


Figure 5.7 CIT's input quantity indexes, 2006–2021



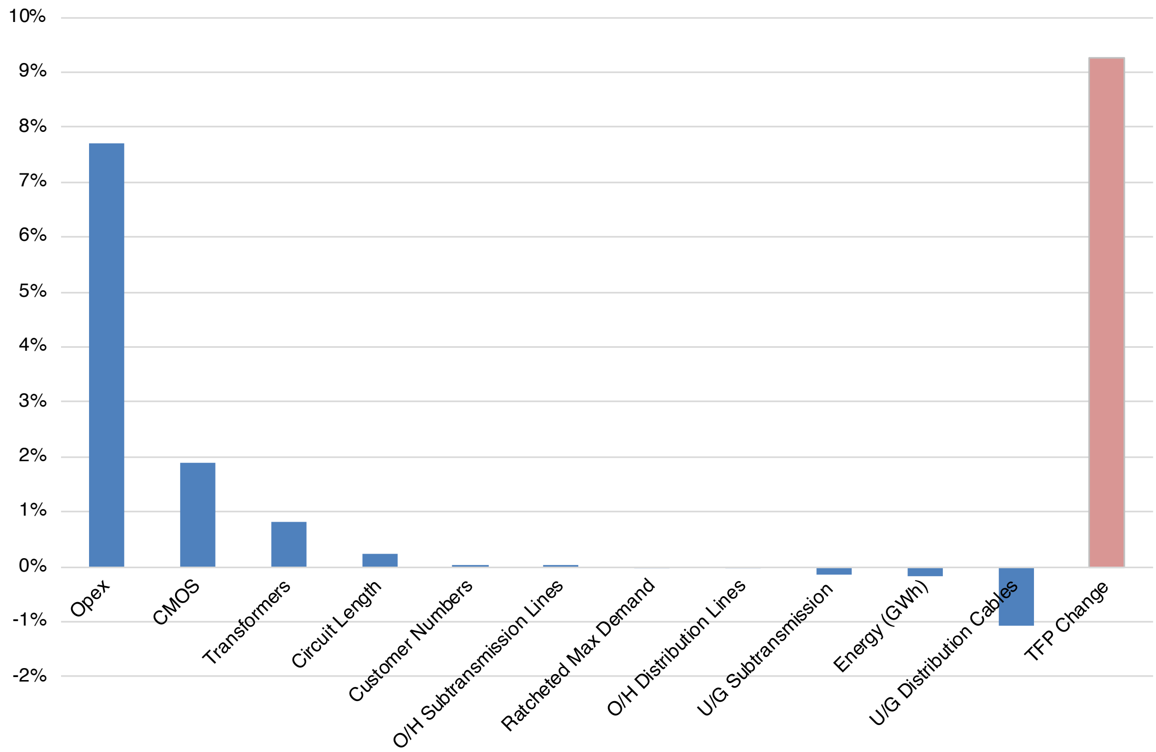
5.2.3 CIT's output and input contributions to TFP change

Table 5.4 shows the decomposition of CIT's rate of TFP change into the contributions of the individual outputs and inputs for the whole 16-year period, for the periods up to and after 2012, and for 2021. Figure 5.8 shows the contributions of outputs and inputs to CIT's rate of TFP change in 2021.

Table 5.4 CIT's output and input percentage point contributions to average annual TFP change: various periods

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2020 to 2021*
Energy (GWh)	-0.10%	0.03%	-0.18%	-0.19%
Ratcheted Max Demand	0.38%	0.58%	0.24%	-0.01%
Customer Numbers	0.21%	0.25%	0.18%	0.04%
Circuit Length	0.41%	0.58%	0.30%	0.23%
CMOS	0.05%	-0.19%	0.21%	1.90%
Opex	-0.03%	-2.13%	1.37%	7.70%
O/H Subtransmission Lines	0.00%	0.00%	0.00%	0.00%
O/H Distribution Lines	0.04%	0.01%	0.06%	-0.02%
U/G Subtransmission Cables	-0.28%	-0.33%	-0.25%	-0.14%
U/G Distribution Cables	-0.55%	-1.13%	-0.17%	-1.07%
Transformers	-0.35%	-0.59%	-0.19%	0.80%
TFP Change	-0.23%	-2.92%	1.57%	9.25%

Figure 5.8 CIT's output and input percentage point contributions to TFP change, 2021



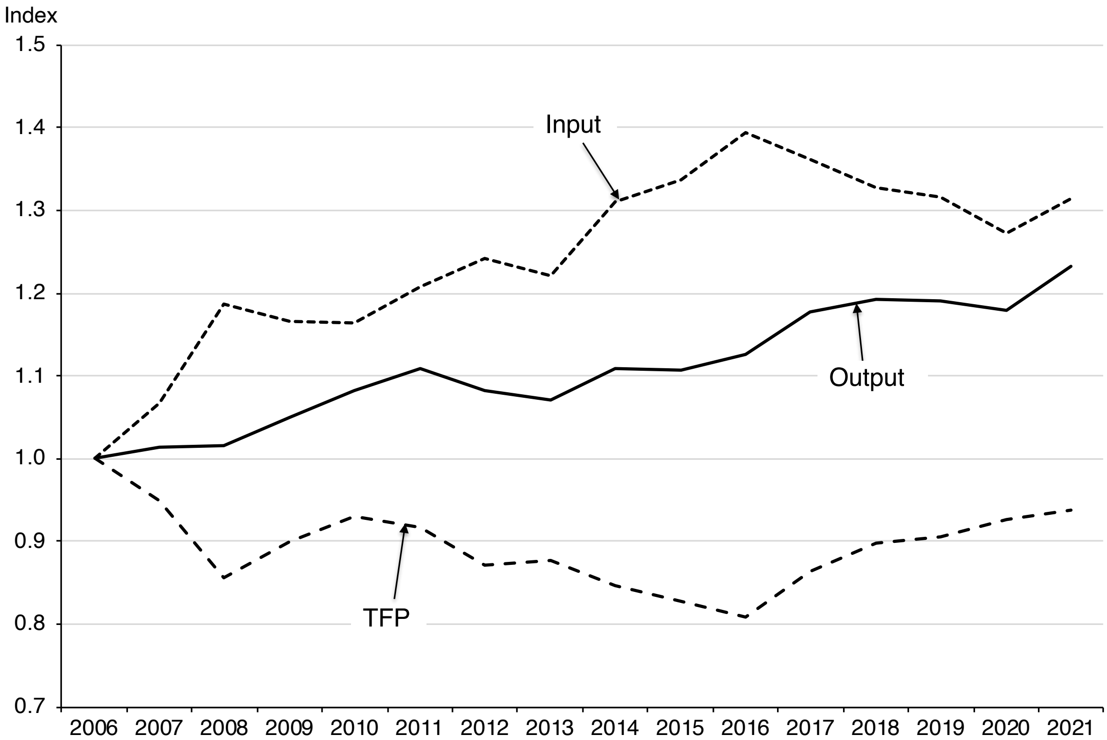
5.3 Endeavour Energy (END)

In 2021, END delivered 16,717 GWh to 1.07 million customers over 39,146 circuit kilometres of lines and cables. END distributes electricity to Sydney's Greater West, the Blue Mountains, Southern Highlands, the Illawarra and the South Coast regions of NSW. It is the second largest of the three NSW DNSPs in terms of customer numbers and energy throughput.

5.3.1 END's productivity performance

END's total output, total input and TFP indexes are presented in Figure 5.9 and Table 5.5. Opex and capital PFP indexes are also presented in Table 5.5.

Figure 5.9 END's output, input and TFP indexes, 2006–2021



Over the 16-year period 2006 to 2021, END's TFP *decreased* at an average annual rate of 0.4 per cent, which is similar to the industry's average annual change of –0.5 per cent over the same period. END's total output increased over the same period at an average annual rate of 1.4 per cent, which higher than the industry average rate of output growth of 1.0 per cent per annum. END's average annual rate of increase in input use of 1.8 per cent is also higher than the industry's rate of increase in total input use of 1.5 per cent per year. END's TFP had an overall declining trend up to 2016 but has since increased steadily. Over the period from 2006 to 2012, the average annual rate of TFP change was –2.3 per cent, and over the period from 2012 to 2021 the average annual rate of TFP change was 0.8 per cent. Again, these trends are broadly similar to those for the industry as a whole.

The rate of output growth in the periods before and after 2012 were similar, whereas the rate of growth of input usage was much higher in the period 2006 to 2012 (averaging 3.6 per cent per year) than in the period 2012 to 2021 (averaging 0.6 per cent per year). The large change in input growth explains the turn-around in the TFP trend.

The PFP indexes in Table 5.5 show the following trends:

- Capital PFP *declined* at an average rate of 1.4 per cent per year over the 16-year period. The rate of decline was greater in the period up to 2012 (–2.3 per cent), but decline continued in the period after 2012 (–0.8 per cent).
- Opex PFP increased on average over the 16-year period (averaging 1.1 per cent per year), but this covers very different trends in the period up to 2012 (with an average annual rate of –2.3 per cent) and after 2012 (with an average increase of 3.4 per cent per annum).

Table 5.5 END’s output, input, TFP and PFP indexes, 2006–2021

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	1.014	1.068	0.949	0.940	0.959
2008	1.015	1.187	0.856	0.771	0.922
2009	1.049	1.166	0.900	0.869	0.924
2010	1.082	1.164	0.929	0.933	0.923
2011	1.108	1.208	0.917	0.908	0.920
2012	1.082	1.242	0.872	0.873	0.869
2013	1.071	1.221	0.877	0.965	0.827
2014	1.109	1.310	0.847	0.884	0.823
2015	1.107	1.336	0.829	0.861	0.808
2016	1.125	1.393	0.808	0.815	0.804
2017	1.177	1.361	0.865	0.930	0.824
2018	1.193	1.328	0.898	1.034	0.819
2019	1.191	1.316	0.906	1.093	0.803
2020	1.179	1.272	0.927	1.212	0.785
2021	1.232	1.314	0.937	1.187	0.807
Growth Rate 2006-2021	1.4%	1.8%	-0.4%	1.1%	-1.4%
Growth Rate 2006-2012	1.3%	3.6%	-2.3%	-2.3%	-2.3%
Growth Rate 2012-2021	1.4%	0.6%	0.8%	3.4%	-0.8%
Growth Rate 2021	4.3%	3.3%	1.1%	-2.0%	2.7%

5.3.2 END’s output and input quantity changes

Figure 5.10 graphs the quantity indexes for END’s individual outputs. Figure 5.11 graphs quantity indexes for its six individual inputs.

Regarding outputs in Figure 5.10:

- END’s circuit length has increased steadily and by 2021 was 20.7 per cent above the 2006 level (compared to a 5.2 per cent increase for the industry over the same period).
- END’s energy throughput decreased marginally over the 16-year period, following a similar pattern to the industry. In 2021, END’s energy throughput was 2.8 per cent below its level in 2006 (compared to a total decrease of 4.8 per cent for the industry over the same period).
- RMD increased from 2006 through to 2011 by 10.1 per cent in total and then increased further in 2017, so that by 2021, RMD was 15.0 per cent above its 2006 level. This pattern is similar to the industry as a whole (an increase of 18.1 per cent in RMD over the same period), reflecting an increase in the ratio of maximum demand to energy throughput in recent years.
- END’s customers increased at an average rate of 1.5 per cent per annum from 2006 to 2021, or 25.6 per cent in total, which is similar to the rate of customer growth for the industry (22.0 per cent in total over the same period).
- CMOS’s annual growth rate in 2021 was –26.5 per cent, and in that year, CMOS was 16.6 per cent lower than in 2006. This decrease between 2006 to 2021 was greater than that for the industry (–11.4 per cent total change) over the same period, although CMOS for individual DNSPs is usually volatile. Recall that a reduction in CMOS increases output.

Turning to inputs shown in Figure 5.11, we see:

- The quantity of END’s opex input increased at an average annual rate of 0.2 per cent over the period from 2006 to 2021, or 3.7 per cent in total over that period. This compares favourably to the industry, for which opex input increased by 8.7 per cent in total over the same period. END’s opex increased in the period 2006 to 2012 (averaging 3.6 per cent per annum), substantially offset by a decrease after 2012 (at an average rate of –2.0 per cent per annum).
- Overhead subtransmission and distribution lines in 2021 were decreased from 2006, being 1.0 and 3.8 per cent *lower* respectively. This contrasts with the industry total increases in these two inputs of 14.4 per cent and 13.6 per cent respectively over the same period.
- END’s underground subtransmission and distribution cables inputs in 2021 were 129.6 and 123.9 per cent higher than in 2006 respectively. These increases are much higher than those for the industry as a whole for these two inputs (37.6 per cent and 68.6 per cent respectively).
- END’s quantity of transformers increased steadily over the 16-year period at an average annual rate of 2.7 per cent, and by 2021 transformer inputs were 49.3 per cent above the 2006 level, which is a larger increase than the industry’s 42.2 per cent.

Figure 5.10 END's output quantity indexes, 2006–2021

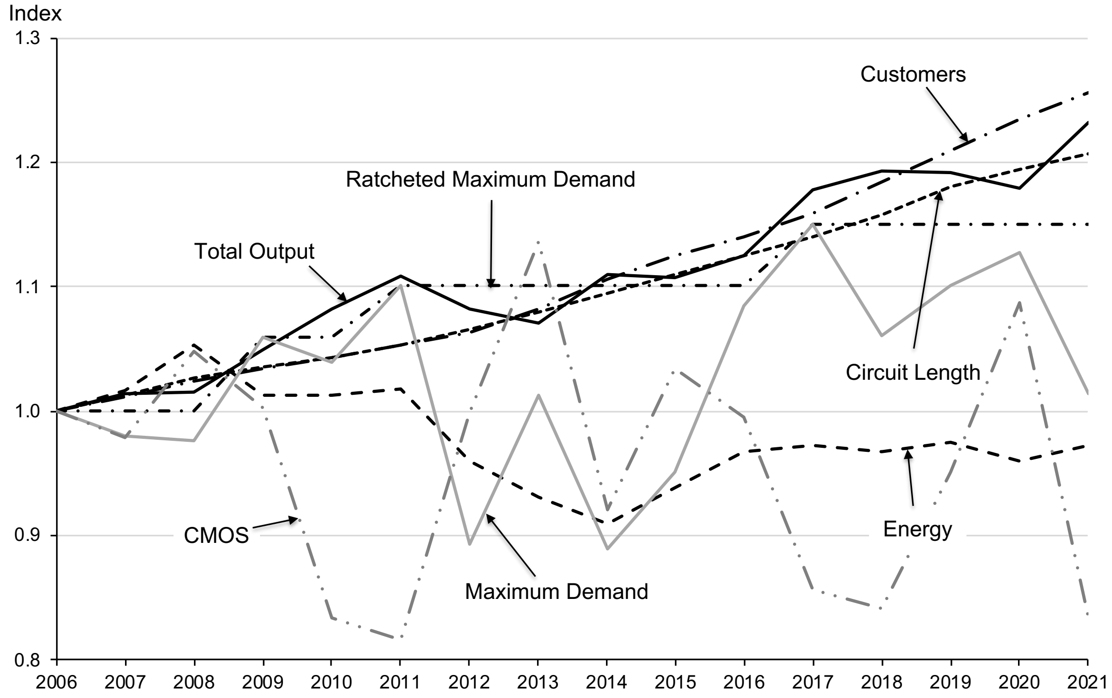
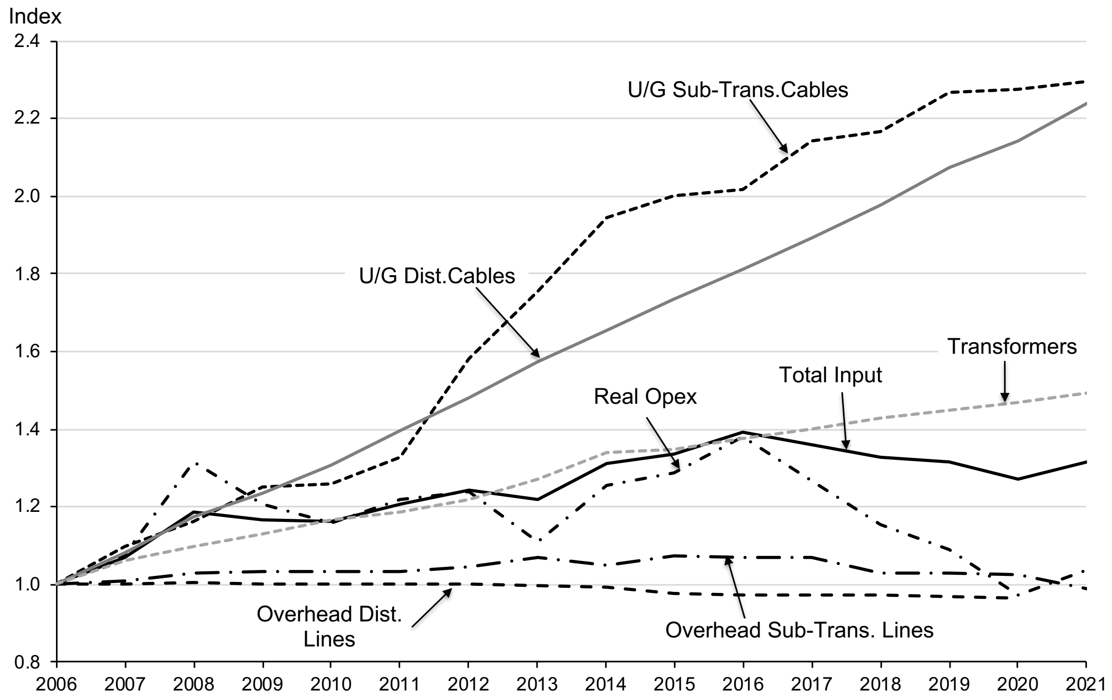


Figure 5.11 END's input quantity indexes, 2006–2021



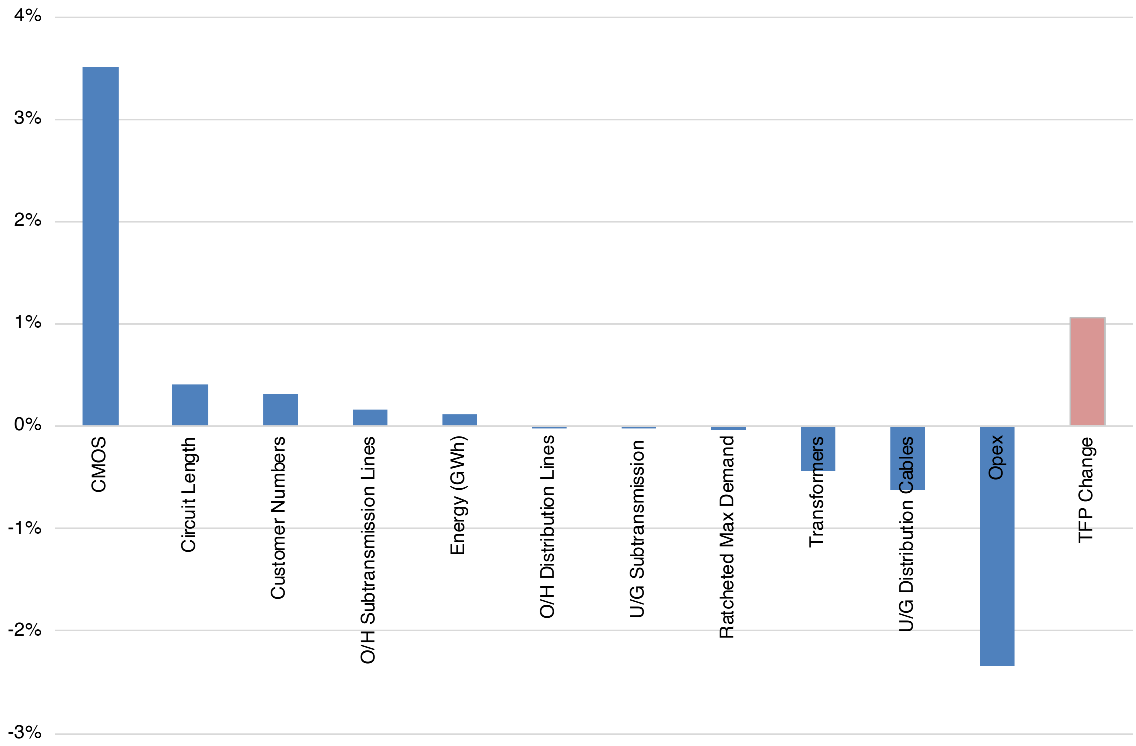
5.3.3 END's output and input contributions to TFP change

Table 5.6 shows the decomposition of END's rate of TFP change into the contributions of the individual outputs and inputs for the whole 16-year period, for the periods up to and after 2012, and for 2021. Figure 5.12 shows the contributions of outputs and inputs to END's rate of TFP change in 2021.

Table 5.6 END's output and input percentage point contributions to average annual TFP change: various periods

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2020 to 2021*
Energy (GWh)	-0.02%	-0.07%	0.01%	0.12%
Ratcheted Max Demand	0.36%	0.63%	0.18%	-0.03%
Customer Numbers	0.32%	0.23%	0.38%	0.32%
Circuit Length	0.56%	0.49%	0.61%	0.41%
CMOS	0.16%	0.03%	0.25%	3.50%
Opex	-0.11%	-1.41%	0.77%	-2.35%
O/H Subtransmission Lines	0.01%	-0.03%	0.03%	0.16%
O/H Distribution Lines	0.02%	0.00%	0.04%	0.00%
U/G Subtransmission Cables	-0.10%	-0.14%	-0.08%	-0.01%
U/G Distribution Cables	-0.88%	-1.08%	-0.74%	-0.62%
Transformers	-0.76%	-0.94%	-0.64%	-0.44%
TFP Change	-0.43%	-2.29%	0.81%	1.07%

Figure 5.12 END's output and input percentage point contributions to TFP change, 2021



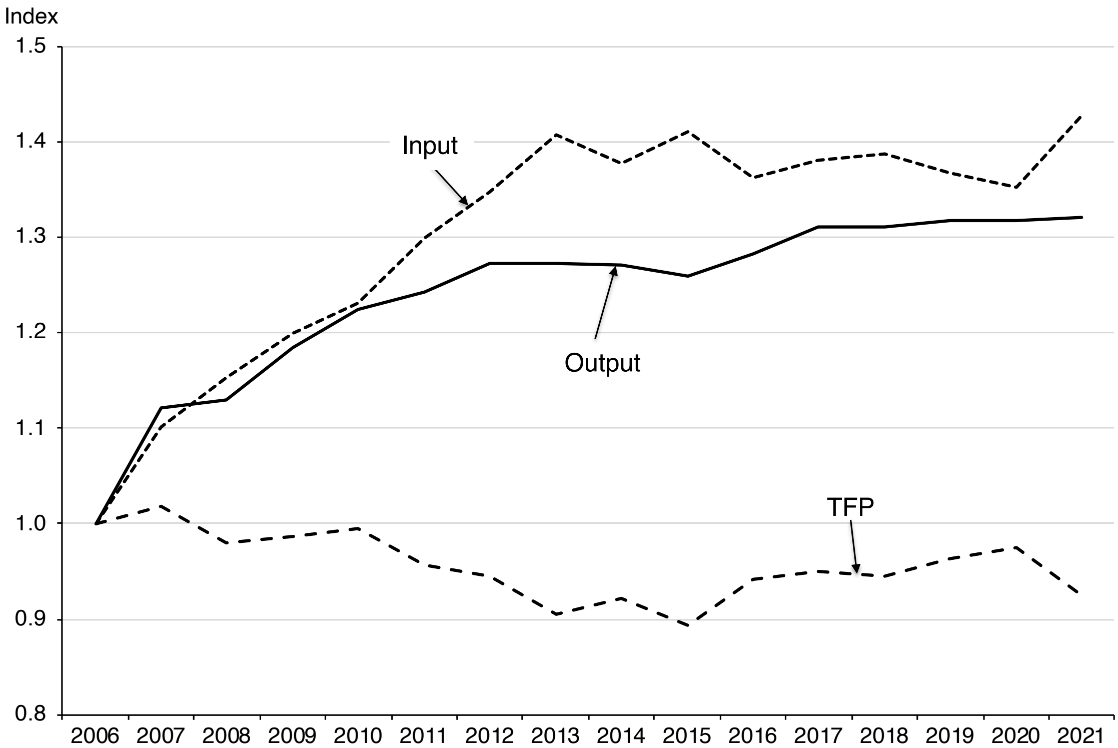
5.4 Energex (ENX)

In 2021, ENX delivered 21,133 GWh to 1.54 million customers over 55,530 circuit kilometres of lines and cables. ENX distributes electricity in South East Queensland including the major urban areas of Brisbane, Gold Coast, Sunshine Coast, Logan, Ipswich, Redlands and Moreton Bay. ENX's electricity distribution area runs from the NSW border north to Gympie and west to the base of the Great Dividing Range. It is the second largest DNSP in the NEM in terms of customer numbers and energy throughput.

5.4.1 ENX's productivity performance

ENX's total output, total input and TFP indexes are presented in Figure 5.13 and Table 5.7. Opex and capital PFP indexes are also presented in Table 5.7.

Figure 5.13 ENX's output, input and TFP indexes, 2006–2021



Over the whole period from 2006 to 2021, ENX's TFP *decreased* at an annual rate of 0.5 per cent. This is the same as the industry's average annual change over the same period. As Figure 5.13 shows, ENX's TFP decreased significantly in the period from 2006 to 2012, on average at –0.9 per cent per year, and decreased more slowly in the period from 2012 to 2021, an average growth rate of –0.2 per cent per year. This differs from the industry average TFP trends, which deteriorated at a higher rate in the period up to 2012 and saw TFP growth in the period after 2012.

While for many DNSPs, shifts in trends on the input side were the major influence on shifts in TFP trends, for ENX there were important changes in both output and input trends before and after 2012. ENX's total output increased at an average rate of 4.0 per cent per annum up to 2012, reducing to 0.4 per cent per annum after 2012. The average output growth of 1.9 per cent per annum over the whole 16-year period is considerably higher than that for the industry of 1.0 per cent per annum. ENX's inputs increased at an average rate of 5.0 per cent per annum over the period from 2006 to 2012, and by 0.6 per cent per annum from 2012 to 2021. The average rate of increase in inputs of 2.4 per cent per annum over the 16-year period is also much higher than the industry's average input increase of 1.5 per cent per annum. These output and input trends resulted in ENX's TFP trends previously discussed.

The PFP indexes in Table 5.7 show the following trends:

- Capital PFP declined on average by 0.6 per cent per year from 2006 to 2021, although this decline has been concentrated in the period after 2012.
- Opex PFP declined in the period up to 2012, averaging an annual rate of –2.7 per cent, whereas it increased at a rate of 1.3 per cent per annum after 2012. On average over the full period, opex PFP averaged an annual rate of change of –0.3 per cent.

Table 5.7 ENX's output, input, TFP and PFP indexes, 2006–2021

Year	*Output*	*Input*	*TFP*	*PFP Index*	
	Index	*Index*	*Index*	*Opex*	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	1.121	1.101	1.018	0.964	1.050
2008	1.129	1.152	0.980	0.932	1.010
2009	1.184	1.199	0.987	0.941	1.014
2010	1.223	1.231	0.994	0.961	1.013
2011	1.243	1.298	0.957	0.889	0.998
2012	1.273	1.347	0.945	0.850	0.999
2013	1.272	1.406	0.905	0.794	0.977
2014	1.271	1.378	0.922	0.864	0.959
2015	1.259	1.410	0.893	0.839	0.924
2016	1.283	1.363	0.941	0.961	0.930
2017	1.311	1.380	0.950	0.978	0.936
2018	1.310	1.388	0.944	0.974	0.927
2019	1.317	1.367	0.963	1.037	0.924
2020	1.317	1.352	0.975	1.095	0.912
2021	1.321	1.427	0.925	0.954	0.907
Growth Rate 2006-2021	1.9%	2.4%	-0.5%	-0.3%	-0.6%
Growth Rate 2006-2012	4.0%	5.0%	-0.9%	-2.7%	0.0%
Growth Rate 2012-2021	0.4%	0.6%	-0.2%	1.3%	-1.1%
Growth Rate 2021	0.3%	5.5%	-5.2%	-13.8%	-0.5%

5.4.2 ENX's output and input quantity changes

Figure 5.14 graphs the quantity indexes for ENX's individual outputs. Figure 5.15 graphs quantity indexes for its six individual inputs.

Regarding outputs in Figure 5.14:

- ENX's circuit length output increased in total by 19.0 per cent between 2006 to 2021 (which is higher than the industry increase of 5.2 per cent over the same period).
- ENX's energy throughput increased marginally over the 16-year period, by 2.5 per cent in total from 2006 to 2021 (compared to a decline of 4.8 per cent for the industry over the same period).
- On average ENX's RMD increased considerably up to 2010 but remained constant for most subsequent years except for a small further increase in 2020. In 2021 it was 26.3 per cent above its level in 2006. This is a larger increase than for the industry as a whole (18.1 per cent over the same period).
- ENX's customers output increased by 26.7 per cent in total from 2006 to 2021, or 1.6 per cent per year, which is slightly higher than industry customer growth (22.0 per cent in total, or 1.3 per cent per annum).
- CMOS *decreased* over the 16-year period 2006 to 2021 by 26.6 per cent in total. This compares favourably to the industry average decrease in CMOS of 11.4 per cent, and thus represents an above average improvement in reliability by ENX.

Turning to inputs shown in Figure 5.15, we see:

- The quantity of ENX's opex increased at an average annual rate of 2.2 per cent from 2006 to 2021. This average is affected by a particularly large 14.0 per cent increase in opex input in 2021. In 2021 opex input was 38.5 per cent above its 2006 level. This compares unfavourably to the industry, for which opex input increased by 8.7 per cent in total over the same period.
- Overhead sub-transmission and distribution lines in 2021 were 22.4 per cent and 2.7 per cent higher respectively, than in 2006 (compared to the industry increases of 14.4 per cent and 13.6 per cent respectively over the same period).
- ENX's underground sub-transmission and distribution cables in 2021 were 97.1 and 86.1 per cent higher than in 2006 respectively (compared to increases of 37.6 per cent and 68.6 per cent respectively for the industry as a whole over the same period).
- ENX's quantity of transformer inputs increased strongly over the 16-year period at an average annual rate of 2.7 per cent, and by 2021 transformer inputs were 49.3 per cent above the 2006 level; a larger increase than the industry's 42.2 per cent.

Figure 5.14 ENX's output quantity indexes, 2006–2021

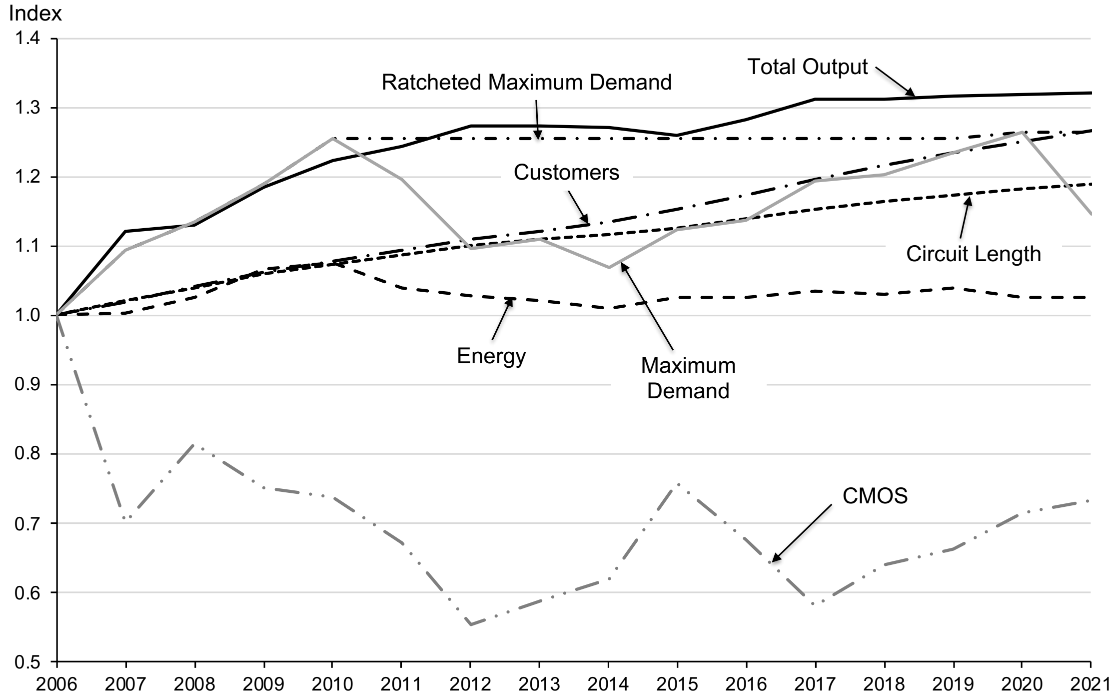
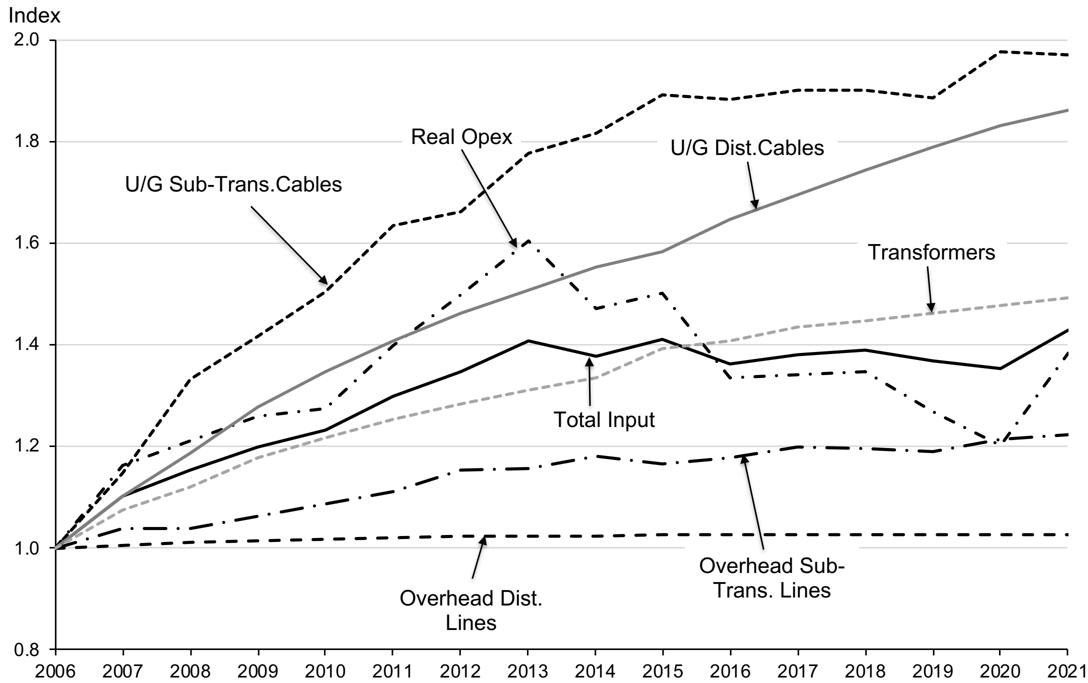


Figure 5.15 ENX's input quantity indexes, 2006–2021



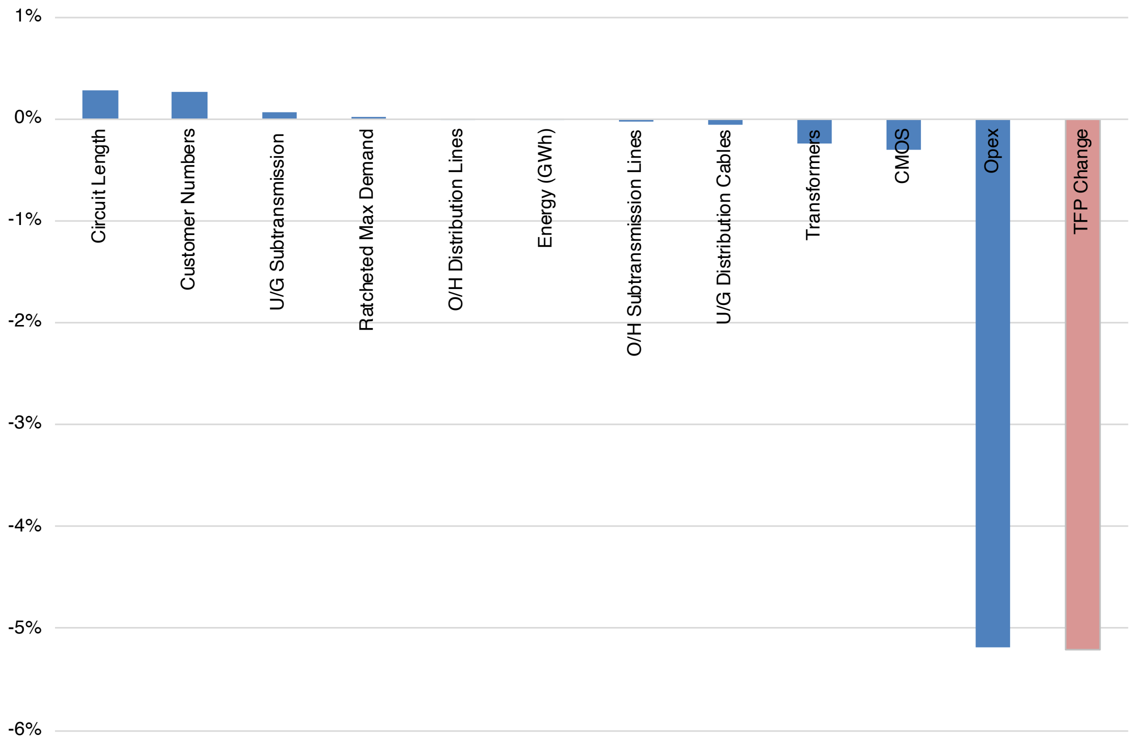
5.4.3 ENX's output and input contributions to TFP change

Table 5.8 shows the decomposition of ENX's rate of TFP change into the contributions of the individual outputs and inputs for the whole 16-year period, for the periods up to and after 2012, and for 2021. Figure 5.16 shows the contributions of outputs and inputs to ENX's rate of TFP change between 2020 and 2021.

Table 5.8 ENX's output and input percentage point contributions to average annual TFP change: various periods

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2020 to 2021*
Energy (GWh)	0.02%	0.05%	0.00%	0.00%
Ratcheted Max Demand	0.61%	1.48%	0.03%	0.01%
Customer Numbers	0.33%	0.38%	0.30%	0.27%
Circuit Length	0.52%	0.73%	0.38%	0.28%
CMOS	0.38%	1.39%	-0.30%	-0.30%
Opex	-0.79%	-2.38%	0.27%	-5.19%
O/H Subtransmission Lines	-0.05%	-0.08%	-0.02%	-0.03%
O/H Distribution Lines	-0.02%	-0.05%	-0.01%	0.00%
U/G Subtransmission Cables	-0.20%	-0.38%	-0.08%	0.06%
U/G Distribution Cables	-0.48%	-0.74%	-0.30%	-0.06%
Transformers	-0.83%	-1.33%	-0.51%	-0.25%
TFP Change	-0.52%	-0.94%	-0.23%	-5.20%

Figure 5.16 ENX's output and input percentage point contributions to TFP change in 2021



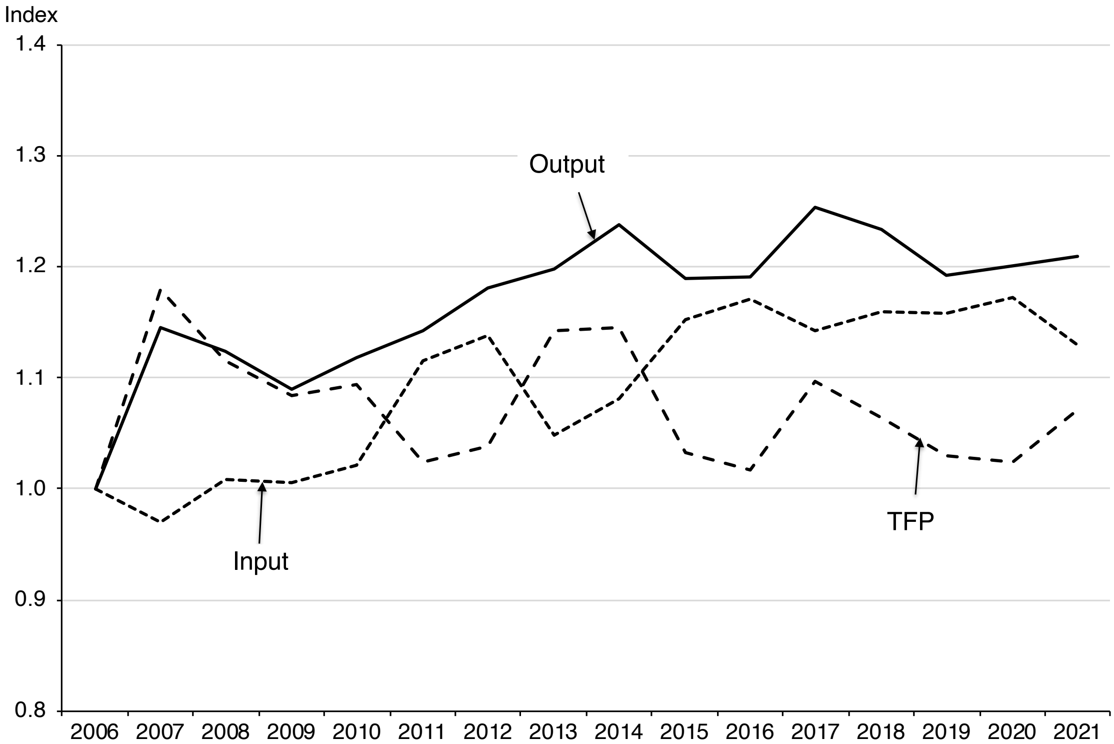
5.5 Ergon Energy (ERG)

In 2021, ERG delivered 13,477 GWh to 767,583 customers over 153,799 circuit kilometres of lines and cables. ERG distributes electricity throughout regional Queensland, excluding South East Queensland. ERG is around the seventh largest DNSP in the NEM in terms of customer numbers but is the second-largest in terms of network length.

5.5.1 ERG's productivity performance

ERG's total output, total input and TFP indexes are presented in Figure 5.17 and Table 5.9. Opex and capital PFP indexes are also presented in Table 5.9.

Figure 5.17 ERG's output, input and total factor productivity indexes, 2006–2021



Over the 16-year period 2006 to 2021, ERG's TFP increased at an average annual rate of change of 0.5 per cent. This compares favourably to the industry's average annual TFP change of –0.5 per cent over the same period. In some years there have been large increases in ERG's TFP, such as 2007, 2013 and 2017, and other years have seen substantial decreases, including 2008, 2011 and 2015.

ERG's total output increased over the 16-year period at an average annual rate of 1.3 per cent, which compares to the industry average output growth rate of 1.0 per cent per annum. ERG's average annual rate of increase in input use of 0.8 per cent over the 16-year period is much lower than the average rate of increase in industry total input use of 1.5 per cent per year. The higher output growth and lower input growth compared to the industry resulted in the more favourable TFP outcome.

The rates of growth of output and input usage were both much higher in the period 2006 to 2012 (averaging 2.8 and 2.1 per cent per year respectively) than in the period 2012 to 2021 (where they averaged 0.3 and –0.1 per cent per year respectively). The average rate of TFP change from 2006 to 2012 was 0.6 per cent per year, while from 2012 to 2021 it averaged an increase of 0.4 per cent per annum.

The PFP indexes in Table 5.9 show that Opex PFP has improved at an average annual rate of 2.1 per cent over the 16-year period. Capital PFP improved slightly in the period from 2006 to 2012 (at an average annual rate of 0.4 per cent) but deteriorated after 2012; with an average rate of change of –1.1 per cent per annum. The average trend growth rate in capital MPFP over the 16-year period was –0.5 per cent per annum.

Table 5.9 ERG's output, input, TFP and PFP indexes, 2006–2021

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	1.144	0.970	1.179	1.286	1.116
2008	1.124	1.008	1.115	1.179	1.079
2009	1.090	1.006	1.084	1.185	1.023
2010	1.118	1.021	1.094	1.242	1.013
2011	1.143	1.116	1.024	1.033	1.014
2012	1.180	1.138	1.038	1.044	1.022
2013	1.198	1.048	1.143	1.334	1.043
2014	1.238	1.082	1.145	1.373	1.028
2015	1.190	1.153	1.032	1.145	0.968
2016	1.190	1.170	1.017	1.137	0.949
2017	1.253	1.142	1.097	1.330	0.980
2018	1.234	1.160	1.063	1.274	0.954
2019	1.191	1.158	1.029	1.223	0.928
2020	1.200	1.172	1.024	1.188	0.935
2021	1.210	1.129	1.072	1.369	0.928
Growth Rate 2006-2021	1.3%	0.8%	0.5%	2.1%	-0.5%
Growth Rate 2006-2012	2.8%	2.1%	0.6%	0.7%	0.4%
Growth Rate 2012-2021	0.3%	-0.1%	0.4%	3.0%	-1.1%
Growth Rate 2021	0.8%	-3.8%	4.5%	14.2%	-0.7%

5.5.2 ERG's output and input quantity changes

Figure 5.18 graphs the quantity indexes for ERG's individual outputs. Figure 5.19 graphs quantity indexes for its six individual inputs.

Regarding outputs in Figure 5.18:

- ERG's circuit length output increased by 3.7 per cent in total between 2006 and 2021 (compared to a total increase of 5.2 per cent for the industry over the same period).
- ERG's energy throughput in 2021 was essentially the same as that in 2006 (being 0.1 per cent below its 2006 level). This compares to the industry's total reduction in energy throughput of 4.8 per cent over the same period.
- The increase of ERG's RMD output from 2006 to 2021 was 15.5 per cent. All of this increase occurred in the period up to 2010. The timing and size of this RMD increase is broadly similar to that for the industry (a 14.5 per cent increase concentrated in the period before 2012).
- ERG's customers increased at an average annual rate of 1.4 per cent from 2006 to 2021, or 23.0 per cent in total, which is similar to customer growth for the industry over the same period (1.3 per cent per annum, or 22.0 per cent in total).
- CMOS *decreased* for ERG over the 16-year period to 2021 by 14.3 per cent in total, which is comparable to the industry CMOS decrease of 11.4 per cent over the same period.

Turning to inputs shown in Figure 5.19, we see:

- The quantity of ERG's opex input *decreased* by 11.6 per cent in total between 2006 and 2021, which represents an average annual rate of change of –0.8 per cent. This compares favourably to the industry, for which opex input increased by 8.7 per cent in total over the 16-year period. ERG's opex increased in the period 2006 to 2012 at an average rate of 2.0 per cent per annum, and it *decreased* after 2012 at an average rate of 2.7 per cent per annum.
- Overhead sub-transmission and distribution lines in 2021 were 2.3 per cent and 15.5 per cent higher respectively, than in 2006. These changes compare to the industry increases of 14.4 per cent and 13.6 per cent respectively over the same period.
- ERG's underground sub-transmission and distribution cables in 2021 were 75.5 and 107.2 per cent higher than in 2006 respectively. These increases are higher than those for the industry as a whole, namely 37.6 per cent and 68.6 per cent respectively over the same period.
- ERG's quantity of transformer inputs increased steadily over most of the 16-year period, plateauing from 2017. The average annual rate of change from 2006 to 2021 was 2.5 per cent, an increase of 46.4 per cent in total (compared to the industry's 42.2 per cent increase over the same period). Transformers is the input with the largest weight in the capital input index.

Figure 5.18 ERG's output quantity indexes, 2006–2021

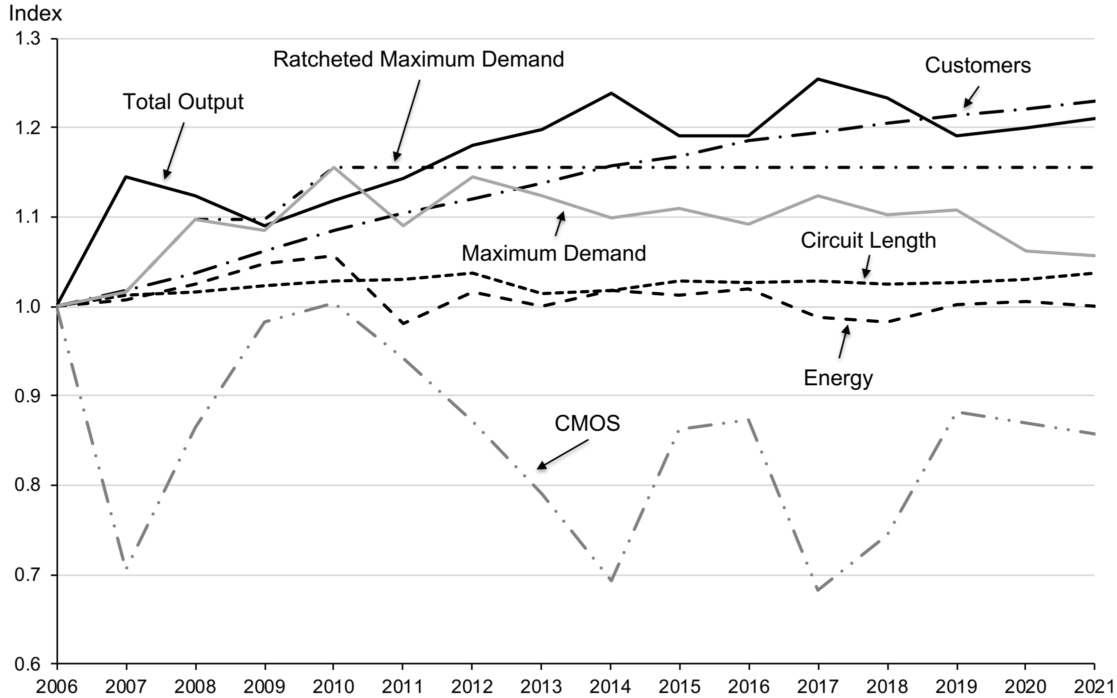
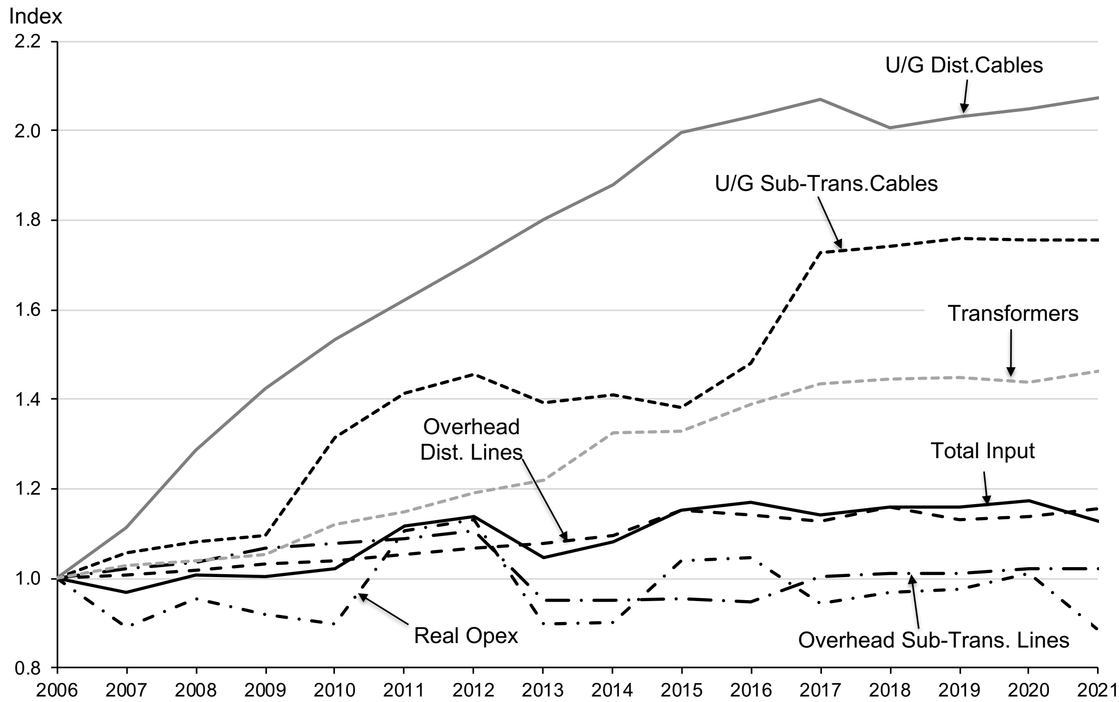


Figure 5.19 ERG's input quantity indexes, 2006–2021



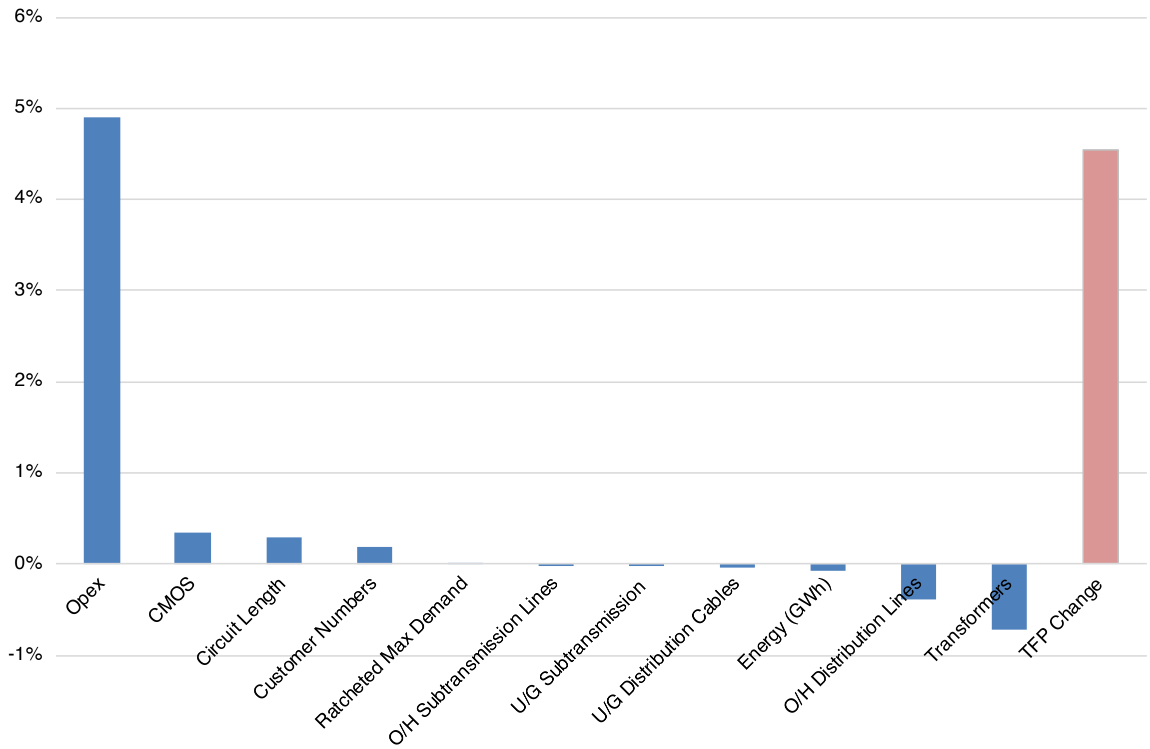
5.5.3 ERG's output and input contributions to TFP change

Table 5.10 shows the decomposition of ERG's rate of TFP change into the contributions of the individual outputs and inputs for the whole 16-year period, for the periods up to and after 2012, and for 2021. Figure 5.20 shows the contributions of outputs and inputs to ERG's rate of TFP change in 2021.

Table 5.10 ERG's output and input percentage point contributions to average annual TFP change: various sources

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2020 to 2021*
Energy (GWh)	0.00%	0.03%	-0.02%	-0.07%
Ratcheted Max Demand	0.43%	1.08%	0.00%	0.01%
Customer Numbers	0.34%	0.48%	0.24%	0.19%
Circuit Length	0.12%	0.31%	0.00%	0.30%
CMOS	0.37%	0.87%	0.04%	0.36%
Opex	0.30%	-0.67%	0.95%	4.90%
O/H Subtransmission Lines	-0.01%	-0.17%	0.09%	0.00%
O/H Distribution Lines	-0.21%	-0.23%	-0.20%	-0.38%
U/G Subtransmission Cables	-0.02%	-0.02%	-0.01%	-0.01%
U/G Distribution Cables	-0.15%	-0.28%	-0.07%	-0.04%
Transformers	-0.72%	-0.78%	-0.68%	-0.71%
TFP Change	0.46%	0.62%	0.36%	4.54%

Figure 5.20 ERG's output and input percentage point contributions to TFP change, 2021



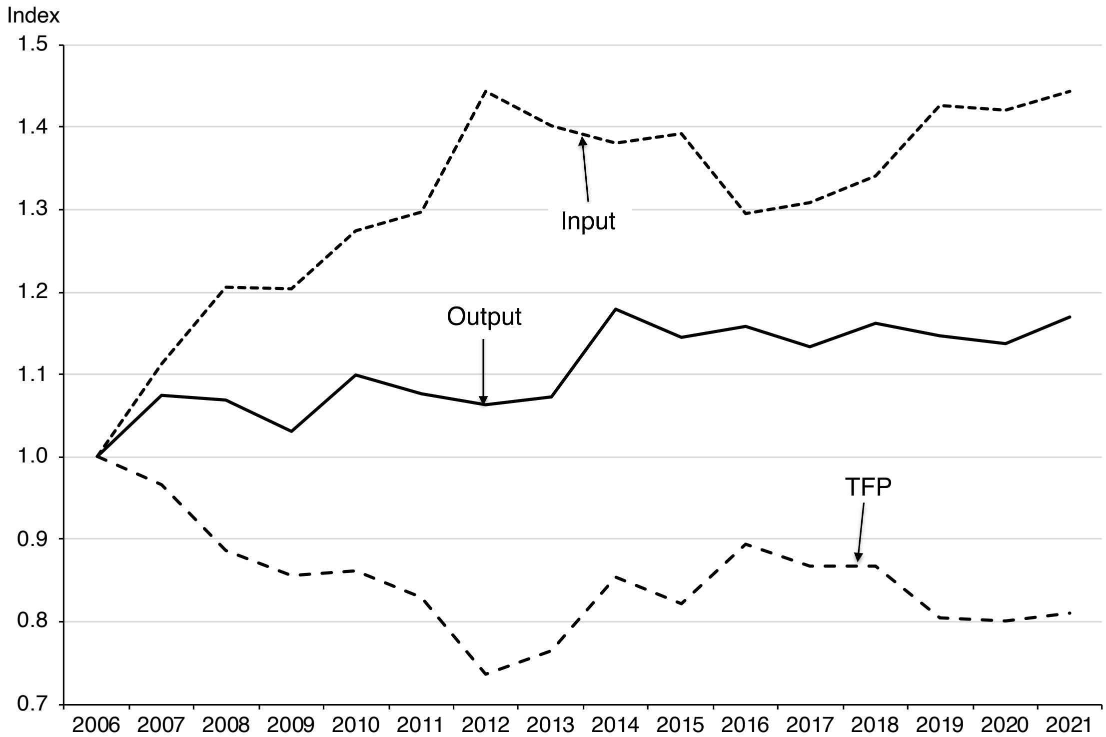
5.6 Essential Energy (ESS)

In 2021, ESS delivered 12,440 GWh to 935,179 customers over 192,883 circuit kilometres of lines and cables. ESS distributes electricity throughout 95 per cent of New South Wales's land mass and parts of southern Queensland. ESS is the fourth largest NEM DNSP in terms of customer numbers but by far the largest in terms of network length.

5.6.1 ESS's productivity performance

ESS's total output, total input and TFP indexes are presented in Figure 5.21 and Table 5.11. Opex and capital PFP indexes are also presented in Table 5.11.

Figure 5.21 ESS's output, input and TFP indexes, 2006–2021



Over the 16-year period 2006 to 2021, ESS's TFP *decreased* at an average annual rate of change of 1.4 per cent. This compares unfavourably to the industry's average annual change of –0.5 per cent over the same period. Most of the decline in ESS's TFP occurred in the period up to 2012, where the average rate of TFP change was –5.1 per cent per year. However, in the period 2012 to 2021, ESS's TFP increased at an average rate of 1.1 per cent per year. Its TFP increase in 2021 was 1.4 per cent.

ESS's total output increased over the 16-year period at an average annual rate of 1.0 per cent (the same as the industry average over the same period). ESS's average annual rate of increase in input use was 2.4 per cent in the period 2006 to 2021, which is considerably higher than the industry's rate of increase in total input use (1.5 per cent per year). Whereas output growth was at a reasonably steady rate, input use increased mostly in the period up to 2012 (at an average annual rate of 6.1 per cent) and had very little further increase, with the average rate of change being zero from 2012 to 2021.

The PFP indexes in Table 5.11 show the following trends:

- Capital PFP *declined* on average rate of 1.7 per cent per year from 2006 to 2021. The decline was greater in the period up to 2012, averaging –2.8 per cent per annum, with a continued but lesser decline, averaging –1.0 per cent per annum after 2012.
- Opex PFP declined rapidly in the period up to 2012, averaging –8.3 per cent per annum, whereas it has increased at a rate of 4.0 per cent per annum after 2012. Over the full period, Opex PFP declined, averaging –0.9 per cent per annum.

Table 5.11 ESS's output, input, TFP and PFP indexes, 2006–2021

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	1.074	1.112	0.966	0.895	1.023
2008	1.069	1.206	0.886	0.757	0.994
2009	1.031	1.204	0.857	0.781	0.915
2010	1.099	1.274	0.863	0.777	0.924
2011	1.077	1.297	0.830	0.763	0.877
2012	1.064	1.443	0.737	0.609	0.845
2013	1.073	1.401	0.766	0.679	0.829
2014	1.179	1.380	0.854	0.786	0.902
2015	1.145	1.392	0.822	0.780	0.853
2016	1.157	1.295	0.894	1.000	0.839
2017	1.134	1.308	0.867	0.973	0.814
2018	1.162	1.340	0.867	0.950	0.820
2019	1.147	1.426	0.805	0.826	0.791
2020	1.137	1.420	0.801	0.850	0.766
2021	1.170	1.442	0.811	0.872	0.771
Growth Rate 2006-2021	1.0%	2.4%	-1.4%	-0.9%	-1.7%
Growth Rate 2006-2012	1.0%	6.1%	-5.1%	-8.3%	-2.8%
Growth Rate 2012-2021	1.1%	0.0%	1.1%	4.0%	-1.0%
Growth Rate 2021	2.9%	1.5%	1.4%	2.6%	0.7%

5.6.2 ESS's output and input quantity changes

Figure 5.22 graphs the quantity indexes for ESS's individual outputs. Figure 5.23 graphs quantity indexes for its six individual inputs. Regarding outputs:

- Circuit length is the output with the largest weight in the output index. ESS's circuit length *decreased* by 3.3 per cent in total between 2006 and 2021. This compares to a total increase of 5.2 per cent for the industry over the same period.

- ESS's energy throughput increased at an average annual rate of 0.3 per cent per year over the 16-year period, or 4.0 per cent in total (compared to a total decline of 4.8 per cent for the industry over the same period).
- ESS's RMD increased by 22.5 per cent in total between 2006 and 2021. This shows that maximum demand has grown much more strongly than energy throughput, especially in the period from 2012 to 2021. Consequently, RMD grew at an average annual rate of 1.7 per cent from 2012 to 2021, whereas energy throughput increased at an average annual rate of 0.5 per cent over this period.
- ESS's customers output increased at an average rate of 1.0 per cent per annum 2006 and 2021, or 17.0 per cent in total, which is less than the average rate of customer growth for the industry over the same period (22.0 per cent in total).
- CMOS *decreased* over the 16-year period by 15.2 per cent in total. This was aided by an 11.2 per cent decrease in 2021. The overall decrease of ESS's CMOS is comparable to the industry decline of 11.4 per cent.

Turning to inputs shown in Figure 5.23, we see:

- The quantity of ESS's opex increased at an average annual rate of 2.0 per cent over the period from 2006 to 2021, or 34.3 per cent in total. This compares unfavourably to the industry, for which opex input increased by 8.7 per cent in total over the same period. ESS's opex increased strongly in the period 2006 to 2012, at an average rate of 9.3 per cent per annum, and it *decreased* after 2012 at an average rate of 2.3 per cent per annum.
- Overhead sub-transmission and distribution lines in 2021 were 65.5 per cent and 56.2 per cent higher, respectively, than in 2006. These changes are greater than the industry increases of 14.4 per cent and 13.6 per cent respectively over the same period.
- ESS's underground sub-transmission and distribution cables inputs in 2021 were 86.1 and 87.6 per cent higher than in 2006 respectively. These increases are higher than those for the industry as a whole, namely 37.6 per cent and 68.6 per cent respectively over the same period.
- ESS's quantity of transformer inputs increased steadily over the 16-year period at an average annual rate of 2.2 per cent, and by 2021, transformer inputs were 39.9 per cent above the 2006 level, which is similar to the industry's 42.2 per cent increase.

Figure 5.22 ESS's output quantity indexes, 2006–2021

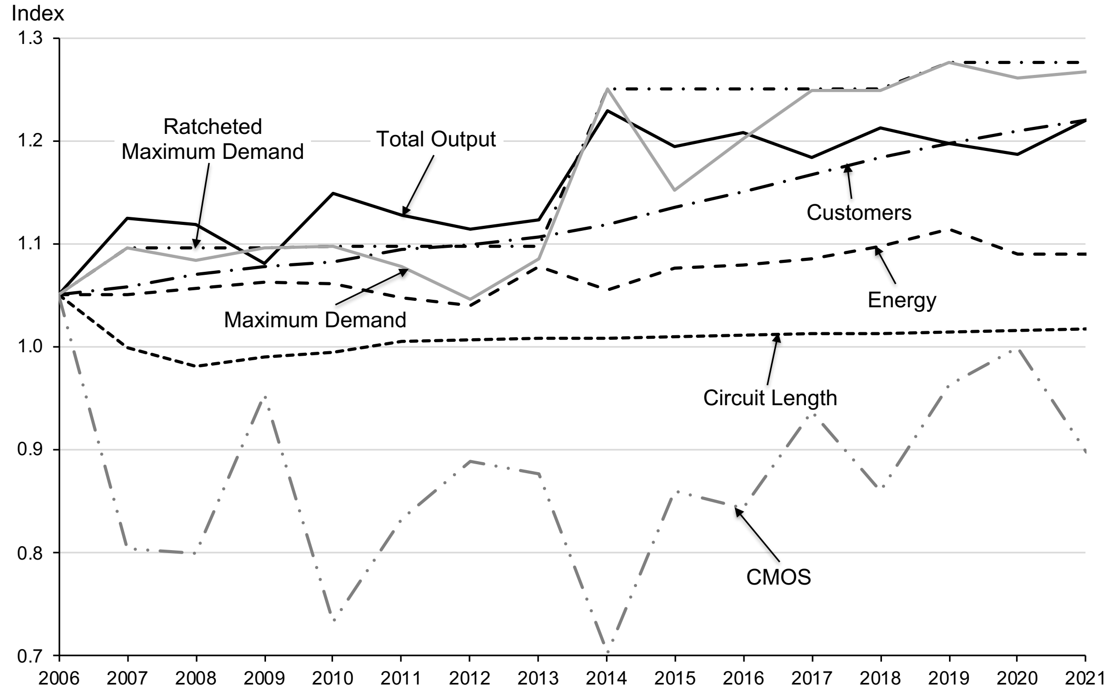
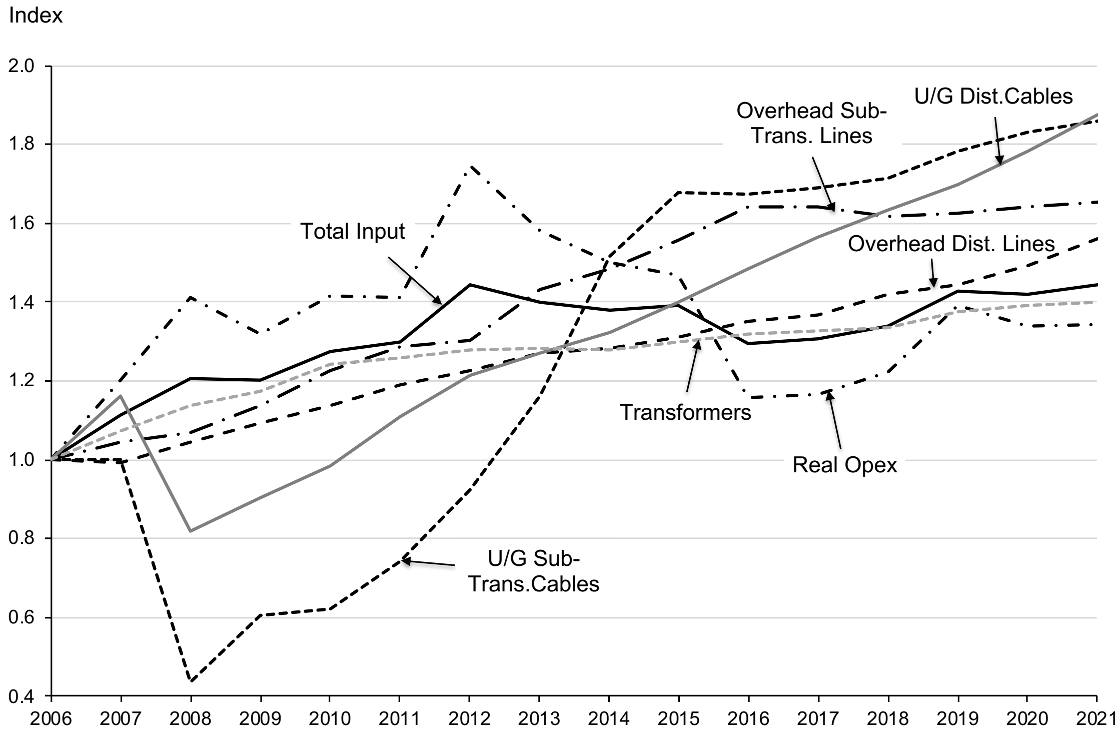


Figure 5.23 ESS's input quantity indexes, 2006–2021



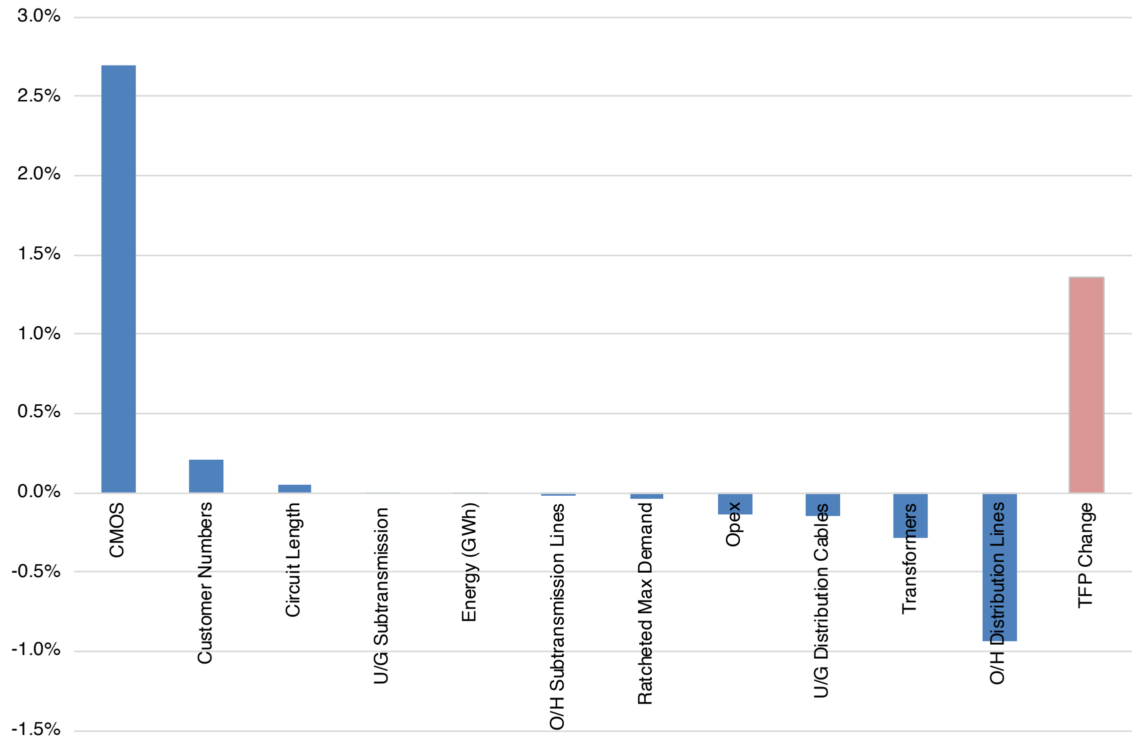
5.6.3 ESS's output and input contributions to TFP change

Table 5.12 shows the decomposition of ESS's rate of TFP change into the contributions of the individual outputs and inputs for the whole 16-year period, for the periods up to and after 2012, and for 2021. Figure 5.24 shows the contributions of outputs and inputs to ESS's rate of TFP change in 2021.

Table 5.12 ESS's output and input percentage point contributions to average annual TFP change: various periods

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2020 to 2021*
Energy (GWh)	0.03%	-0.01%	0.06%	-0.01%
Ratcheted Max Demand	0.57%	0.37%	0.71%	-0.04%
Customer Numbers	0.24%	0.20%	0.27%	0.21%
Circuit Length	-0.11%	-0.37%	0.06%	0.05%
CMOS	0.32%	0.85%	-0.04%	2.70%
Opex	-0.80%	-3.84%	1.22%	-0.14%
O/H Subtransmission Lines	-0.24%	-0.34%	-0.18%	-0.02%
O/H Distribution Lines	-0.60%	-0.62%	-0.58%	-0.94%
U/G Subtransmission Cables	-0.01%	0.00%	-0.02%	0.00%
U/G Distribution Cables	-0.16%	-0.12%	-0.18%	-0.15%
Transformers	-0.64%	-1.20%	-0.26%	-0.28%
TFP Change	-1.39%	-5.08%	1.06%	1.36%

Figure 5.24 ESS's output and input percentage point contributions to TFP change, 2021



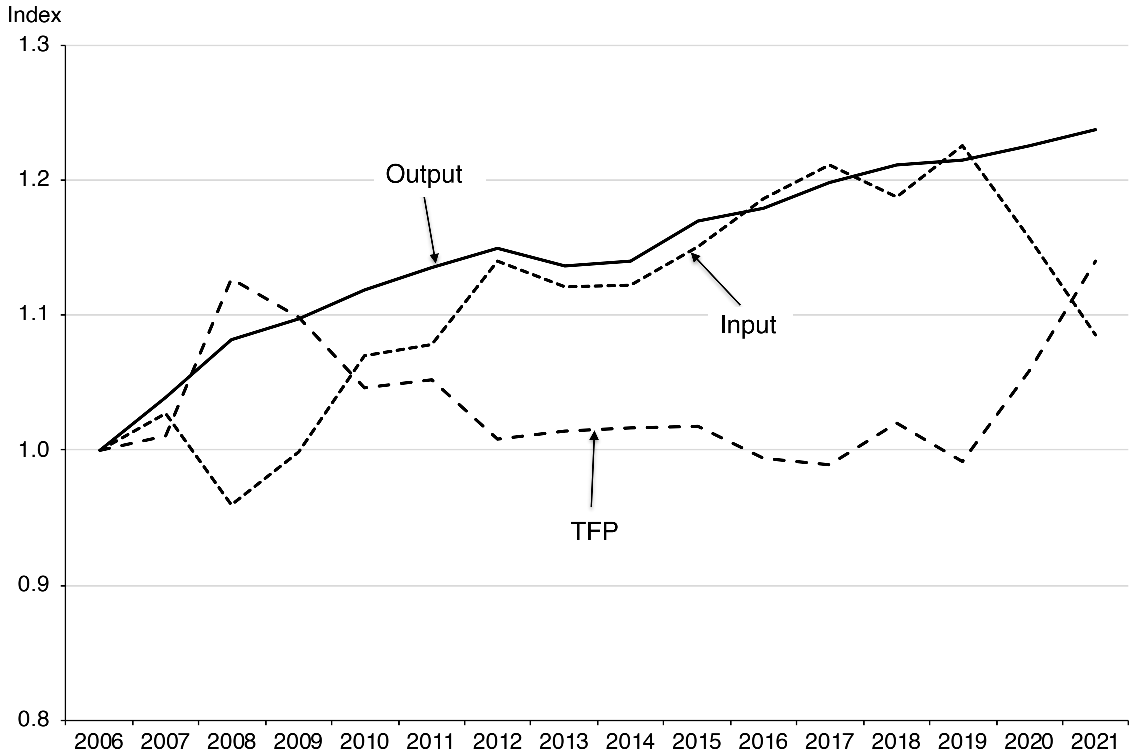
5.7 Jemena Electricity Networks (JEN)

In 2021, JEN delivered 4,109 GWh to 369,332 customers over 6,756 circuit kilometres of lines and cables. JEN distributes electricity across 950 square kilometres of north–west greater Melbourne. JEN's network footprint incorporates a mix of major industrial areas, residential growth areas, established inner suburbs and Melbourne International Airport.

5.7.1 JEN's productivity performance

JEN's total output, total input and TFP indexes are presented in Figure 5.25 and Table 5.13. Opex and capital PFP indexes are also presented in Table 5.13.

Figure 5.25 JEN's output, input, and TFP indexes, 2006–2021



Over the 16-year period 2006 to 2021, JEN's TFP increased at an average annual rate of change of 0.9 per cent per annum. This compares favourably to the industry's average annual change of –0.5 per cent over the same period. Over the period from 2006 to 2012, the rate of increase in TFP was 0.1 per cent per annum, and in the period from 2012 to 2021, the rate of increase was 1.5 per cent per annum.

JEN's total output increased over 16-year period at an average annual rate of 1.5 per cent, which is higher than the industry average rate of growth in output of 1.0 per cent per annum. JEN's average annual rate of increase in input use of 0.6 per cent over the same period is lower than for the industry (1.5 per cent per year). JEN's rate of output growth was higher in the period up to 2012 (at 2.3 per cent per annum) than in the period after 2012 (at 0.9 per cent per annum). Its rate of input growth was also higher in the period up to 2012 (at 2.2 per cent per annum) than in the period after 2012 (at –0.6 per cent per annum).

The PFP indexes in Table 5.13 show the following trends:

- Capital PFP increased marginally, at an average rate of 0.1 per cent per year, from 2006 to 2021. In the period up to 2012, Capital PFP increased at a rate of 1.0 per cent per annum, whilst in the period after 2012, the rate of change in Capital PFP averaged –0.5 per cent per annum.
- Opex PFP increased on average at a rate of 2.1 per cent per annum from 2006 to 2021. In the period up to 2012, Opex PFP *decreased* by 1.0 per cent per annum on average, whereas it has increased at a rate of 4.2 per cent per annum after 2012.

Table 5.13 JEN's output, input, TFP and PFP indexes, 2006–2021

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	1.039	1.027	1.011	0.984	1.034
2008	1.082	0.960	1.127	1.269	1.043
2009	1.097	0.999	1.098	1.179	1.039
2010	1.118	1.070	1.046	1.025	1.061
2011	1.135	1.078	1.052	1.054	1.051
2012	1.149	1.140	1.008	0.940	1.065
2013	1.136	1.121	1.014	0.971	1.046
2014	1.140	1.122	1.016	0.988	1.036
2015	1.170	1.150	1.017	0.988	1.039
2016	1.179	1.186	0.994	0.941	1.033
2017	1.198	1.211	0.989	0.913	1.048
2018	1.211	1.187	1.020	1.005	1.032
2019	1.214	1.225	0.991	0.964	1.011
2020	1.225	1.157	1.059	1.131	1.014
2021	1.237	1.085	1.140	1.347	1.017
Growth Rate 2006-2021	1.5%	0.6%	0.9%	2.1%	0.1%
Growth Rate 2006-2012	2.3%	2.2%	0.1%	-1.0%	1.0%
Growth Rate 2012-2021	0.9%	-0.6%	1.5%	4.2%	-0.5%
Growth Rate 2021	1.9%	-12.9%	14.7%	35.0%	0.6%

5.7.2 JEN's output and input quantity changes

Figure 5.26 graphs the quantity indexes for JEN's individual outputs. Figure 5.27 graphs quantity indexes for its six individual inputs. Regarding outputs:

- The output with largest weight in the output index, circuit length, increased steadily at an average rate of 1.1 per cent per annum from 2006 to 2021; a total increase of 18.1

per cent (which is higher than the increase of 5.2 per cent for the industry over the 16-year period).

- JEN's energy throughput *decreased* at an average rate of 0.3 per cent per annum between 2006 and 2021; the same rate as that for the industry. In 2021, JEN's energy throughput was 4.0 per cent below its 2006 level.
- RMD increased up to 2009, with further increases in 2019 and 2020. In total, RMD increased by 25.5 per cent between 2006 and 2021. This is greater than that of the industry (18.1 per cent in total).
- JEN's customers increased at an average rate of 1.6 per cent per annum between 2006 and 2021, or 26.0 per cent in total (compared to total customer growth of 22.0 per cent for the industry over the same period).
- CMOS *decreased* by 15.4 per cent in total over the period from 2006 to 2021 (compared to a decrease in CMOS of 11.4 per cent for the industry over the same period).

Turning to inputs shown in Figure 5.27, we see:

- The quantity of JEN's opex input decreased between 2006 and 2021, averaging an annual rate of change of –0.6 per cent. By 2021, opex was 8.2 per cent below its level in 2006. This compares favourably to the total increase of industry opex inputs of 8.7 per cent over the same period. In the periods before and after 2012, there are two distinct trends in JEN's opex input. From 2006 to 2012 opex increased at a rate of 3.3 per cent per annum, whereas from 2012 to 2021, JEN's opex *decreased* at a rate of 3.4 per cent per annum. This is largely attributable to substantial declines in 2020 (–15.0 per cent) and 2021 (–33.1 per cent).
- Overhead sub-transmission and distribution lines in 2021 were 16.2 and 2.6 per cent higher, respectively, than their 2006 level. These outcomes compare with 14.4 per cent and 13.6 per cent increases, respectively, for the industry over the same period.
- Underground sub-transmission and distribution cables in 2021 were 58.7 and 100.7 per cent higher than in 2006 respectively. This can be compared to increases of 37.6 per cent and 68.6 per cent respectively for the industry over the same period.
- JEN's quantity of transformers increased reasonably steadily over the 16-year period, at an average rate of 2.7 per cent per annum. By 2021, transformer inputs were 47.9 per cent above the 2006 level, which is a larger increase than the industry's 42.2 per cent.

Figure 5.26 JEN's output quantity indexes, 2006–2021

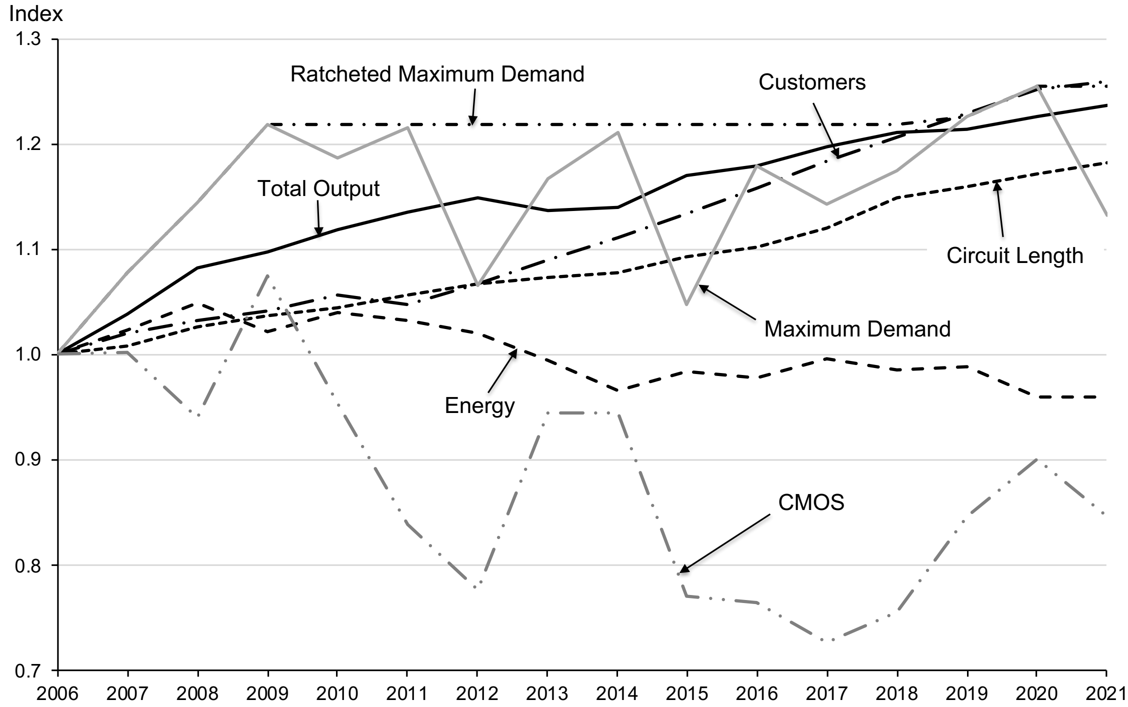
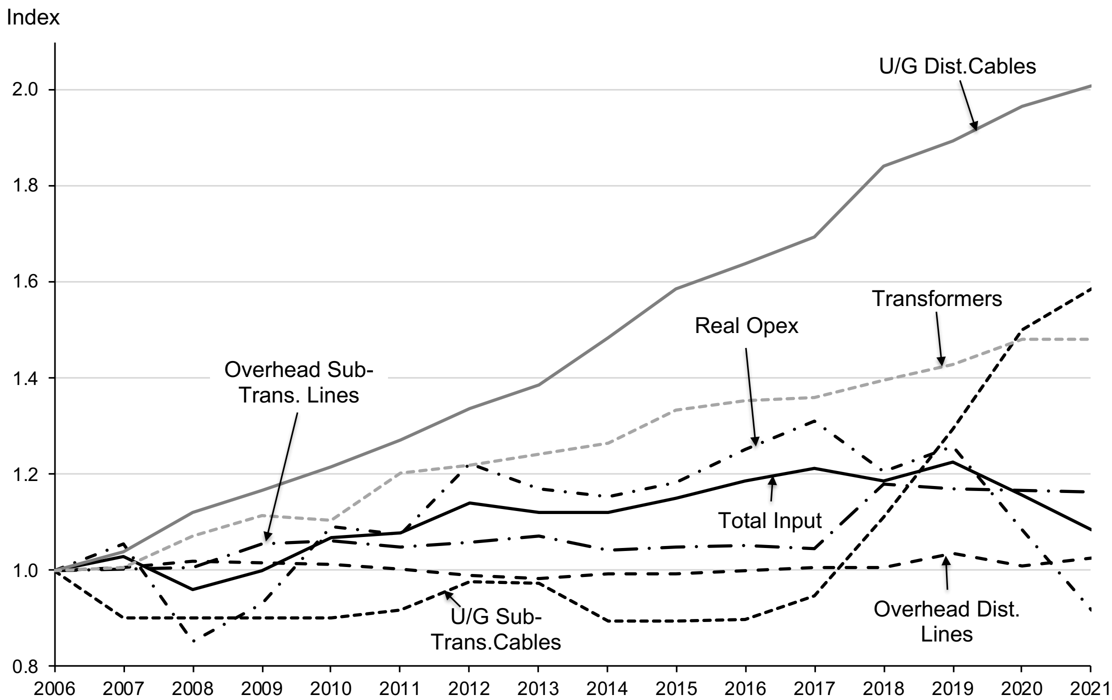


Figure 5.27 JEN's DNSP input quantity indexes, 2006–2021



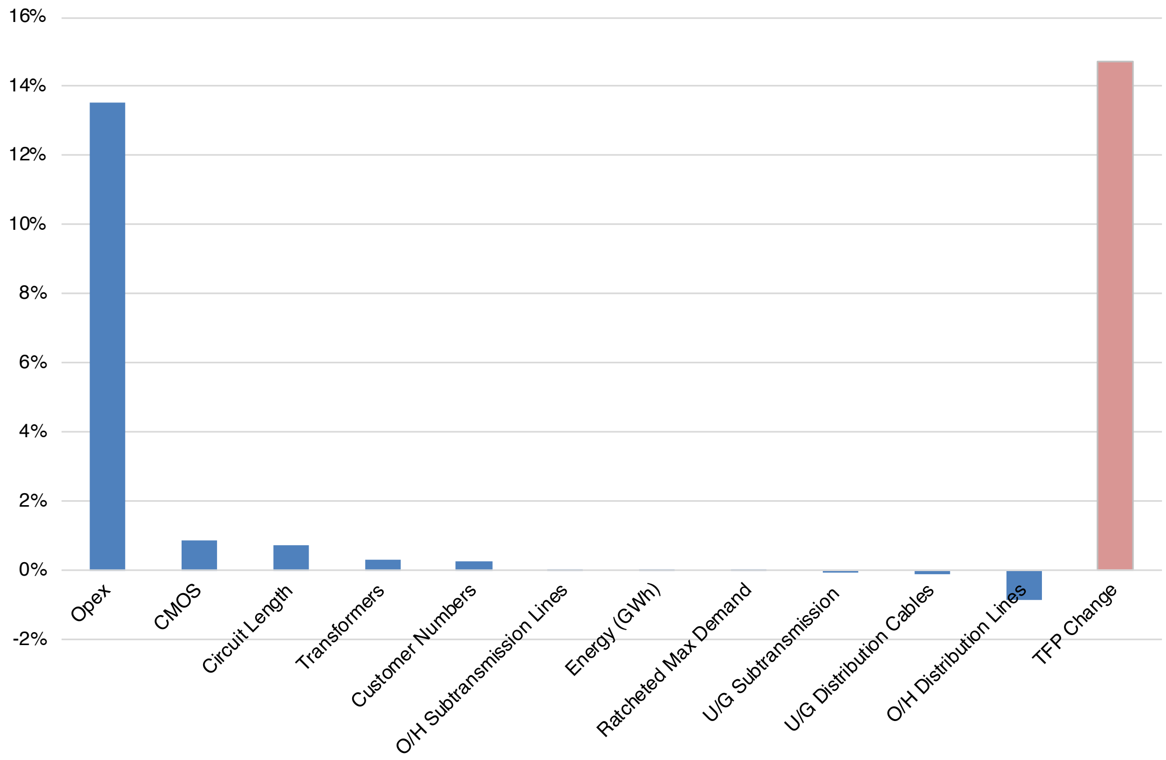
5.7.3 JEN's output and input contributions to TFP change

Table 5.14 shows the decomposition of JEN's rate of TFP change into the contributions of the individual outputs and inputs for the whole 16-year period, for the periods up to and after 2012, and for 2021. Figure 5.28 shows the contributions of outputs and inputs to JEN's rate of TFP change between 2020 and 2021.

Table 5.14 JEN's output and input percentage point contributions to average annual TFP change: various points

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2020 to 2021*
Energy (GWh)	-0.02%	0.03%	-0.06%	0.01%
Ratcheted Max Demand	0.56%	1.22%	0.12%	0.00%
Customer Numbers	0.32%	0.22%	0.38%	0.27%
Circuit Length	0.50%	0.47%	0.51%	0.72%
CMOS	0.13%	0.37%	-0.03%	0.86%
Opex	0.66%	-1.48%	2.08%	13.53%
O/H Subtransmission Lines	-0.05%	-0.04%	-0.05%	0.03%
O/H Distribution Lines	-0.08%	0.05%	-0.16%	-0.87%
U/G Subtransmission Cables	-0.01%	0.00%	-0.01%	-0.02%
U/G Distribution Cables	-0.10%	-0.11%	-0.10%	-0.10%
Transformers	-0.54%	-0.61%	-0.49%	0.31%
TFP Change	1.37%	0.13%	2.19%	14.74%

Figure 5.28 JEN's output and input percentage point contributions to TFP change, 2021



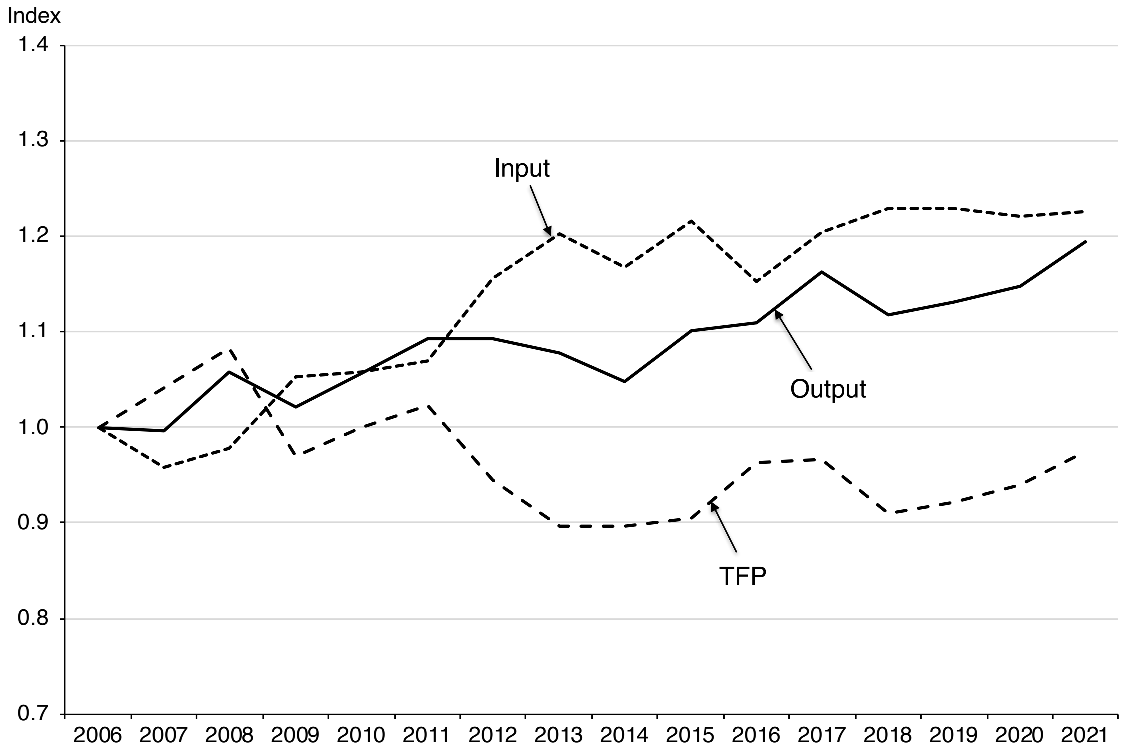
5.8 Powercor (PCR)

In 2021, PCR delivered 10,776 GWh to 877,935 customers over 76,545 circuit kilometres of lines and cables. PCR distributes electricity to the western half of Victoria, including the western suburbs of Melbourne and stretching west to the border of South Australia and north to New South Wales.

5.8.1 PCR's productivity performance

PCR's total output, total input and TFP indexes are presented in Figure 5.29 and Table 5.15. Opex and capital PFP indexes are also presented in Table 5.15.

Figure 5.29 PCR's output, input and TFP indexes, 2006–2021



Over the 16-year period 2006 to 2021, PCR's TFP marginally decreased, with an average annual rate of change of –0.2 per cent. This can be compared to the industry's average annual change of –0.5 per cent over the same period. The period from 2006 to 2012 saw a higher rate of decline in PCR's TFP, at an average rate of change of –0.9 per cent per year, while in the period from 2012 to 2021, TFP increased at an average annual rate of 0.4 per cent. The rate of TFP change in the latter period is close to the industry average for that period (0.5 per cent per year).

PCR's total output increased over the 16-year period at an average annual rate of 1.2 per cent (similar to the industry average rate of output growth of 1.0 per cent per annum). PCR's average annual rate of increase in input use of 1.4 per cent over the same period was similar to that for the industry (1.5 per cent per year). The average rate of growth of output for PCR in the period up to 2012 was 1.5 per cent per year, and in the period after 2012 it was 1.0 per cent per year. PCR's input usage increased at an average rate of 2.4 per cent per year from 2006 to 2012, and by 0.7 per cent per year after 2012.

The PFP indexes in Table 5.15 show the following trends:

- Capital PFP decreased reasonably consistently, averaging an annual rate of change of –0.9 per cent per annum.
- Opex PFP increased on average at a rate of 0.9 per cent per annum from 2006 to 2021. In the period up to 2012, Opex PFP *decreased* by 1.2 per cent per annum, on average, whereas it has increased at a rate of 2.3 per cent per annum from 2012 to 2021.

Table 5.15 PCR's output, input, TFP and PFP indexes, 2006–2021

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	0.997	0.958	1.041	1.137	0.975
2008	1.058	0.978	1.082	1.181	1.017
2009	1.020	1.053	0.969	1.032	0.925
2010	1.057	1.057	1.000	1.114	0.928
2011	1.093	1.069	1.022	1.108	0.965
2012	1.092	1.155	0.945	0.933	0.953
2013	1.077	1.202	0.896	0.866	0.917
2014	1.048	1.168	0.897	0.928	0.874
2015	1.101	1.216	0.905	0.909	0.901
2016	1.110	1.153	0.963	1.072	0.893
2017	1.162	1.204	0.966	1.042	0.913
2018	1.117	1.229	0.909	0.977	0.862
2019	1.132	1.229	0.921	1.021	0.856
2020	1.147	1.220	0.940	1.100	0.844
2021	1.194	1.225	0.975	1.133	0.875
Growth Rate 2006-2021	1.2%	1.4%	-0.2%	0.9%	-0.9%
Growth Rate 2006-2012	1.5%	2.4%	-0.9%	-1.2%	-0.8%
Growth Rate 2012-2021	1.0%	0.7%	0.4%	2.3%	-1.0%
Growth Rate 2021	7.9%	0.8%	7.1%	5.8%	7.1%

5.8.2 PCR's output and input quantity changes

Figure 5.30 graphs the quantity indexes for PCR's individual outputs. Figure 5.31 graphs quantity indexes for its six individual inputs.

Regarding outputs in Figure 5.30:

- PCR's circuit length increased steadily at an average rate of 0.5 per cent per annum from 2006 to 2021; and by 2021 was 6.8 per cent above the 2006 level (slightly higher than the increase of 5.2 per cent for the industry over the same period).
- PCR's energy throughput increased at an average rate of 0.4 per cent per annum between 2006 and 2021 (compared to –0.3 per cent per annum for the industry). PCR's energy throughput in 2021 was 6.2 per cent above its 2006 level.
- RMD increased at an average annual rate of 1.8 per cent per annum on average over the 16-year period to 2021. In 2021, RMD was 29.4 per cent higher than it was in 2006 (a greater increase than the industry RMD increase of 18.1 per cent in total over the same period).
- PCR's customers increased at an average rate of 1.9 per cent per annum between 2006 and 2021, or 32.2 per cent in total. This is higher than the 22.0 per cent customer increase for the industry in total over the same period.
- Although CMOS was volatile there was an upward trend, and over the period from 2006 to 2021, PCR's CMOS increased by 11.2 per cent in total (compared to –11.4 per cent for the industry). This detracted from PCR's output growth since CMOS has a negative weight.

Turning to inputs shown in Figure 5.31, we see:

- The quantity of opex input increased at an average annual rate of 0.4 per cent from 2006 to 2021, so that opex input in 2021 was 5.4 per cent above its level in 2006 (compared to 8.7 per cent for the industry over the same period). In the period up to 2012, PCR's opex input increased at an average rate of 2.6 per cent per annum. After 2012, opex input decreased, averaging –1.2 per cent per annum.
- Overhead sub-transmission and distribution lines in 2021 were 1.3 and 1.8 per cent higher, respectively, than their 2006 level. These increases were lower than the 14.4 per cent and 13.6 per cent increases, respectively, for the industry over the same period.
- Underground sub-transmission and distribution cables in 2021 were 327.7 per cent and 133.7 per cent higher than in 2006 respectively. This can be compared to increases of 37.6 per cent and 68.6 per cent respectively for the industry over the same period.
- PCR's quantity of transformers increased steadily over the 16-year period, at an average rate of 2.6 per cent per annum. By 2021, transformer inputs were 46.0 per cent above the 2006 level (comparable to the industry increase of 42.2 per cent over the same period).

Figure 5.30 PCR's output quantity indexes, 2006–2021

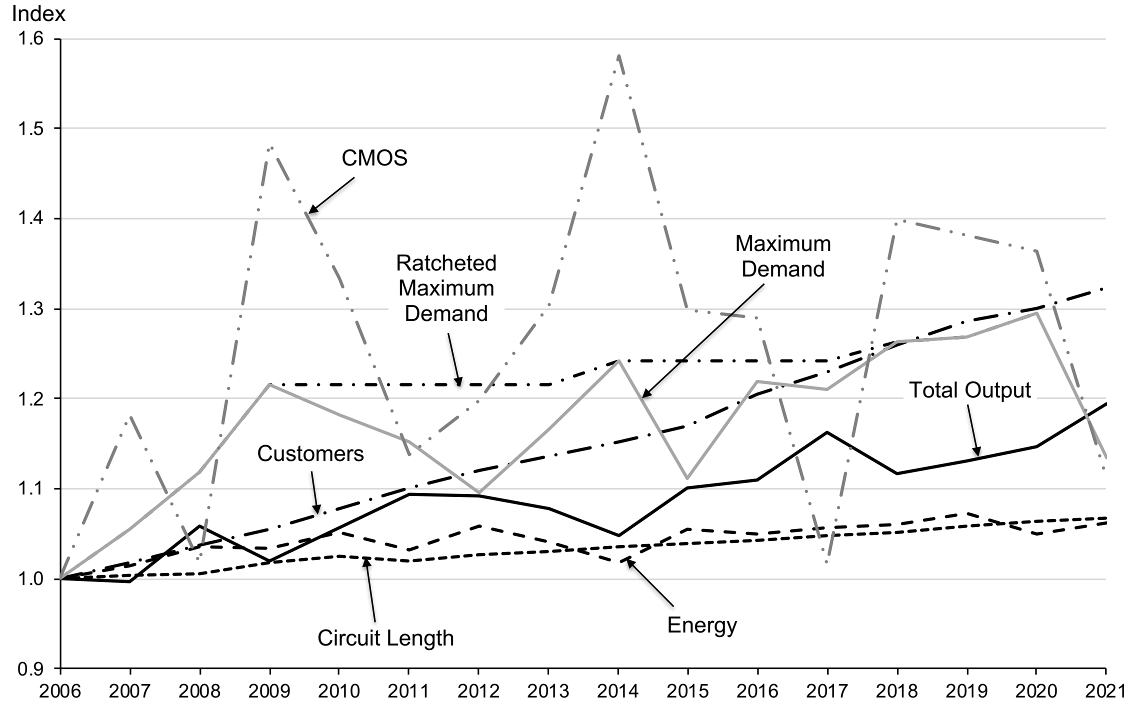
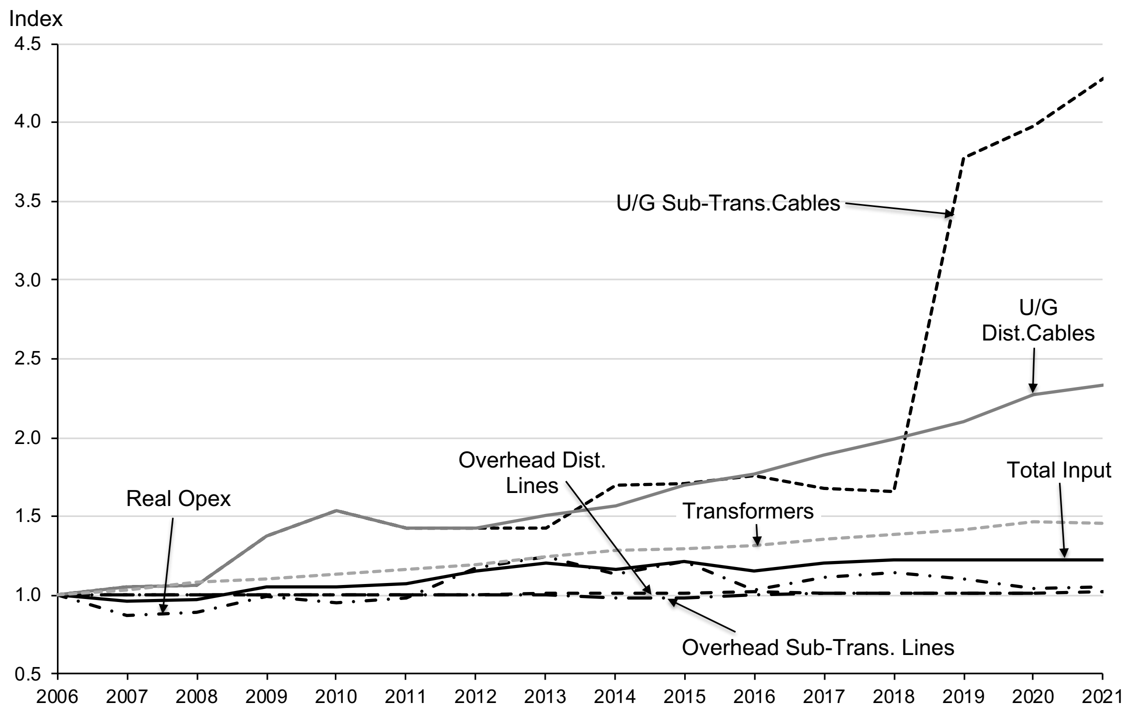


Figure 5.31 PCR's DNSP input quantity indexes, 2006–2021



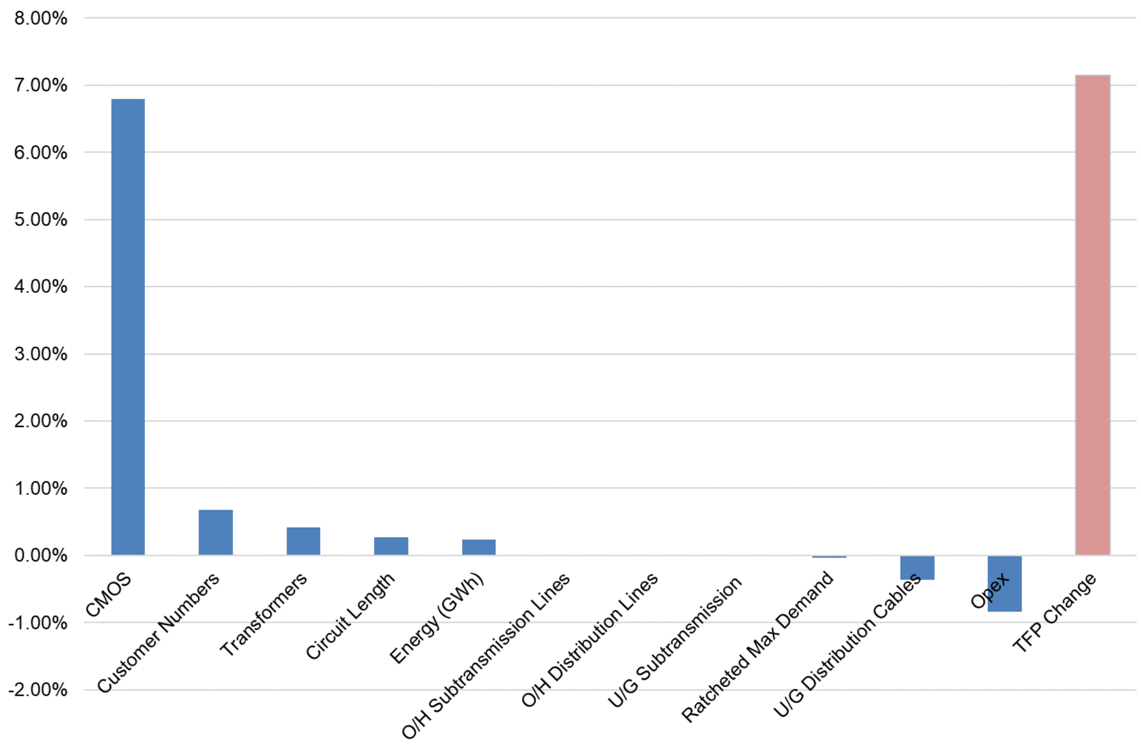
5.8.3 PCR's output and input contributions to TFP change

Table 5.16 shows the decomposition of PCR's rate of TFP change into the contributions of the individual outputs and inputs for the whole 16-year period, for the periods up to and after 2012, and for 2021. Figure 5.32 shows the contributions of outputs and inputs to PCR's rate of TFP change in 2021.

Table 5.16 PCR's output and input percentage point contributions to average annual TFP change: various periods

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2020 to 2021*
Energy (GWh)	0.05%	0.10%	0.02%	0.24%
Ratcheted Max Demand	0.68%	1.31%	0.27%	-0.04%
Customer Numbers	0.43%	0.41%	0.44%	0.68%
Circuit Length	0.21%	0.20%	0.21%	0.26%
CMOS	0.07%	-0.56%	0.50%	6.80%
Opex	-0.18%	-1.11%	0.44%	-0.84%
O/H Subtransmission Lines	0.00%	0.00%	0.00%	0.00%
O/H Distribution Lines	-0.03%	-0.02%	-0.03%	-0.01%
U/G Subtransmission Cables	-0.01%	-0.01%	-0.01%	-0.01%
U/G Distribution Cables	-0.64%	-0.68%	-0.61%	-0.36%
Transformers	-0.53%	-0.60%	-0.48%	0.42%
TFP Change	0.07%	-0.94%	0.74%	7.14%

Figure 5.32 PCR's output and input percentage point contributions to TFP change, 2021



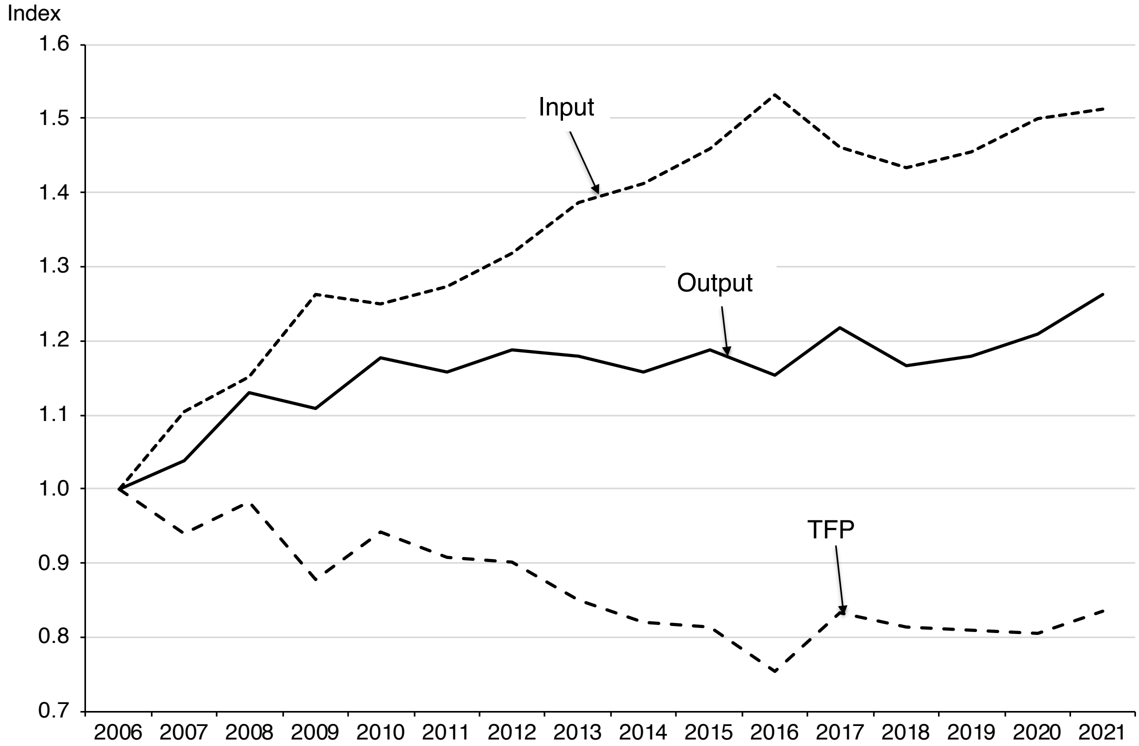
5.9 AusNet Services Distribution (AND)

In 2021, AND delivered 7,465 GWh to 784,286 customers over 45,879 circuit kilometres of lines and cables. AND distributes electricity to eastern Victoria (including Melbourne's outer northern and eastern suburbs) across an area of 80,000 square kilometres.

5.9.1 AND's productivity performance

AND's total output, total input and TFP indexes are presented in Figure 5.33 and Table 5.17. Opex and capital PFP indexes are also presented in Table 5.17.

Figure 5.33 AND's output, input and TFP indexes, 2006–2021



Over the 16-year period 2006 to 2021, AND's TFP *decreased* at an average annual rate of 1.2 per cent. This compares unfavourably to the industry's average annual change of –0.5 per cent over the same period. With a few exceptions, the decline in AND's TFP was consistent over the 16-year period.

AND's total output increased over the 16-year period at an average annual rate of 1.6 per cent, which is higher than the industry average rate of output growth of 1.0 per cent per annum over the same period. AND's output increased more strongly in the period up to 2012 (averaging 2.9 per year) than in the period from 2012 to 2021 (averaging 0.7 per cent per year).

AND's average annual rate of increase in input use of 2.9 per cent from 2006 to 2021 was higher than the rate of increase in total input use for the industry (1.5 per cent per year). AND's input usage increased most strongly in the period up to 2012 (averaging 4.6 per year) and continued to increase, but less strongly, after 2012 (averaging 1.6 per cent per year). By 2021, the input index was 51.2 per cent higher than in 2006 (compared to 25.2 per cent higher for the industry).

The PFP indexes in Table 5.17 show the following trends:

- After a marginal increase in the period from 2006 to 2012 (at an average rate of 0.2 per cent per year), capital PFP decreased in the period after 2012 (averaging an annual rate of change of –0.8 per cent). On average over the full 16-year period, the average rate of change in capital PFP was –0.4 per cent per annum.
- Opex PFP declined over the 16-year period, the average rate of change being –2.5 per cent per annum. This contrasts with the industry overall, for which opex PFP grew at an average rate of 0.4 per cent per year over the same period.

Table 5.17 AND's output, input, TFP and PFP indexes, 2006–2021

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index Opex*	*PFP Index Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	1.039	1.105	0.940	0.852	0.999
2008	1.131	1.152	0.982	0.862	1.073
2009	1.110	1.262	0.879	0.731	0.997
2010	1.178	1.249	0.943	0.802	1.052
2011	1.157	1.274	0.908	0.783	1.007
2012	1.187	1.317	0.901	0.758	1.014
2013	1.179	1.387	0.850	0.679	0.988
2014	1.158	1.412	0.820	0.653	0.957
2015	1.187	1.459	0.813	0.632	0.968
2016	1.154	1.531	0.754	0.558	0.924
2017	1.217	1.462	0.832	0.671	0.960
2018	1.167	1.434	0.814	0.699	0.902
2019	1.180	1.456	0.811	0.684	0.909
2020	1.209	1.500	0.806	0.668	0.915
2021	1.263	1.512	0.835	0.693	0.949
Growth Rate 2006-2021	1.6%	2.9%	-1.2%	-2.5%	-0.4%
Growth Rate 2006-2012	2.9%	4.6%	-1.7%	-4.6%	0.2%
Growth Rate 2012-2021	0.7%	1.6%	-0.9%	-1.1%	-0.8%
Growth Rate 2021	8.8%	1.7%	7.2%	7.3%	7.3%

5.9.2 AND's output and input quantity changes

Figure 5.34 graphs the quantity indexes for AND's individual outputs. Figure 5.35 graphs quantity indexes for its six individual inputs. Regarding outputs:

- Circuit length, which has the largest weight in the output index, increased at an average rate of 0.7 per cent per annum from 2006 to 2021, and was 10.5 per cent higher than the 2006 level in 2021 (which is higher than the increase of 5.2 per cent for the industry over the same period).

- AND's energy throughput increased marginally, at an average rate of 0.1 per cent per annum between 2006 and 2021, and by 2021 was only 0.9 per cent above its 2006 level.
- RMD increased between 2006 and 2021 in total by 30.8 per cent, representing an average annual growth rate of 1.9 per cent. This is a much larger increase than the 18.1 per cent total increase in RMD for the industry between 2006 and 2021.
- AND's customers increased at an average rate of 1.8 per cent per annum between 2006 and 2021, or 29.5 per cent in total. This is higher than total customer growth for the industry over the same period of 22.0 per cent.
- Although CMOS was higher in the period 2018 to 2020, in 2021 it declined by 60.4 per cent and was 13.5 per cent below the 2006 level. This is similar to the average for the industry, which in 2021 was 11.4 per cent below the 2006 level.

Turning to inputs shown in Figure 5.35, we see:

- The quantity of AND's opex input increased at an average annual rate of 4.1 per cent from 2006 to 2021, and in the latter year it was 82.4 per cent above its level in 2006, which compares unfavourably to the total increase of 8.7 per cent for the industry over the same period. In the period up to 2012, AND's opex input increased at an average rate of 7.5 per cent per annum, and from 2012 to 2021 it increased at an average rate of 1.8 per cent per annum.
- Overhead sub-transmission and distribution lines in 2021 were 12.7 and 0.2 per cent higher, respectively, than their 2006 level. These increases compare to the 14.4 per cent and 13.6 per cent increases respectively for the industry over the same period.
- Underground sub-transmission and distribution cables in 2021 were 226.8 per cent and 109.2 per cent higher than in 2006 respectively, compared to increases of 37.6 per cent and 68.6 per cent respectively for the industry over the same period.
- AND's transformer inputs, which have the largest weight in the input index, increased over the 16-year period at an average rate of 2.5 per cent per annum. By 2021, transformer inputs were 44.3 per cent above the 2006 level, similar to the industry increase of 42.2 per cent over the same period.

Figure 5.34 AND's output quantity indexes, 2006–2021

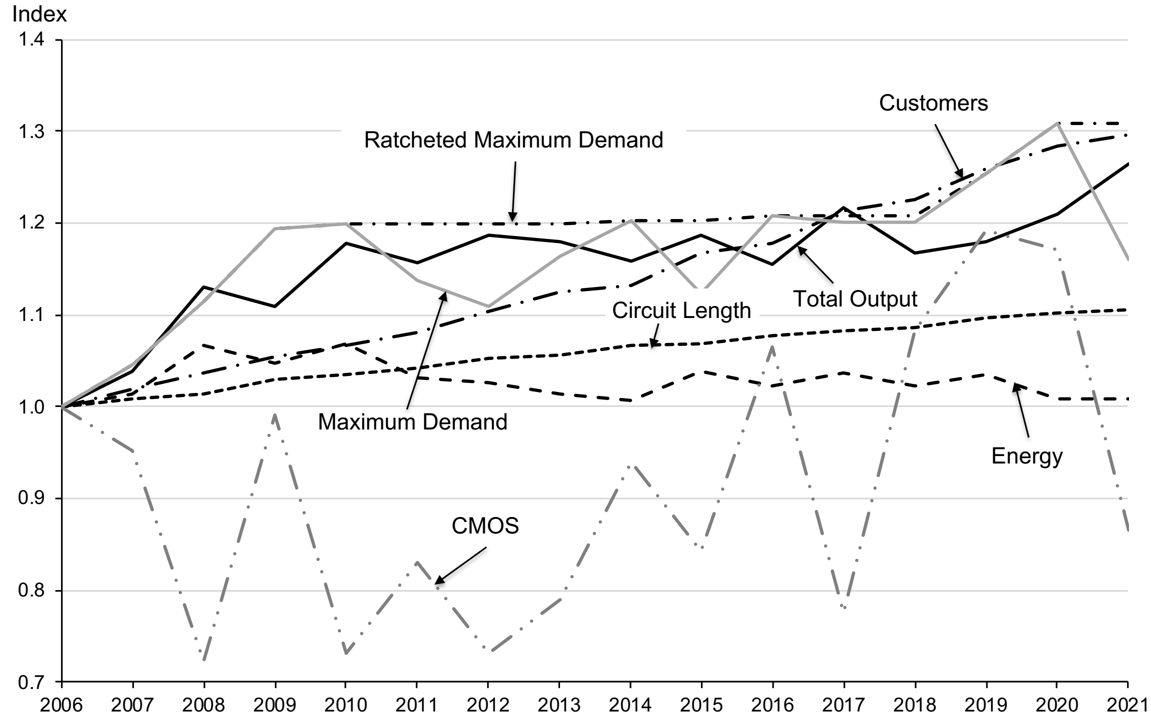
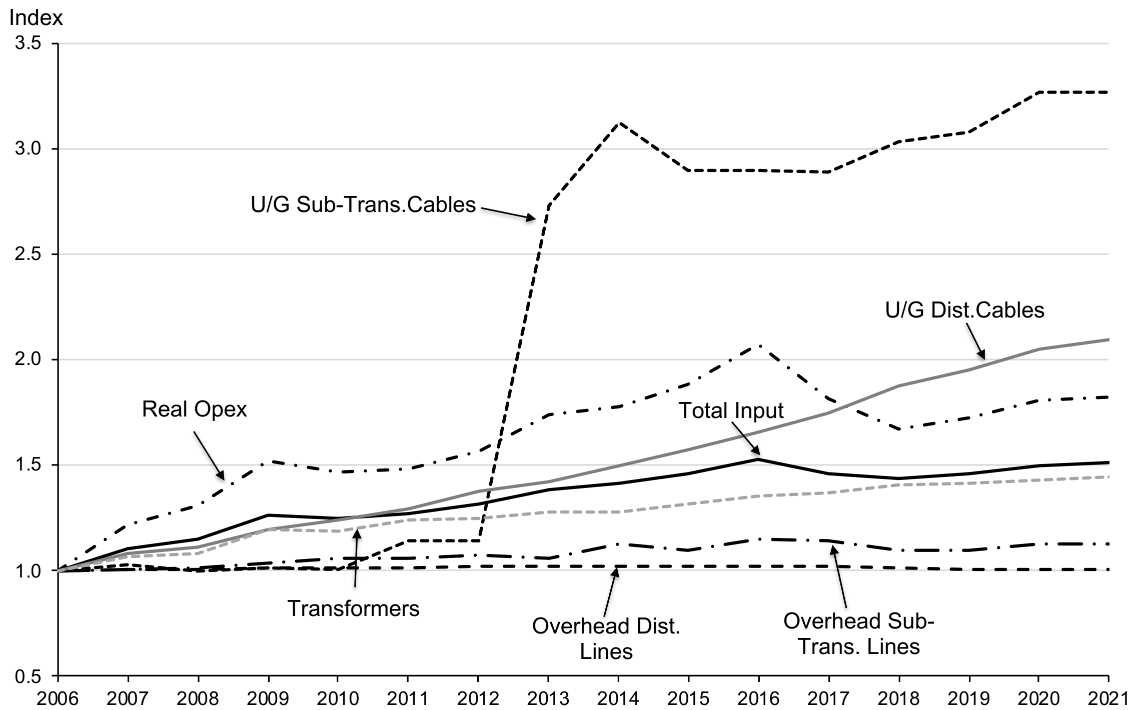


Figure 5.35 AND's input quantity indexes, 2006–2021



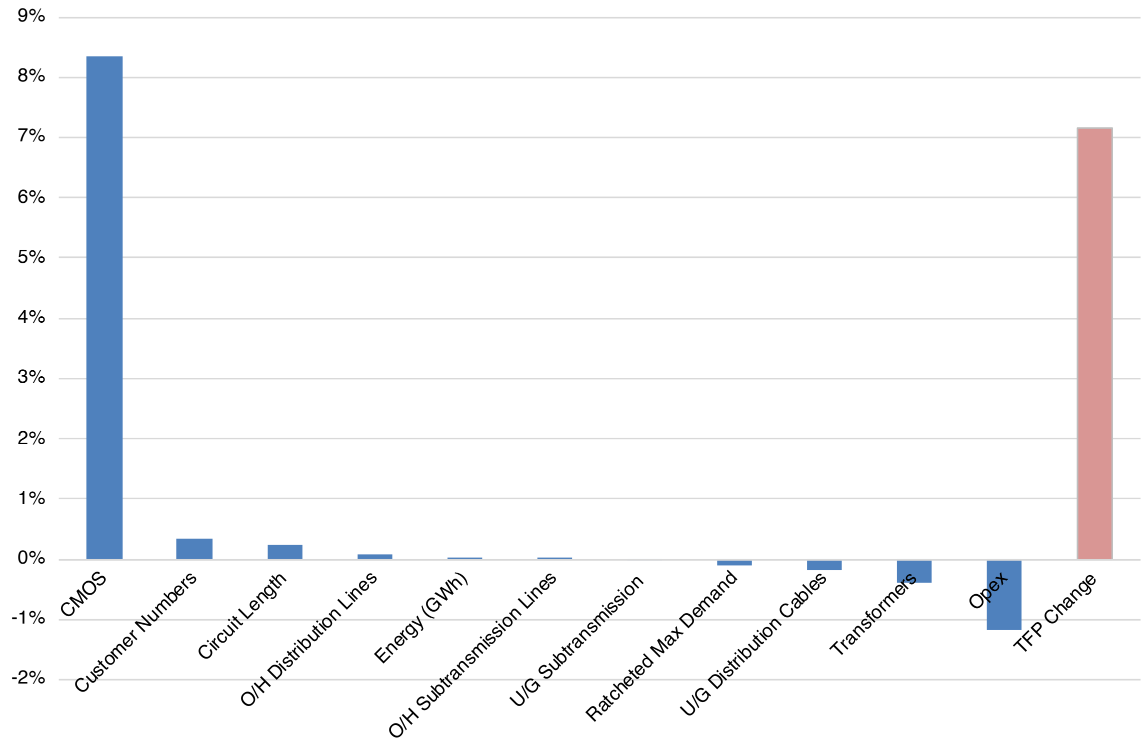
5.9.3 AND's output and input contributions to TFP change

Table 5.18 shows the decomposition of AND's rate of TFP change into the contributions of the individual outputs and inputs for the whole 16-year period, for the periods up to and after 2012, and for 2021. Figure 5.36 shows the contributions of outputs and inputs to AND's rate of TFP change between 2020 and 2021.

Table 5.18 AND's output and input percentage point contributions to average annual TFP change: various periods

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2020 to 2021*
Energy (GWh)	0.01%	0.05%	-0.02%	0.02%
Ratcheted Max Demand	0.70%	1.22%	0.36%	-0.09%
Customer Numbers	0.38%	0.37%	0.39%	0.33%
Circuit Length	0.31%	0.40%	0.25%	0.23%
CMOS	0.45%	0.82%	0.19%	8.34%
Opex	-1.68%	-3.02%	-0.78%	-1.18%
O/H Subtransmission Lines	-0.02%	-0.03%	-0.01%	0.01%
O/H Distribution Lines	0.00%	-0.08%	0.06%	0.09%
U/G Subtransmission Cables	-0.02%	-0.01%	-0.03%	-0.01%
U/G Distribution Cables	-0.58%	-0.67%	-0.53%	-0.17%
Transformers	-0.52%	-0.78%	-0.34%	-0.40%
TFP Change	-0.96%	-1.73%	-0.45%	7.17%

Figure 5.36 AND's output and input percentage point contributions to TFP change, 2021



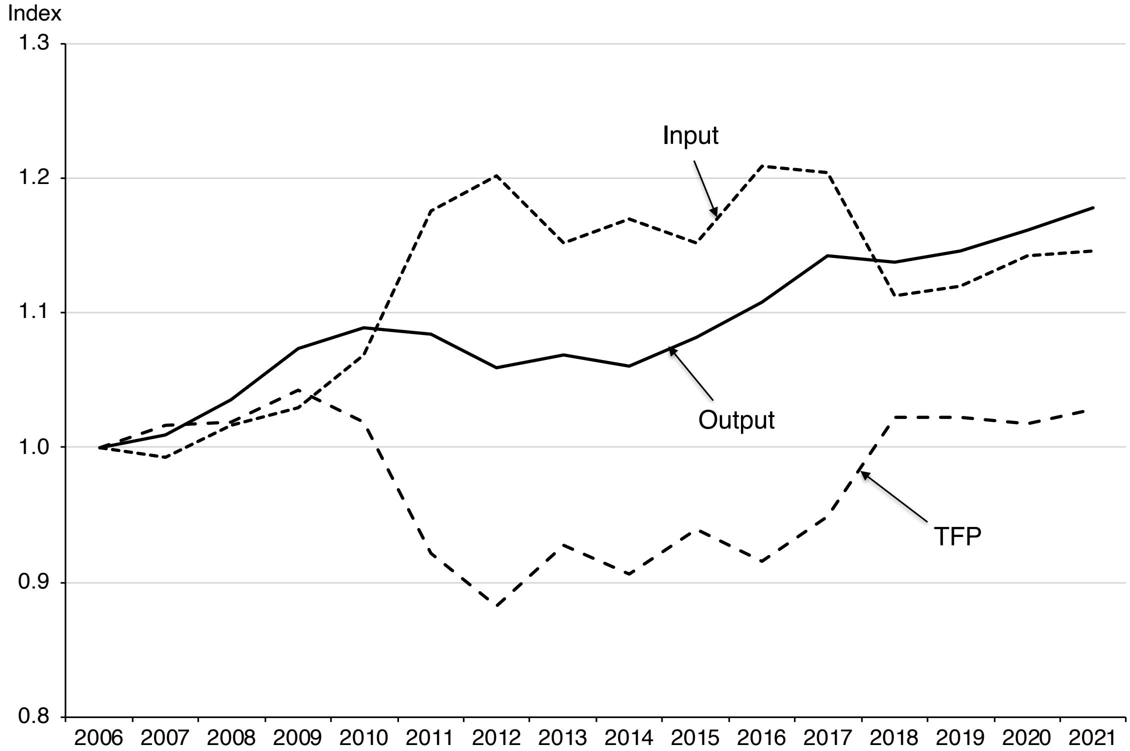
5.10 United Energy (UED)

In 2021, UED delivered 7,487 GWh to 705,367 customers over 13,453 circuit kilometres of lines and cables. UED distributes electricity across east and south–east Melbourne and the Mornington Peninsula.

5.10.1 UED's productivity performance

UED's total output, total input and TFP indexes are presented in Figure 5.37 and Table 5.19. Opex and capital PFP indexes are also presented in Table 5.19.

Figure 5.37 UED's output, input and TFP indexes, 2006–2021



Over the 16-year period 2006 to 2021, UED's TFP increased marginally, at an average annual rate of 0.2 per cent per annum, which can be compared to the industry's average annual change of –0.5 per cent over the same period. UED's TFP *decreased* by 2.1 per cent per year, on average, from 2006 to 2012. It increased by an average of 1.8 per cent per year from 2012 to 2021.

UED's total output increased over the period from 2006 to 2021 at an average annual rate of 1.1 per cent, similar to the industry average rate of growth in output of 1.0 per cent per annum for the same period. UED's average annual rate of increase in input use of 0.9 per cent was lower than the rate of increase in total input use for the industry (1.5 per cent per year). The rate of growth of input usage was much higher in the period 2006 to 2012 (averaging 3.1 per cent per year) and decreased in the period 2012 to 2021 (averaging –0.6 per cent per year).

The PFP indexes in Table 5.19 show the following trends:

- Capital PFP declined on average over the 16-year period, although this decline was concentrated in the period up to 2012. In the period from 2006 to 2012, the rate of change in Capital PFP averaged –1.7 per cent per annum, and after 2012 its average rate of change was 0.2 per cent per annum. On average from 2006 to 2021, the average rate of change UED's in capital PFP was –0.6 per cent per annum.
- Opex PFP increased over the 16-year period, the average rate of change being 1.4 per cent per annum. Over the period to 2012, the average rate of change of opex PFP was –2.6 per cent per annum, and in the period after 2012, it was 4.2 per cent per annum.

Table 5.19 UED's output, input, TFP and PFP indexes, 2006–2021

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	1.009	0.993	1.016	1.070	0.983
2008	1.036	1.016	1.019	1.094	0.974
2009	1.074	1.029	1.043	1.115	0.998
2010	1.088	1.069	1.018	1.083	0.978
2011	1.084	1.176	0.922	0.880	0.954
2012	1.060	1.201	0.882	0.855	0.904
2013	1.068	1.152	0.927	0.967	0.902
2014	1.060	1.170	0.906	0.939	0.885
2015	1.082	1.152	0.940	1.010	0.897
2016	1.107	1.209	0.916	0.894	0.927
2017	1.142	1.204	0.949	0.980	0.927
2018	1.137	1.112	1.022	1.229	0.916
2019	1.146	1.120	1.023	1.235	0.914
2020	1.161	1.142	1.017	1.194	0.920
2021	1.178	1.146	1.028	1.216	0.922
Growth Rate 2006-2021	1.1%	0.9%	0.2%	1.4%	-0.6%
Growth Rate 2006-2012	1.0%	3.1%	-2.1%	-2.6%	-1.7%
Growth Rate 2012-2021	1.3%	-0.6%	1.8%	4.2%	0.2%
Growth Rate 2021	2.9%	0.7%	2.2%	3.8%	0.3%

5.10.2 UED's output and input quantity changes

Figure 5.38 graphs the quantity indexes for UED's individual outputs. Figure 5.39 graphs quantity indexes for its six individual inputs. Regarding outputs:

- UED's circuit length increased at an average rate of 0.6 per cent per annum from 2006 to 2021; with a total increase of 8.6 per cent over this period (which is higher than the increase of 5.2 per cent total increase for the industry over the same period).

- UED's energy throughput decreased between 2006 and 2021, averaging an annual rate of –0.4 per cent per annum (similar to –0.3 per cent per annum for the industry). UED's energy throughput in 2021 was 5.4 per cent below its 2006 level.
- RMD increased from 2006 to 2009 and has remained essentially constant thereafter, except for a small further increase in 2014. In 2021, UED's RMD was 24.3 per cent higher than it was in 2006.
- UED's customers increased at an average rate of 1.0 per cent per annum between 2006 and 2021, or 15.1 per cent in total, which is less than the average rate of customer growth for the industry over the same period of 1.3 per cent per annum, or 22.0 per cent in total.
- CMOS increased considerably in the period up to 2012 but has since declined. In 2021, UED's level of CMOS was 40.5 per cent below its level in 2006. This compares favourably to a decrease of 11.4 per cent for the industry over the same period.

Turning to inputs shown in Figure 5.39, we see:

- The quantity of opex *decreased* at an average annual rate of 0.2 per cent from 2006 to 2021, and by 2021 opex was 3.1 per cent below its level in 2006, which compares favourably to the total increase of 8.7 per cent for the industry over the same period. In the period up to 2012, opex input increased at an average rate of 3.6 per cent per annum. After 2012, opex input *decreased* at an average rate of 2.9 per cent per annum.
- Overhead sub-transmission and distribution lines in 2021 were 24.3 and 4.4 per cent higher, respectively, than their 2006 level. These increases can be compared to the 14.4 per cent and 13.6 per cent increases, respectively, for the industry over the same period.
- Underground sub-transmission and distribution cables in 2021 were 22.5 per cent and 52.7 per cent higher than in 2006 respectively. This can be compared to increases of 37.6 per cent and 68.6 per cent respectively for the industry over the same period.
- UED's quantity of transformers increased, at an average rate of 2.5 per cent per annum over the 16-year period. By 2021, transformer inputs were 44.7 per cent above the 2006 level, which is similar to the increase for the industry.

Figure 5.38 UED's output quantity indexes, 2006–2021

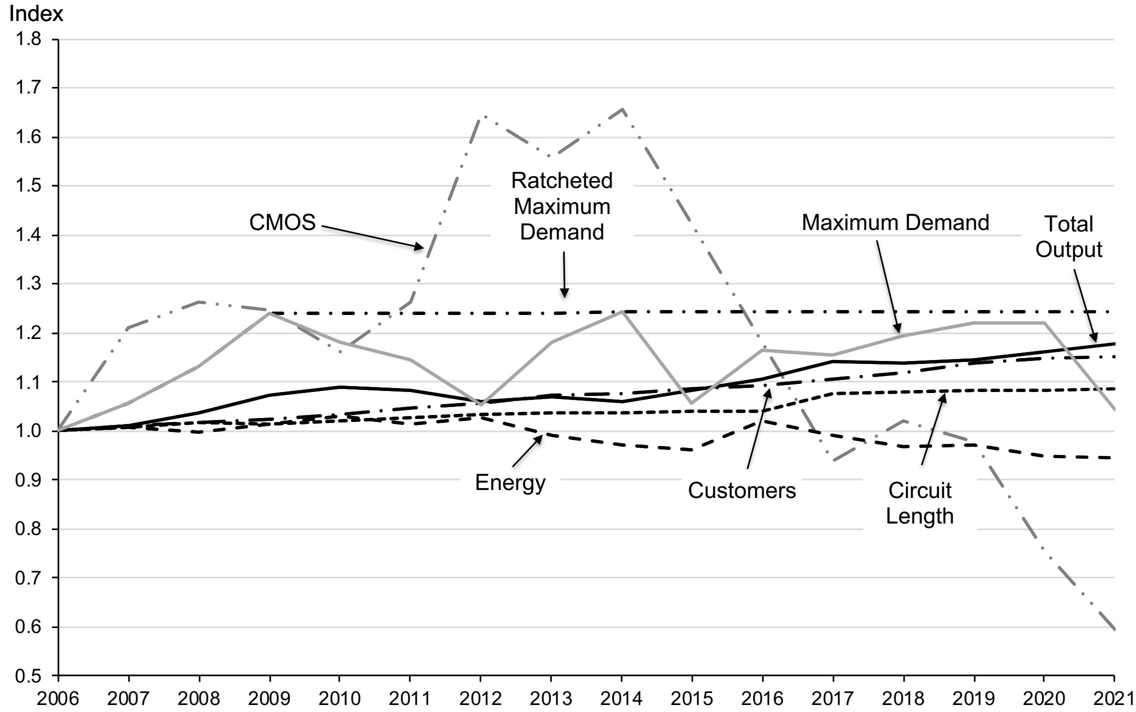
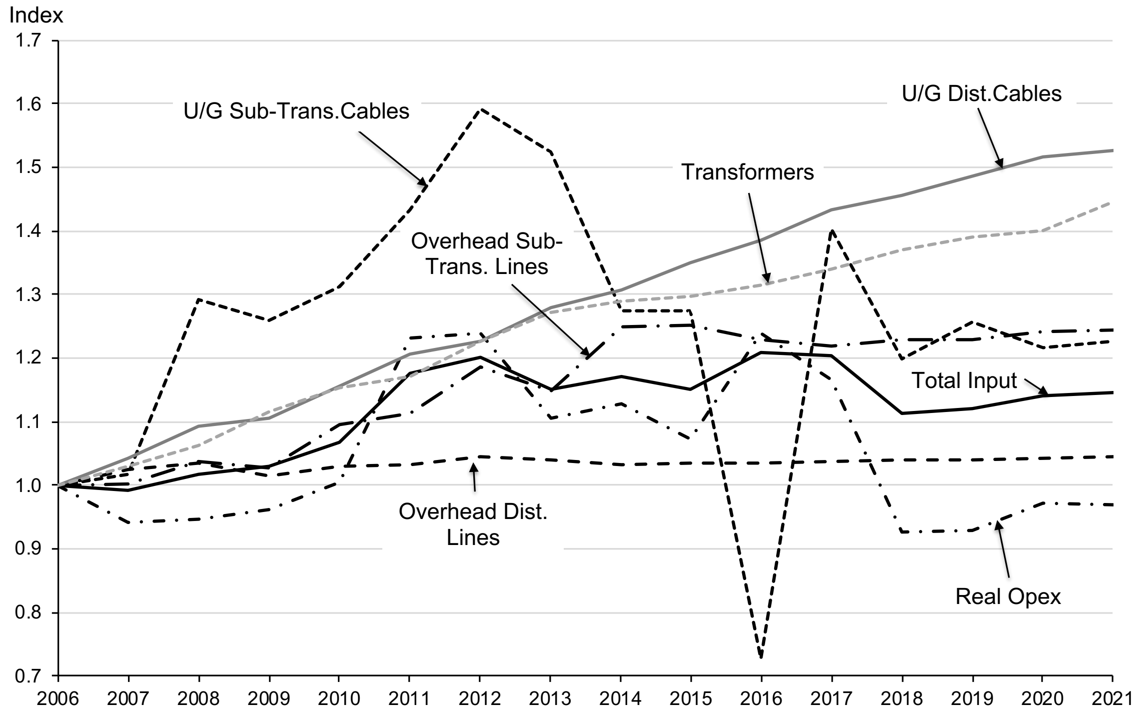


Figure 5.39 UED's input quantity indexes, 2006–2021



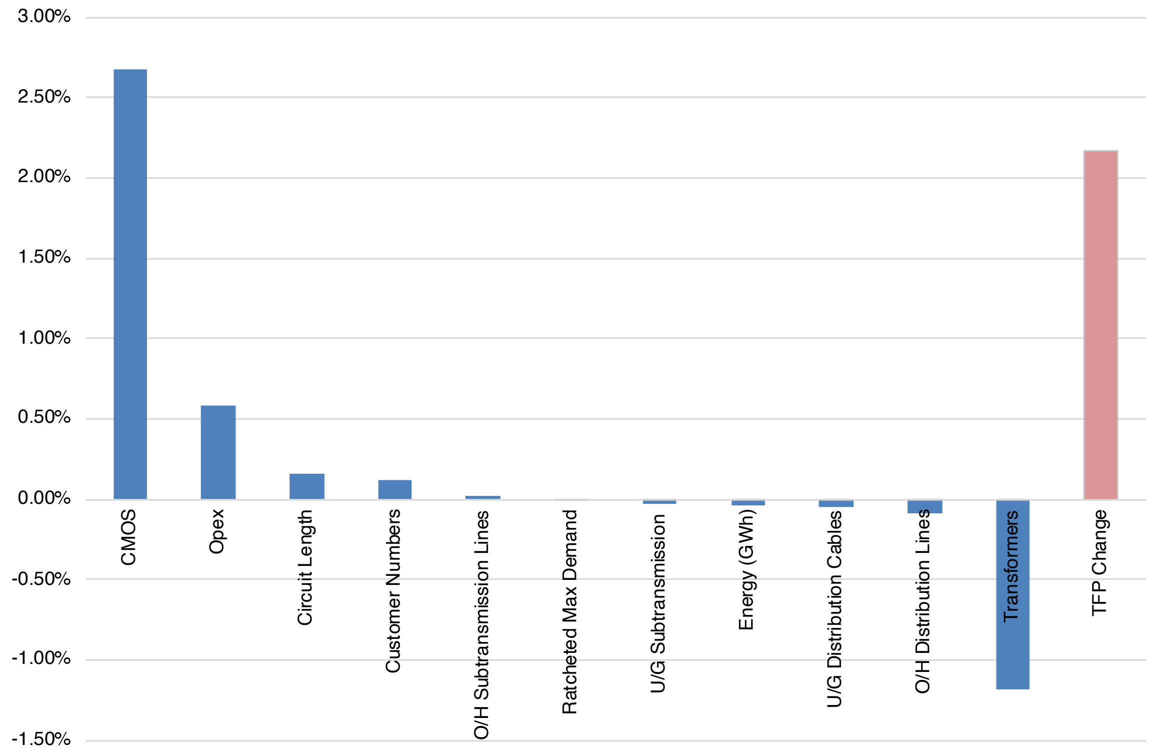
5.10.3 UED's output and input contributions to TFP change

Table 5.20 shows the decomposition of UED's rate of TFP change into the contributions of the individual outputs and inputs for the whole 16-year period, for the periods up to and after 2012, and for 2021 . Figure 6.40 shows the contributions of outputs and inputs to UED's rate of TFP change between 2020 and 2021.

Table 5.20 UED's output and input percentage point contributions to average annual TFP change: various points

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2020 to 2021*
Energy (GWh)	-0.03%	0.04%	-0.09%	-0.04%
Ratcheted Max Demand	0.53%	1.31%	0.01%	0.00%
Customer Numbers	0.19%	0.18%	0.19%	0.12%
Circuit Length	0.24%	0.24%	0.23%	0.16%
CMOS	0.27%	-0.81%	1.00%	2.68%
Opex	0.10%	-1.46%	1.14%	0.58%
O/H Subtransmission Lines	-0.09%	-0.18%	-0.04%	0.02%
O/H Distribution Lines	-0.06%	-0.15%	0.00%	-0.08%
U/G Subtransmission Cables	-0.02%	-0.14%	0.06%	-0.03%
U/G Distribution Cables	-0.26%	-0.30%	-0.23%	-0.05%
Transformers	-0.60%	-0.84%	-0.45%	-1.19%
TFP Change	0.26%	-2.09%	1.83%	2.17%

Figure 5.40 UED's output and input percentage point contributions to TFP change, 2021



Appendix A: Methodology

A1 Indexing Methods

Productivity refers to the quantitative relationship between the outputs produced (by a firm, industry, or economy) and the inputs used to produce those outputs. This report concerns the outputs produced and inputs used by electricity distribution businesses, and the relationship of outputs to inputs is measured using an index of outputs produced and an index of inputs used. ‘Total factor productivity’ (TFP) refers to the ratio of an index of all outputs produced by a business to an index of all inputs consumed in producing those outputs. ‘Partial factor productivity’ (PFP) refers to a ratio of a measure of all or some outputs to a measure of a single input. This report measures TFP using the multilateral Törnqvist TFP (MTFP) index method developed by Caves, Christensen and Diewert (1982).

A1.1 Multilateral Törnqvist TFP index

The method for calculating time series TFP rates of change for individual DNSPs is the same method as that used for calculating the comparative levels of TFP between DNSPs, namely the multilateral Törnqvist TFP index (MTFP) of Caves, Christensen and Diewert (1982) shown in equation (1). For the productivity growth and contributions analyses the multilateral Törnqvist index is applied to the annual time-series observations for each of the 13 DNSP individually, to each of the aggregated data at the state level, and to the aggregated time-series for the industry as a whole. For productivity comparative analysis, for comparing between DNSPs, the data is pooled as panel data and the index is applied across the full sample of 208 observations. For productivity comparative analysis of States (and Territories), the data for the six States is pooled as panel data and the index is applied across the resulting sample of 96 observations.

$$\ln\left(\frac{TFP_m}{TFP_n}\right) = \sum_i \left(\frac{R_{im} + R_i^*}{2}\right) \ln\left(\frac{Y_{im}}{Y_i^*}\right) - \sum_i \left(\frac{R_{in} + R_i^*}{2}\right) \ln\left(\frac{Y_{in}}{Y_i^*}\right) \qquad (1)$$

$$- \sum_j \left(\frac{S_{jm} + S_j^*}{2}\right) \ln\left(\frac{X_{jm}}{X_j^*}\right) + \sum_j \left(\frac{S_{jn} + S_j^*}{2}\right) \ln\left(\frac{X_{jn}}{X_j^*}\right)$$

where m and n are two adjacent observations;[13] i denotes individual outputs; j denotes individual inputs; and

- R_{im} is the revenue share of the ith output at observation m;

[13] A sequence of observations will be ordered by firm and by time-period. When the sample includes more than one firm, m might represent the period after n for the same firm, or n might represent the last observation for one firm and m would then represent the first observation of the next firm. If there is only one firm in the sample, the m is the period after n.

- S_{jm} is the cost share of the *j*th input at observation *m*;
- R_i^* is the revenue share of the *i*th output averaged over the whole sample;[14]
- S_j^* is the cost share of the *j*th input averaged over the whole sample;
- Y_{im} is the quantity of the *i*th output at observation *m*;
- X_{jm} is the quantity of the *j*th input at observation *m*;
- Y_i^* is the average quantity of the *i*th output over the whole sample;
- X_j^* is the average quantity of the *j*th input over the whole sample.

To derive the TFP index, an arbitrarily chosen observation is set equal to 1.0. Here the first observation in the sample is used, and the rates of change for every subsequent observation in the sample, calculated using (A.1), are applied sequentially from this base.

The MTFP allows comparisons of the absolute levels as well as growth rates of productivity. It satisfies the technical properties of transitivity and characteristicity which are required to accurately compare TFP levels within panel data. Transitivity states that direct comparisons between observations *m* and *n* should be the same as indirect comparisons of *m* and *n* via any intermediate observation *k*. 'Characteristicity' says that when comparing two observations, the index should use sufficient information relating to those two observations.[15] The multilateral Törnqvist index satisfies these properties for the whole sample by making comparisons through the sample mean.

Because the multilateral Törnqvist productivity indexes focus on preserving comparability of productivity levels across NSPs and over time by doing all comparisons through the sample mean, there may sometimes be minor changes in historical results as the sample is updated in each annual benchmarking report and, hence, the sample mean changes over time. This is a necessary trade-off for the MTFP index to satisfy the technical properties of transitivity and characteristicity which allow comparability of productivity levels across NSPs and over time.

A1.2 Output and Input Indexes

The rate of change in TFP is equal to the rate of change in the output index minus the rate of change in the input index. Equation (1) can be separated into these two components. The rate of change in the output index is given by:

[14] If there is more than one firm in the sample, it is the average over all firms and all periods. If there is only one firm in the sample, it is the average over all periods.

[15] Caves, Christensen and Diewert (1982, 74) state that 'characteristicity' refers to the "degree to which weights are specific to the comparison at hand". The OECD (2012, 236) (in relation to purchasing power parities) suggests that 'characteristicity' is a property whereby multilateral comparisons differ as little as possible from binary comparisons, subject to satisfying transitivity.

$$\ln\left(\frac{Y_m}{Y_n}\right) = \sum_i \left(\frac{R_{im} + R_i^*}{2}\right) \ln\left(\frac{Y_{im}}{Y_i^*}\right) - \sum_i \left(\frac{R_{in} + R_i^*}{2}\right) \ln\left(\frac{Y_{in}}{Y_i^*}\right) \tag{2}$$

Similarly, the rate of change in the input index is given by:

$$\ln\left(\frac{X_m}{X_n}\right) = \sum_j \left(\frac{S_{jm} + S_j^*}{2}\right) \ln\left(\frac{X_{jm}}{X_j^*}\right) - \sum_j \left(\frac{S_{jn} + S_j^*}{2}\right) \ln\left(\frac{X_{jn}}{X_j^*}\right) \tag{3}$$

Again. these are converted into output and input indexes by setting the value for the index at the first observation of the sample as equal to 1.0 and applying the rates of change specified by (2) or (3), as appropriate, sequentially for every subsequent observation in the sample.

A1.3 Partial Factor Productivity Indexes

Analysis of partial factor productivity (PFP) trends, where total output is expressed relative to individual inputs, assists to interpret the sources of TFP trends. A partial factor productivity measure is obtained by dividing the index of all outputs over an index of one input, or over an index of a sub-group of inputs. Also note that for the construction of PFP indexes, we may need inputs indexes for individual inputs, or for sub-groups of inputs. For a sub-group of inputs, equation (3) applies, but the summation is only over the inputs in the sub-group, and the cost shares need to be re-scaled to sum to 1 for the sub-group. For an individual input k, the growth rate is given simply by: $\ln(X_{km}/X_{kn})$. Again, the index is obtained by setting the first observation in the data set to 1.0.

A1.4 Growth Rates of Indexes

Growth rates in productivity indexes have generally been reported in earlier Economic Insights reports as logarithmic measures, and this report uses the same method of calculation for growth rates presented in Tables. That is, the growth rate of a variable Y between period t – 1 and period t is calculated as: $g_t^Y = \ln Y_t - \ln Y_{t-1}$.[16] The log-difference growth rate can be related to the more common growth rate measure based on the first period as follows: $(Y_t - Y_{t-1})/Y_{t-1} = \exp(g_t^Y) - 1$. That is, the relative index values are: $Y_t/Y_{t-1} = \exp(g_t^Y)$.

Although reported annual growth rates are measured as log-differences, the discussion in this report also refers to total percentage changes over the whole period from 2006 to 2021, and these comparisons are not expressed in terms of log growth rates. Economic Insights (2020a Appendix C) also included, as supplementary information, trend measures of annual growth

[16] It follows that some decreases in positively-valued variables can be larger (in absolute terms) than –100 per cent. For example, if $Y_{t-1} = 150$ and $Y_t = 50$, then the rate of change using the log measure is –109.9 per cent. This is because the basis for the rate of change measure is not period t – 1, but at a mid-point between periods t – 1 and t.

rates based on linear regression.[17] This report also presents regression-based trend estimates for TFP indexes in Appendix B.

A2 Output and input contributions to TFP change

Analysis of contributions to TFP change of the individual outputs and inputs, which involves decomposing TFP change into its constituent parts. Since TFP change is the change in total output quantity less the change in total input quantity, the contribution of an individual output (input) will depend on the change in the output's (input's) quantity and the weight it receives in forming the total output (total input) quantity index. However, this calculation has to be done in a way that is consistent with the index methodology to provide a decomposition that is consistent and robust. The multilateral Törnqvist index methodology allows us to readily decompose productivity change into the contributions of changes in each output and each input.

The analysis of contributions to TFP change is carried out only for individual firm and industry TFP trends. In this case subscripts n and m in equation (1) refer only to successive periods. To emphasise this, m is denoted t and n is denoted $t-1$. The *percentage point contribution* of output i to productivity change between years t and $t-1$ ($Cont_{i,t}^{Y}$) is given by the following equation:

$$Cont_{i,t}^{Y} = \left(\frac{R_{i,t} + R_i^*}{2}\right) \ln\left(\frac{Y_{i,t}}{Y_i^*}\right) - \left(\frac{R_{i,t-1} + R_i^*}{2}\right) \ln\left(\frac{Y_{i,t-1}}{Y_i^*}\right) \quad (4)$$

And, the *percentage point contribution* of input j to productivity change between years t and $t-1$ ($Cont_{j,t}^{X}$) is given by the following equation:

$$Cont_{j,t}^{X} = \left(\frac{S_{j,t} + S_j^*}{2}\right) \ln\left(\frac{X_{j,t}}{X_j^*}\right) - \left(\frac{S_{j,t-1} + S_j^*}{2}\right) \ln\left(\frac{X_{j,t-1}}{X_j^*}\right) \quad (5)$$

where all variables in equations (4) and (5) have the same definition as those in equation (1). Using these consistent equations ensures the sum of the percentage point contributions of all outputs and all inputs equals the rate of TFP change obtained in equation (1).

A3 Index Weights

This section explains the method by which index weights are calculated based on value shares of outputs and cost shares of inputs. The value shares applied to outputs are shadow prices based on estimates of the marginal cost of producing each output. For four of the outputs, an econometric cost analysis was used to derive the marginal cost estimates for each output used

[17] For the linear regression model: $\ln Y_t = a + b.t + \varepsilon_t$, the estimated coefficient $\hat{b}$ is a measure of the average annual growth rate of Y over the sample period.

as the basis for value-share weights. Economic Insights (2020a Appendix B) estimated the costs attributable to each output using the data and method described below. Those estimates are intended to apply for several years and are used in this study.

A3.1 Leontief Cost Function Estimation

In the index analysis in this study, the output specification is based on functional outputs, and the weights for these outputs are based on the imputed or shadow values of these outputs. These imputed values were estimated by Economic Insights (2020a) using econometric analysis of the total cost function. A multi–output Leontief cost function specification was used, and output cost shares were estimated for each of the outputs used in the index analysis. The method used by Economic Insights was a similar procedure to that used in Lawrence (2003) and Lawrence and Diewert (2006). This study uses the same weights, which are shown in Table A.1.

A3.2 Weight of CMOS & Re-calibration of Output Weights

The fifth output is Customer Minutes Off-supply (CMOS), the negative of which is a measure supply reliability. The formal way in which reliability is incorporated into the analysis is to treat CMOS as an undesirable output. The method of incorporating undesirable outputs into the multilateral productivity index originates with Pittman (1983), and the method used here is consistent with that approach.

The weight applied to the reliability output is based on the estimated (negative) value of CMOS (i.e. the cost imposed on consumers) as measured by the Values of Customer Reliability (VCR) published by the AER (2019a; 2019b). Since direct data are not readily available on the cost of improving DNSP reliability, economic benchmarking has relied on the VCR, which is a measure of how consumers value supply interruptions. The VCR, expressed on a per minute basis, is multiplied by the quantity of CMOS. That is, the cost of CMOS is based on: $CMOS \times VCR$.

Weights are then re-calibrated as shares of 'gross revenue', which is defined as the sum of total revenue plus the value of energy not supplied. Since reliability carries a negative weight in the output index, this ensures that all the weights sum to unity. This is shown in Table A.1, using sample average values; weights as shares of total revenue vary across observations in the sample because both revenue and the value of CMOS vary.

Table A.1 Output cost-based weights (industry average*)

Output	*Shares of gross revenue (%)*	*Shares of revenue (%)*
Energy throughput	8.58[(a)]	9.74
Ratcheted max. demand	33.76[(a)]	38.34
Customer numbers	18.52[(a)]	21.03
Circuit length	39.14[(a)]	44.45
CMOS	-11.97	-13.56
Total		100.00

Note: Percentages shown may not sum to 100.00 due to rounding.
* Average across all observations (DNSPs and years);
(a) Derived from Economic Insights' Leontief cost function analysis.

The average output weights for each DNSP and for the aggregated industry are shown in Table A.2.

Table A.2 Output cost share weights by DNSP (%, average 2006 to 2021)

Input	*EVO*	*AGD*	*CIT*	*END*	*ENX*	*ERG*	*ESS*
Energy throughput	8.89	9.48	8.95	9.74	9.50	10.86	10.42
Ratcheted max. demand	35.00	37.30	35.23	38.32	37.37	42.73	40.99
Customer numbers	19.20	20.46	19.32	21.02	20.50	23.44	22.49
Circuit length	40.58	43.25	40.84	44.43	43.33	49.54	47.52
CMOS	-3.67	-10.50	-4.34	-13.52	-10.71	-26.57	-21.42
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Input	*JEN*	*PCR*	*SAP*	*AND*	*TND*	*UED*	*Industry**
Energy throughput	9.26	10.21	10.02	9.88	10.15	9.29	9.87
Ratcheted max. demand	36.45	40.18	39.41	38.89	39.95	36.55	38.83
Customer numbers	19.99	22.04	21.62	21.33	21.92	20.05	21.30
Circuit length	42.25	46.58	45.69	45.08	46.32	42.37	45.02
CMOS	-7.96	-19.01	-16.74	-15.18	-18.35	-8.26	-15.02
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Note: Percentages shown may not sum to 100.00 due to rounding.
* Average across years for aggregated industry.

A3.4 Input weights & Asset Unit Costs

The input weights are the estimated cost shares of each input. The cost of the opex input is nominal opex. The cost of the capital inputs, in aggregate, is calculated by the AER from the other components of the building block calculation, namely: (a) the return on capital – i.e., the weighted average cost of capital (WACC) applied to the opening regulatory asset base (RAB); (b) the return of capital – the straight-line depreciation of the RAB less the inflation indexation of the RAB; and (c) benchmark tax liability. Using this information, the annual user cost (AUC) is calculated for each asset class. Table A.3 shows the average cost shares of each input for each DNSP.

Table A.3 Input cost share weights by DNSP (%, average 2006 to 2021)

Input	*EVO*	*AGD*	*CIT*	*END*	*ENX*	*ERG*	*ESS*
Real opex	38.84	36.03	26.63	39.30	36.33	35.92	40.19
O/H Subtrans. lines	3.41	4.04	0.55	3.91	3.61	9.42	6.96
O/H Distribution lines	12.33	6.72	6.82	9.81	12.13	21.60	20.10
U/G Subtrans. cables	0.06	5.96	6.77	1.69	4.82	0.47	0.20
U/G Distribution cables	18.54	14.26	34.46	16.45	11.92	3.40	3.84
Transformers	26.82	32.98	24.77	28.84	31.19	29.19	28.72
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Input	*JEN*	*PCR*	*SAP*	*AND*	*TND*	*UED*	*Industry**
Real opex	42.07	40.32	34.97	40.29	35.33	38.46	37.25
O/H Subtrans. lines	4.87	3.82	2.00	2.60	0.43	7.32	4.72
O/H Distribution lines	29.00	22.34	10.50	24.99	27.58	21.32	15.44
U/G Subtrans. cables	0.19	0.10	0.33	0.22	0.35	1.95	2.31
U/G Distribution cables	2.09	11.38	17.92	11.82	11.85	9.57	11.46
Transformers	21.80	22.03	34.29	20.09	24.46	21.36	28.83
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Note: Percentages shown may not sum to 100.00 due to rounding.
* Average across years for aggregated industry.

A4 Opex Cost Function Methodologies

This section documents the methods used to estimate the econometric cost functions, the results of which are discussed in section 3.2 and presented in detail in Appendix C. To outline the methods used, we begin by defining the following notation:

C = nominal opex;

$Y = (Y_1, Y_2, \ldots, Y_G)$ = a $G \times 1$ vector of output quantities;

$K = (K_1, K_2, \ldots, K_H)$ = a $H \times 1$ vector of capital quantities;[18]

$Z = (Z_1, Z_2, \ldots, Z_R)$ = a $R \times 1$ vector of operating environment factors;[19] and

$W = (W_1, W_2, \ldots, W_S)$ = a $S \times 1$ vector of input prices.

To simplify this notation, we define a vector (X) of length $M = G + H + R + S$, which contains these four vectors together:

$X = (Y, K, Z, W) = (X_1, X_2, \ldots, X_M)$ = an $M \times 1$ vector of output quantities, capital quantities, operating environment factors and input prices.

[18] Note that this is the general functional form for the opex econometric models. In the specific specification used in this report, we have not included capital quantity as an explanatory variable.

[19] In the specific specification used in this report, we have incorporated one operating environment factor into the model, namely the percentage of lines underground.

Lower case notation is used to define the natural logarithms of variables. For example, $x_1 = \ln(X_1)$.

A4.1 Least squares opex cost function methods

The two most commonly used functional forms in econometric estimation of cost functions are the Cobb–Douglas and translog functional forms. These functions are linear in logs and quadratic in logs, respectively. The Cobb–Douglas cost function may be written as:

$$c_{it} = \beta_0 + \sum_{m=1}^{M} \beta_m x_{mit} + \lambda_1 t + v_{it} \tag{6}$$

while the translog cost frontier may be specified as:

$$c_{it} = \beta_0 + \sum_{m=1}^{M} \beta_m x_{mit} + 0.5 \sum_{m=1}^{M} \sum_{l=1}^{M} \beta_{ml} x_{mit} x_{lit} + \lambda_1 t + v_{it} \tag{7}$$

where subscripts i and t denote DNSP and year, respectively. Furthermore, the regressor variable 't' is a time trend variable used to capture the effects of year-to-year technical change (and other factors not modelled that have changed over time such as increasing regulatory obligations), v_{it} is a random disturbance term and the Greek letters denote the unknown parameters that are to be estimated.

One of the two approaches used to measure comparative efficiency of DNSPs in econometric opex cost function is to use fixed effects. One can then include a set of $N – 1$ dummy variables into models (6) and (7) to capture efficiency differences across the N firms in the sample (see Pitt and Lee 1981; Kumbhakar and Lovell 2000). These dummy variables are defined as:

$D_{nit} = 1$ when $n = i$, and is 0 otherwise, (n = 2,…,N).

Including these dummy variables into model (6) we obtain:

$$c_{it} = \beta_0 + \sum_{m=1}^{M} \beta_m x_{mit} + \sum_{n=2}^{N} \delta_n D_{nit} + \lambda_1 t + v_{it} \tag{8}$$

And with the dummy variables, model (7) becomes:

$$c_{it} = \beta_0 + \sum_{m=1}^{M} \beta_m x_{mit} + 0.5 \sum_{m=1}^{M} \sum_{l=1}^{M} \beta_{ml} x_{mit} x_{lit} \tag{9}$$

$$+\sum_{n=2}^{N}\delta_n D_{nit} + \lambda_1 t + v_{it}$$

In this study, the models in equations (8) and (9) are estimated using a variant of *ordinary least squares* (OLS) regression, where OLS is applied to data that has been transformed to correct for serial correlation (assuming a common autoregressive parameter across the DNSPs). Following Economic Insights, we report *panel–corrected standard errors*, where the standard errors have been corrected for cross–sectional heteroskedasticity. The estimation methods used follow those described in Beck and Katz (1995) and Greene (2012 ch.11), and have been calculated using the *xtpcse* command in *Stata Release 16* (StataCorp 2020).

The estimated coefficients of the dummy variables are then used to predict firm–level cost efficiency scores as:

$$CE_n = \exp\left[\min(\hat{\delta}_n) - \hat{\delta}_n\right] \tag{10}$$

where $\delta_1 = 0$ by definition, because it is arbitrarily chosen as the base firm. These cost efficiency scores vary between zero and one with a value of one indicating full cost efficiency, while a value of 0.8 (for example) would imply that the inefficient firm could reduce its opex by 20 per cent and still produce the same level of output.

A4.2 Stochastic frontier analysis opex cost function methods

The above least squares dummy variables approach to estimating cost functions and predicting firm–level cost efficiencies requires access to panel data and an assumption that cost inefficiencies are invariant over time. An alternative approach (that can also be applied to cross–sectional data) is the stochastic frontier analysis (SFA) method proposed by Aigner, Lovell and Schmidt (1977). Following Pitt and Lee (1981), Battese and Coelli (1988) and Kumbhakar and Lovell (2000), we add a one–sided, time–invariant inefficiency disturbance term to the cost function model in (6) to obtain a Cobb–Douglas stochastic cost frontier:

$$c_{it} = \beta_0 + \sum_{m=1}^{M}\beta_m x_{mit} + \lambda_1 t + v_{it} + u_i \tag{11}$$

and to model (7) to obtain a translog stochastic cost frontier:

$$c_{it} = \beta_0 + \sum_{m=1}^{M}\beta_m x_{mit} + 0.5\sum_{m=1}^{M}\sum_{l=1}^{M}\beta_{ml} x_{mit} x_{lit} + \lambda_1 t + v_{it} + u_i \tag{12}$$

where it is assumed that the random disturbance term v_{it} is normally distributed $N(0, \sigma_v^2)$ and independent of the one–sided inefficiency disturbance term u_i, which is assumed to have a truncated normal distribution $|N(\mu, \sigma_u^2)|$. With these distributional assumptions, the unknown parameters in models (11) and (12) can be estimated using Maximum Likelihood Estimation (MLE) methods. In this study we do this using the *xtfrontier* command in *Stata Release 16.*

The cost efficiency score of the *n*th firm is defined as:

$$CE_n = \exp[u_n] \qquad (n = 1,2, \dots, N) \tag{13}$$

However, given that u_n is unobservable, *Stata* makes use of the results in Battese and Coelli (1988) to predict the cost efficiency scores using the conditional expectation:

$$CE_n = E[\exp(u_n)|(v_n + u_n)] \qquad (n = 1,2, \dots, N) \tag{14}$$

where $v_n = (v_{n1}, v_{n2}, \dots, v_{nT})$. Confidence intervals for these predictions can be obtained using the formula presented in Horrace and Schmidt (1996). We have calculated these using the *frontier_teci* Stata ado code written by Merryman (2010).

Appendix B: Regression–based trend growth rates

Table B.1 Output, input, TFP and PFP index trend annual growth rates, 2006–2021

DNSP	*Output*	*Input*	*TFP*	*PFP Index*	
Period	*Index*	*Index*	*Index*	*Opex*	*Capital*
Industry					
Growth Rate 2006–21	0.8%	1.4%	-0.6%	0.4%	-1.2%
Growth Rate 2006–12	1.6%	3.7%	-2.1%	-3.4%	-1.3%
Growth Rate 2012–21	0.5%	0.0%	0.5%	2.9%	-1.0%
EVO					
Growth Rate 2006–21	1.2%	1.1%	0.1%	0.9%	-0.3%
Growth Rate 2006–12	1.2%	3.7%	-2.5%	-5.5%	-0.5%
Growth Rate 2012–21	0.8%	-1.1%	2.0%	5.7%	-0.5%
AGD					
Growth Rate 2006–21	0.5%	0.4%	0.2%	2.4%	-1.0%
Growth Rate 2006–12	1.1%	3.5%	-2.4%	-4.2%	-1.5%
Growth Rate 2012–21	0.1%	-1.7%	1.8%	6.4%	-0.5%
CIT					
Growth Rate 2006–21	0.8%	1.5%	-0.7%	-0.7%	-0.7%
Growth Rate 2006–12	1.2%	3.8%	-2.6%	-5.9%	-1.5%
Growth Rate 2012–21	0.7%	-0.3%	1.0%	3.5%	0.1%
END					
Growth Rate 2006–21	1.3%	1.6%	-0.3%	1.6%	-1.5%
Growth Rate 2006–12	1.7%	3.1%	-1.4%	-1.0%	-1.8%
Growth Rate 2012–21	1.5%	0.5%	1.0%	3.7%	-0.7%
ENX					
Growth Rate 2006–21	1.4%	1.8%	-0.4%	0.4%	-0.9%
Growth Rate 2006–12	3.6%	4.6%	-1.0%	-2.2%	-0.4%
Growth Rate 2012–21	0.5%	0.1%	0.4%	2.8%	-0.9%
ERG					
Growth Rate 2006–21	0.9%	1.2%	-0.3%	0.9%	-1.0%
Growth Rate 2006–12	1.7%	2.4%	-0.7%	-0.9%	-0.7%
Growth Rate 2012–21	0.1%	0.6%	-0.5%	0.9%	-1.3%
ESS					
Growth Rate 2006–21	0.9%	1.7%	-0.8%	0.6%	-1.8%
Growth Rate 2006–12	0.8%	5.2%	-4.4%	-6.4%	-3.2%
Growth Rate 2012–21	0.7%	0.1%	0.6%	3.4%	-1.3%
JEN					
Growth Rate 2006–21	1.2%	1.2%	0.0%	0.1%	-0.1%
Growth Rate 2006–12	2.2%	2.1%	0.1%	-0.9%	0.8%
Growth Rate 2012–21	1.0%	0.2%	0.8%	2.5%	-0.5%

Table B2 (cont.)

DNSP	*Output*	*Input*	*TFP*	*PFP Index*	
Period	*Index*	*Index*	*Index*	*Opex*	*Capital*
PCR					
Growth Rate 2006–21	1.0%	1.7%	-0.7%	-0.2%	-1.0%
Growth Rate 2006–12	1.6%	2.6%	-1.0%	-1.1%	-0.9%
Growth Rate 2012–21	1.0%	0.6%	0.5%	2.5%	-0.9%
SAP					
Growth Rate 2006–21	0.6%	2.1%	-1.5%	-2.2%	-1.1%
Growth Rate 2006–12	1.7%	4.3%	-2.5%	-5.6%	-1.0%
Growth Rate 2012–21	0.2%	0.6%	-0.4%	0.9%	-1.1%
AND					
Growth Rate 2006–21	1.0%	2.4%	-1.4%	-2.2%	-0.9%
Growth Rate 2006–12	2.8%	4.3%	-1.5%	-3.8%	0.1%
Growth Rate 2012–21	0.5%	1.1%	-0.6%	-0.1%	-0.9%
TND					
Growth Rate 2006–21	0.5%	1.2%	-0.7%	-0.3%	-1.0%
Growth Rate 2006–12	0.6%	3.8%	-3.2%	-5.9%	-1.8%
Growth Rate 2012–21	0.2%	0.6%	-0.4%	0.4%	-0.8%
UED					
Growth Rate 2006–21	0.9%	1.0%	0.0%	0.9%	-0.6%
Growth Rate 2006–12	1.3%	3.4%	-2.0%	-3.1%	-1.3%
Growth Rate 2012–21	1.3%	-0.5%	1.8%	4.1%	0.3%

Appendix C: Opex Cost Function Regression Results

C1 Full sample results

C1.1 Regression outputs

The models in this section all have 1,074 observations over 69 DNSPs. The LSE models use panel-corrected standard errors. Table C.1 shows that LSE Cobb-Douglas cost frontier model.

Table C.1 LSE Cobb–Douglas cost function estimates using 2006–2021 data

Variable	*Coefficient*	*Standard error*	*t–ratio*
ln(Custnum)	0.594	0.067	8.914
ln(CircLen)	0.153	0.029	5.268
ln(RMDemand)	0.228	0.061	3.737
ln(ShareUGC)	-0.150	0.023	-6.505
Year	0.011	0.002	6.896
Country dummy variables:			
New Zealand	-0.219	0.139	-1.575
Ontario	-0.069	0.138	-0.500
DNSP dummy variables:			
AGD	0.012	0.187	0.066
CIT	-0.660	0.159	-4.137
END	-0.230	0.157	-1.465
ENX	-0.248	0.148	-1.669
ERG	-0.165	0.166	-0.996
ESS	-0.298	0.172	-1.731
JEN	-0.339	0.161	-2.106
PCR	-0.733	0.156	-4.696
SAP	-0.496	0.156	-3.174
AND	-0.416	0.154	-2.701
TND	-0.470	0.164	-2.861
UED	-0.523	0.158	-3.300
Constant	-12.812	3.331	-3.846
R–Square			0.992

In this model, the coefficients on the output variables (Custnum, CircLen, RMDemand) represent the cost elasticities with respect to each output. They are all statistically significant and positive. The sum of these three elasticities is 0.98, which suggests that a proportionate increase in all three outputs by 1 per cent would raise operating costs by almost 1 per cent.

Table C.2 shows that LSE translog cost frontier model. The elasticities of cost with respect to each output are not constant in the translog model, but vary with the values of the outputs. These elasticities are calculated for both the LSE and SFA models at the sample means of outputs and at various sub-sample means of outputs in Tables C.5 and C.6.

Table C.2 LSE translog cost function estimates using 2006–2021 data

Variable	*Coefficient*	*Standard error*	*t–ratio*
ln(Custnum)=x1	0.432	0.072	6.020
ln(CircLen)=x2	0.165	0.030	5.517
ln(RMDemand)=x3	0.360	0.059	6.062
x1*x1/2	-0.599	0.472	-1.269
x1*x2	0.298	0.114	2.621
x1*x3	0.232	0.363	0.639
x2*x2/2	-0.013	0.041	-0.329
x2*x3	-0.256	0.092	-2.790
x3*x3/2	0.109	0.282	0.387
ln(ShareUGC)	-0.134	0.027	-5.035
Year	0.013	0.002	7.856
Country dummy variables:			
New Zealand	-0.321	0.132	-2.430
Ontario	-0.204	0.131	-1.558
DNSP dummy variables:			
AGD	-0.087	0.189	-0.461
CIT	-0.695	0.152	-4.564
END	-0.365	0.153	-2.378
ENX	-0.358	0.150	-2.396
ERG	-0.330	0.178	-1.851
ESS	-0.533	0.185	-2.886
JEN	-0.219	0.161	-1.360
PCR	-0.862	0.153	-5.623
SAP	-0.662	0.157	-4.231
AND	-0.469	0.152	-3.086
TND	-0.531	0.158	-3.371
UED	-0.425	0.163	-2.615
Constant	-15.578	3.286	-4.741
R–Square			0.992

The SFA models assume time-invariant inefficiencies with a truncated normal distribution. Table C.3 shows the Cobb-Douglas SFA cost model and Table C.4 shows the translog SFA cost model. In the SFA Cobb-Douglas model the sum of output elasticities is 0.97, which is similar to the LSE Cobb-Douglas model. However, the SFACD model has much smaller elasticities for customer numbers and circuit length and larger elasticity for RMD compared to the LSECD model.

Table C.3 SFA Cobb–Douglas cost frontier estimates using 2006–2021 data

Variable	*Coefficient*	*Standard error*	*t–ratio*
ln(Custnum)	0.420	0.077	5.457
ln(CircLen)	0.105	0.041	2.587
ln(RMDemand)	0.449	0.065	6.859
ln(ShareUGC)	-0.186	0.032	-5.875
Year	0.013	0.001	14.207
Country dummy variables:			
New Zealand	0.217	0.091	2.376
Ontario	0.223	0.071	3.145
Constant	-17.383	1.903	-9.135
Variance parameters:			
Mu	0.332	0.061	5.404
SigmaU squared	0.042	0.011	3.710
SigmaV squared	0.014	0.001	22.405
LLF			648.667

Table C.4 SFA translog cost function estimates using 2006–2021 data

Variable	*Coefficient*	*Standard error*	*t–ratio*
ln(Custnum)=x1	0.464	0.081	5.749
ln(CircLen)=x2	0.082	0.052	1.564
ln(RMDemand)=x3	0.428	0.074	5.798
x1*x1/2	0.266	0.461	0.578
x1*x2	-0.127	0.115	-1.104
x1*x3	-0.207	0.380	-0.546
x2*x2/2	0.048	0.061	0.789
x2*x3	0.129	0.100	1.281
x3*x3/2	0.046	0.317	0.145
ln(ShareUGC)	-0.172	0.040	-4.255
Year	0.013	0.001	11.096
Country dummy variables:			
New Zealand	0.275	0.093	2.404
Ontario	0.196	0.084	2.330
Constant	-15.927	2.304	-6.914
Variance parameters:			
Mu	0.279	0.116	2.400
SigmaU squared	0.074	0.038	1.937
SigmaV squared	0.014	0.001	21.922
LLF			652.340

C1.2 Cost elasticities

Table C.5 shows the cost elasticities with respect to each of the outputs for the two translog cost models, in total and for country sub-samples. The patterns of the output elasticities between outputs on average are broadly similar to those for the corresponding Cobb-Douglas model.

Table C.5 Average DNSP output elasticities by country 2006–2021

	SFATLG model			*LSETLG model*		
Sample	*Customer numbers*	*Circuit length*	*RMD*	*Customer numbers*	*Circuit length*	*RMD*
Australia	0.336	0.170	0.391	0.343	0.252	0.445
New Zealand	0.451	0.060	0.545	0.663	0.208	0.060
Ontario	0.519	0.061	0.379	0.340	0.109	0.491
Full sample	0.464	0.082	0.428	0.432	0.165	0.360

Table C.6 shows the cost elasticities with respect to each of the outputs for the two translog cost models, on average for individual Australian DNSPs.

Table C.6 Average DNSP output elasticities by Aust. DNSP, 2006–2021

	SFATLG model			*LSETLG model*		
Sample	*Customer numbers*	*Circuit length*	*RMD*	*Customer numbers*	*Circuit length*	*RMD*
EVO	0.498	0.080	0.345	0.232	0.214	0.519
AGD	0.345	0.194	0.272	0.083	0.273	0.714
CIT	0.503	0.101	0.254	0.045	0.198	0.745
END	0.305	0.201	0.351	0.276	0.221	0.569
ENX	0.313	0.200	0.331	0.212	0.273	0.585
ERG	0.100	0.274	0.585	0.819	0.185	0.102
ESS	0.150	0.243	0.568	0.740	0.273	0.074
JEN	0.538	0.068	0.280	0.058	0.292	0.616
PCR	0.261	0.199	0.465	0.503	0.278	0.278
SAP	0.221	0.222	0.476	0.543	0.250	0.284
AND	0.354	0.153	0.408	0.348	0.321	0.359
TND	0.305	0.169	0.484	0.569	0.191	0.267
UED	0.480	0.110	0.263	0.029	0.304	0.670
Total (Aust.)	0.336	0.170	0.391	0.343	0.252	0.445

C1.3 Monotonicity Performance

In considering the adequacy of the Cobb-Douglas and translog specifications, the primary consideration used in this report is the extent to which there are serious monotonicity violations. Monotonicity refers to the requirement that, all else being constant, an output cannot be increased without an increase in cost, so that the elasticity of cost with respect to each output should not be negative. This is an economic criterion, rather than a statistical criterion. A focus on the monotonicity criterion is consistent with the approach taken in the 2021 report. Tables C.7 and C.8 show the proportions of observations for which there are monotonicity violations in models estimated using the full sample.

The most notable observation is that in these models no monotonicity violations occur among the Australian DNSPs.

Table C.7 Frequency of monotonicity violations by country 2006–2021

	SFATLG model			*LSETLG model*		
Sample	*Customer numbers*	*Circuit length*	*RMD*	*Customer numbers*	*Circuit length*	*RMD*
Australia	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
New Zealand	0.0%	14.8%	0.0%	0.0%	0.0%	43.4%
Ontario	0.0%	15.1%	0.0%	0.0%	0.4%	0.0%
Full sample	0.0%	12.1%	0.0%	0.0%	0.2%	12.3%

Table C.8 Frequency of monotonicity violations by DNSP (Aust.) 2006-2021

	SFATLG model			*LSETLG model*		
Sample	*Customer numbers*	*Circuit length*	*RMD*	*Customer numbers*	*Circuit length*	*RMD*
EVO	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
AGD	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
CIT	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
END	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ENX	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ERG	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ESS	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
JEN	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
PCR	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SAP	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
AND	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
TND	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
UED	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total (Aust.)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

C1.4 Tests of Translog versus Cobb-Douglas Specifications

It can also be informative to have regard to statistical criteria, and so we test the null hypothesis that the additional variables in the translog model, which don't appear in the Cobb-Douglas model, are jointly equal to zero.

- In the LSETLG model, the Wald test for the null hypothesis that coefficients on the higher-order terms (ie, those parameters in table C.2 which don't appear in C.1), are jointly equal to zero yields a p-value of 0.0000. This is less than 0.05, hence the null hypothesis can be rejected at the usual significance level.
- In the SFATLG model, the Wald test for the null hypothesis that coefficients on the higher-order terms are jointly equal to zero yields a p-value of 0.4440. This means that the null hypothesis cannot be rejected at the usual significance level of 0.05.

This means that the higher-order terms included in the translog specification but not included in the Cobb-Douglas specification are only jointly statistically significant in the least squares estimator model.

C2 Sample from 2012 to 2021

C2.1 Regression results

This section presents the cost function econometric results using a shorter sample period from 2012 to 2021. The models in this section all have 666 observations over 69 DNSPs. Tables C.9 and C.10 present the results for the LSE Cobb-Douglas model and the LSE translog model respectively.

Table C.9 LSE Cobb–Douglas cost function estimates using 2012–2021 data

Variable	*Coefficient*	*Standard error*	*t–ratio*
ln(Custnum)	0.610	0.073	8.354
ln(CircLen)	0.179	0.031	5.822
ln(RMDemand)	0.192	0.070	2.746
ln(ShareUGC)	-0.152	0.026	-5.959
Year	0.004	0.003	1.567
Country dummy variables:			
New Zealand	-0.226	0.173	-1.304
Ontario	-0.060	0.172	-0.351
DNSP dummy variables:			
AGD	-0.045	0.214	-0.212
CIT	-0.585	0.187	-3.126
END	-0.283	0.187	-1.515
ENX	-0.256	0.182	-1.404
ERG	-0.254	0.195	-1.305
ESS	-0.322	0.198	-1.622
JEN	-0.345	0.188	-1.831
PCR	-0.782	0.184	-4.240
SAP	-0.478	0.184	-2.600
AND	-0.387	0.181	-2.142
TND	-0.500	0.200	-2.498
UED	-0.547	0.191	-2.864
Constant	2.075	5.185	0.400
R–Square			0.995

Table C.10 LSE translog cost function estimates using 2012–2021 data

Variable	*Coefficient*	*Standard error*	*t–ratio*
ln(Custnum)=x1	0.395	0.077	5.109
ln(CircLen)=x2	0.208	0.030	7.025
ln(RMDemand)=x3	0.358	0.064	5.575
x1*x1/2	-0.923	0.541	-1.704
x1*x2	0.286	0.124	2.310
x1*x3	0.484	0.413	1.173
x2*x2/2	0.043	0.042	1.028
x2*x3	-0.298	0.099	-3.025
x3*x3/2	-0.034	0.316	-0.107
ln(ShareUGC)	-0.116	0.026	-4.541
Year	0.006	0.002	2.592
Country dummy variables:			
New Zealand	-0.364	0.154	-2.358
Ontario	-0.204	0.153	-1.328
DNSP dummy variables:			
AGD	-0.062	0.202	-0.308
CIT	-0.649	0.169	-3.844
END	-0.391	0.171	-2.294
ENX	-0.293	0.171	-1.712
ERG	-0.480	0.195	-2.464
ESS	-0.572	0.201	-2.839
JEN	-0.165	0.176	-0.938
PCR	-0.851	0.172	-4.942
SAP	-0.625	0.173	-3.611
AND	-0.339	0.172	-1.973
TND	-0.568	0.181	-3.139
UED	-0.373	0.181	-2.057
Constant	-2.381	4.888	-0.487
R–Square			0.995

Tables C.11 and C.12 present the results for the SFA Cobb-Douglas model and the SFA translog model respectively.

Table C.11 SFA Cobb–Douglas cost frontier estimates using 2012–2021 data

Variable	*Coefficient*	*Standard error*	*t–ratio*
ln(Custnum)	0.437	0.101	4.338
ln(CircLen)	0.201	0.051	3.944
ln(RMDemand)	0.323	0.093	3.483
ln(ShareUGC)	-0.099	0.044	-2.263
Year	0.005	0.002	3.042
Country dummy variables:			
New Zealand	0.111	0.096	1.163
Ontario	0.242	0.090	2.673
Constant	-0.565	3.352	-0.169
Variance parameters:			
Mu	0.335	0.061	5.525
SigmaU squared	0.036	0.009	3.937
SigmaV squared	0.011	0.001	17.278
LLF			448.522

Table C.12 SFA translog cost function estimates using 2012–2021 data

Variable	*Coefficient*	*Standard error*	*t–ratio*
ln(Custnum)=x1	0.385	0.118	3.276
ln(CircLen)=x2	0.202	0.054	3.734
ln(RMDemand)=x3	0.386	0.104	3.713
x1*x1/2	-1.535	0.641	-2.394
x1*x2	0.404	0.168	2.407
x1*x3	0.864	0.504	1.714
x2*x2/2	0.046	0.077	0.598
x2*x3	-0.406	0.129	-3.139
x3*x3/2	-0.295	0.414	-0.714
ln(ShareUGC)	-0.080	0.051	-1.556
Year	0.007	0.002	3.663
Country dummy variables:			
New Zealand	-0.037	0.117	-0.318
Ontario	0.091	0.098	0.924
Constant	-3.542	3.614	-0.980
Variance parameters:			
Mu	0.432	0.086	5.026
SigmaU squared	0.036	0.011	3.357
SigmaV squared	0.010	0.001	16.301
LLF			464.838

C2.2 Cost Elasticities

Tables C.13 and C.14 provide information on the average elasticities of real opex with respect to each of the outputs in the translog models.

Table C.13 Average DNSP output elasticities by country 2012–2021

	SFATLG model			*LSETLG model*		
Sample	*Customer numbers*	*Circuit length*	*RMD*	*Customer numbers*	*Circuit length*	*RMD*
Australia	-0.151	0.352	0.643	0.102	0.318	0.582
New Zealand	0.664	0.320	0.020	0.604	0.303	0.024
Ontario	0.433	0.081	0.491	0.390	0.114	0.457
Full sample	0.385	0.202	0.386	0.395	0.208	0.358

Table C.14 Average DNSP output elasticities by Aust. DNSP, 2012–2021

	SFATLG model			*LSETLG model*		
Sample	*Customer numbers*	*Circuit length*	*RMD*	*Customer numbers*	*Circuit length*	*RMD*
EVO	-0.072	0.251	0.716	0.108	0.239	0.604
AGD	-0.629	0.336	1.058	-0.210	0.299	0.931
CIT	-0.319	0.182	0.999	-0.067	0.182	0.859
END	-0.210	0.285	0.762	0.052	0.266	0.716
ENX	-0.453	0.366	0.874	-0.086	0.325	0.782
ERG	0.564	0.347	0.019	0.589	0.327	0.164
ESS	0.285	0.475	0.114	0.435	0.421	0.187
JEN	-0.529	0.357	0.983	-0.165	0.314	0.777
PCR	-0.052	0.441	0.450	0.196	0.389	0.427
SAP	0.070	0.397	0.391	0.269	0.357	0.409
AND	-0.324	0.481	0.645	0.019	0.415	0.537
TND	0.355	0.296	0.281	0.417	0.282	0.310
UED	-0.649	0.366	1.062	-0.232	0.320	0.867
Total (Aust.)	-0.151	0.352	0.643	0.102	0.318	0.582

C2.3 Monotonicity Performance

Tables C.15 and C.16 show the proportions of observations for which there are monotonicity violations in the translog models.

Table C.15 Frequency of monotonicity violations by country 2012–2021

	SFATLG model			*LSETLG model*		
Sample	*Customer numbers*	*Circuit length*	*RMD*	*Customer numbers*	*Circuit length*	*RMD*
Australia	65.4%	0.0%	1.5%	42.3%	0.0%	0.0%
New Zealand	5.8%	0.0%	56.3%	0.5%	0.0%	56.8%
Ontario	9.2%	13.6%	2.9%	2.3%	2.9%	2.9%
Full sample	19.2%	7.1%	17.9%	9.6%	1.5%	17.7%

Table C.16 Frequency of monotonicity violations by DNSP (Aust.) 2012-2021

Sample	*SFATLG model*			*LSETLG model*		
	Customer numbers	*Circuit length*	*RMD*	*Customer numbers*	*Circuit length*	*RMD*
EVO	70.0%	0.0%	0.0%	0.0%	0.0%	0.0%
AGD	100.0%	0.0%	0.0%	100.0%	0.0%	0.0%
CIT	100.0%	0.0%	0.0%	100.0%	0.0%	0.0%
END	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ENX	100.0%	0.0%	0.0%	100.0%	0.0%	0.0%
ERG	0.0%	0.0%	20.0%	0.0%	0.0%	0.0%
ESS	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
JEN	100.0%	0.0%	0.0%	100.0%	0.0%	0.0%
PCR	70.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SAP	10.0%	0.0%	0.0%	0.0%	0.0%	0.0%
AND	100.0%	0.0%	0.0%	50.0%	0.0%	0.0%
TND	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
UED	100.0%	0.0%	0.0%	100.0%	0.0%	0.0%
Total (Aust.)	65.4%	0.0%	1.5%	42.3%	0.0%	0.0%

C2.4 Tests of Translog versus Cobb-Douglas Specifications

As previously noted, in considering the adequacy of the Cobb-Douglas and translog specifications, the primary consideration used in this report is the extent to which there are serious monotonicity violations. This is consistent with the approach taken in the 2021 report. That said, it can also be informative to test whether the additional variables in the translog model, which do not appear in the Cobb-Douglas, are jointly significantly different from zero.

Using the shorter sample period, in the SFA models, the Wald test for the null hypothesis that coefficients on the higher-order terms in C.10, which do not appear in C.9, are jointly equal to zero yields a p-value of 0.0001. This means that the null hypothesis can be rejected at a significance level of 0.05. In the LSE models, the Wald test for the null hypothesis that coefficients on the higher-order terms in C.12, which do not appear in C.11, are jointly equal to zero yields a p-value of 0.0000. This means that the null hypothesis can be rejected at a significance level of 0.05. In both models the additional terms in the translog model are jointly statistically significant.

Appendix D: Individual Output, Input and PFP Growth Rates

Table D.1 Industry individual output, input and PFP growth rates

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2021*
Outputs:				
Energy (GWh)	-0.3%	0.1%	-0.6%	-0.3%
Ratcheted Max Demand (MVA)	1.1%	2.3%	0.4%	0.0%
Customer Numbers	1.3%	1.3%	1.4%	1.2%
Circuit Length (km)	0.3%	0.3%	0.3%	0.4%
CMOS	-0.8%	-2.0%	0.0%	-13.0%
Inputs:				
Real Opex ($'000 2006)	0.6%	5.2%	-2.6%	-0.3%
O/H Sub-tran. Lines (MVA-kms)	0.9%	1.6%	0.4%	0.1%
O/H Distr. Lines (MVA-kms)	0.9%	0.9%	0.8%	1.5%
U/G Sub-tran. Lines (MVA-kms)	2.1%	2.9%	1.6%	-0.5%
U/G Sub-tran. Lines (MVA-kms)	3.5%	4.2%	3.0%	3.2%
Transformers (MVA)	2.4%	3.6%	1.5%	1.1%
All Capital inputs	2.1%	2.9%	1.5%	1.4%
Partial factor productivity:				
Output / Real Opex	0.4%	-3.5%	3.1%	2.5%
Output / OH Sub-tran. Lines	0.1%	0.1%	0.1%	2.2%
Output / OH Distr. Lines	0.1%	0.8%	-0.3%	0.7%
Output / UG Sub-tran. Lines	-1.1%	-1.2%	-1.1%	2.8%
Output / UG Distr. Lines	-2.5%	-2.5%	-2.5%	-0.9%
Output / Transformers	-1.4%	-1.9%	-1.0%	1.2%
Output / Capital	-1.1%	-1.2%	-1.0%	0.8%

Table D.2 EVO's individual output, input and PFP growth rates

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2021*
Outputs:				
Energy (GWh)	0.2%	0.8%	-0.2%	-0.1%
Ratcheted Max Demand (MVA)	0.9%	1.8%	0.3%	0.0%
Customer Numbers	2.1%	1.9%	2.3%	2.5%
Circuit Length (km)	1.1%	1.1%	1.1%	0.8%
CMOS	2.6%	0.7%	3.9%	10.7%
Inputs:				
Real Opex ($'000 2006)	0.7%	6.2%	-2.9%	1.8%
O/H Sub-tran. Lines (MVA-kms)	0.6%	0.6%	0.6%	2.3%
O/H Distr. Lines (MVA-kms)	0.0%	-0.4%	0.3%	0.0%
U/G Sub-tran. Lines (MVA-kms)	9.2%	7.0%	10.8%	-0.1%
U/G Sub-tran. Lines (MVA-kms)	2.2%	2.6%	2.0%	1.1%
Transformers (MVA)	1.8%	2.0%	1.6%	1.2%
All Capital inputs	1.5%	1.6%	1.4%	1.0%

Table D.2 (cont.)

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2021*
Partial factor productivity:				
Output / Real Opex	0.3%	-4.7%	3.7%	-1.4%
Output / OH Sub-tran. Lines	0.5%	0.9%	0.2%	-1.9%
Output / OH Distr. Lines	1.1%	1.9%	0.6%	0.4%
Output / UG Sub-tran. Lines	-8.2%	-5.5%	-9.9%	0.5%
Output / UG Distr. Lines	-1.2%	-1.1%	-1.2%	-0.7%
Output / Transformers	-0.7%	-0.5%	-0.8%	-0.8%
Output / Capital	-0.4%	-0.1%	-0.6%	-0.6%

Table D.3 AGD's individual output, input and PFP growth rates

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2021*
Outputs:				
Energy (GWh)	-1.4%	-0.4%	-2.0%	-1.9%
Ratcheted Max Demand (MVA)	0.5%	1.2%	0.0%	0.0%
Customer Numbers	0.9%	0.8%	1.0%	0.7%
Circuit Length (km)	0.6%	0.8%	0.5%	0.4%
CMOS	-0.5%	-0.8%	-0.3%	-25.9%
Inputs:				
Real Opex ($'000 2006)	-2.2%	4.4%	-6.6%	-5.4%
O/H Sub-tran. Lines (MVA-kms)	-0.2%	0.1%	-0.4%	0.1%
O/H Distr. Lines (MVA-kms)	0.3%	-0.2%	0.7%	1.0%
U/G Sub-tran. Lines (MVA-kms)	0.4%	0.4%	0.4%	-1.2%
U/G Sub-tran. Lines (MVA-kms)	1.9%	2.6%	1.5%	0.9%
Transformers (MVA)	2.1%	3.9%	0.8%	0.5%
All Capital inputs	1.5%	2.6%	0.8%	0.5%
Partial factor productivity:				
Output / Real Opex	2.8%	-3.4%	6.9%	8.4%
Output / OH Sub-tran. Lines	0.8%	0.9%	0.7%	2.9%
Output / OH Distr. Lines	0.2%	1.2%	-0.4%	2.0%
Output / UG Sub-tran. Lines	0.1%	0.6%	-0.2%	4.2%
Output / UG Distr. Lines	-1.4%	-1.6%	-1.3%	2.1%
Output / Transformers	-1.5%	-2.9%	-0.6%	2.5%
Output / Capital	-1.0%	-1.6%	-0.6%	2.5%

Table D.4 CIT's individual output, input and PFP growth rates

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2021*
Outputs:				
Energy (GWh)	-1.1%	0.3%	-2.0%	-2.1%
Ratcheted Max Demand (MVA)	1.1%	1.7%	0.7%	0.0%
Customer Numbers	1.1%	1.3%	1.0%	0.2%
Circuit Length (km)	1.0%	1.4%	0.7%	0.6%
CMOS	0.3%	4.0%	-2.3%	-46.8%

Table D.4 (cont.)

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2021*
Inputs:				
Real Opex ($'000 2006)	1.3%	8.1%	-3.5%	-28.3%
O/H Sub-tran. Lines (MVA-kms)	0.1%	-0.3%	0.4%	-0.2%
O/H Distr. Lines (MVA-kms)	-0.7%	-0.2%	-1.0%	0.3%
U/G Sub-tran. Lines (MVA-kms)	4.3%	5.0%	3.8%	1.8%
U/G Sub-tran. Lines (MVA-kms)	1.6%	3.3%	0.4%	3.1%
Transformers (MVA)	1.4%	2.1%	1.0%	-2.7%
All Capital inputs	1.6%	2.7%	0.8%	0.6%
Partial factor productivity:				
Output / Real Opex	-0.4%	-6.9%	4.2%	30.3%
Output / OH Sub-tran. Lines	0.8%	1.5%	0.3%	2.2%
Output / OH Distr. Lines	1.6%	1.5%	1.6%	1.6%
Output / UG Sub-tran. Lines	-3.4%	-3.8%	-3.2%	0.2%
Output / UG Distr. Lines	-0.7%	-2.1%	0.3%	-1.2%
Output / Transformers	-0.5%	-0.9%	-0.3%	4.7%
Output / Capital	-0.7%	-1.5%	-0.1%	1.3%

Table D.5 END's individual output, input and PFP growth rates

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2021*
Outputs:				
Energy (GWh)	-0.2%	-0.7%	0.1%	1.2%
Ratcheted Max Demand (MVA)	0.9%	1.6%	0.5%	0.0%
Customer Numbers	1.5%	1.0%	1.8%	1.7%
Circuit Length (km)	1.3%	1.1%	1.4%	1.1%
CMOS	-1.2%	0.0%	-2.0%	-26.5%
Inputs:				
Real Opex ($'000 2006)	0.2%	3.6%	-2.0%	6.4%
O/H Sub-tran. Lines (MVA-kms)	-0.1%	0.8%	-0.6%	-3.4%
O/H Distr. Lines (MVA-kms)	-0.2%	0.0%	-0.4%	0.0%
U/G Sub-tran. Lines (MVA-kms)	5.5%	7.6%	4.1%	1.0%
U/G Sub-tran. Lines (MVA-kms)	5.4%	6.6%	4.6%	4.4%
Transformers (MVA)	2.7%	3.3%	2.2%	1.7%
All Capital inputs	2.8%	3.7%	2.3%	1.6%
Partial factor productivity:				
Output / Real Opex	1.1%	-2.3%	3.4%	-2.0%
Output / OH Sub-tran. Lines	1.5%	0.5%	2.1%	7.7%
Output / OH Distr. Lines	1.6%	1.3%	1.9%	4.3%
Output / UG Sub-tran. Lines	-4.2%	-6.3%	-2.7%	3.4%
Output / UG Distr. Lines	-4.0%	-5.2%	-3.2%	0.0%
Output / Transformers	-1.3%	-2.0%	-0.8%	2.7%
Output / Capital	-1.4%	-2.3%	-0.8%	2.7%

Table D.6 ENX's individual output, input and PFP growth rates

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2021*
Outputs:				
Energy (GWh)	0.2%	0.5%	0.0%	0.0%
Ratcheted Max Demand (MVA)	1.6%	3.8%	0.1%	0.0%
Customer Numbers	1.6%	1.7%	1.5%	1.3%
Circuit Length (km)	1.2%	1.6%	0.9%	0.6%
CMOS	-2.1%	-9.8%	3.1%	2.6%
Inputs:				
Real Opex ($'000 2006)	2.2%	6.7%	-0.9%	14.0%
O/H Sub-tran. Lines (MVA-kms)	1.3%	2.4%	0.6%	0.9%
O/H Distr. Lines (MVA-kms)	0.2%	0.4%	0.0%	0.0%
U/G Sub-tran. Lines (MVA-kms)	4.5%	8.5%	1.9%	-0.3%
U/G Sub-tran. Lines (MVA-kms)	4.1%	6.3%	2.7%	1.7%
Transformers (MVA)	2.7%	4.2%	1.7%	1.0%
All Capital inputs	2.5%	4.0%	1.5%	0.8%
Partial factor productivity:				
Output / Real Opex	-0.3%	-2.7%	1.3%	-13.8%
Output / OH Sub-tran. Lines	0.5%	1.6%	-0.2%	-0.6%
Output / OH Distr. Lines	1.7%	3.7%	0.4%	0.2%
Output / UG Sub-tran. Lines	-2.7%	-4.4%	-1.5%	0.6%
Output / UG Distr. Lines	-2.3%	-2.3%	-2.3%	-1.4%
Output / Transformers	-0.8%	-0.1%	-1.3%	-0.7%
Output / Capital	-0.6%	0.0%	-1.1%	-0.5%

Table D.7 ERG's individual output, input and PFP growth rates

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2021*
Outputs:				
Energy (GWh)	0.0%	0.3%	-0.2%	-0.7%
Ratcheted Max Demand (MVA)	1.0%	2.4%	0.0%	0.0%
Customer Numbers	1.4%	1.9%	1.0%	0.7%
Circuit Length (km)	0.2%	0.6%	0.0%	0.6%
CMOS	-1.0%	-2.3%	-0.2%	-1.5%
Inputs:				
Real Opex ($'000 2006)	-0.8%	2.0%	-2.7%	-13.4%
O/H Sub-tran. Lines (MVA-kms)	0.1%	1.7%	-0.9%	0.1%
O/H Distr. Lines (MVA-kms)	1.0%	1.1%	0.9%	1.5%
U/G Sub-tran. Lines (MVA-kms)	3.7%	6.3%	2.1%	0.0%
U/G Sub-tran. Lines (MVA-kms)	4.9%	8.9%	2.1%	1.2%
Transformers (MVA)	2.5%	2.9%	2.3%	1.9%
All Capital inputs	1.8%	2.4%	1.3%	1.5%

Table D.7 (cont.)

Year	2006 to 2021	2006 to 2012	2012 to 2021	2021
Partial factor productivity:				
Output / Real Opex	2.1%	0.7%	3.0%	14.2%
Output / OH Sub-tran. Lines	1.1%	1.1%	1.1%	0.7%
Output / OH Distr. Lines	0.3%	1.7%	-0.6%	-0.7%
Output / UG Sub-tran. Lines	-2.5%	-3.5%	-1.8%	0.8%
Output / UG Distr. Lines	-3.6%	-6.2%	-1.9%	-0.5%
Output / Transformers	-1.3%	-0.1%	-2.0%	-1.1%
Output / Capital	-0.5%	0.4%	-1.1%	-0.7%

Table D.8 ESS's individual output, input and PFP growth rates

Year	2006 to 2021	2006 to 2012	2012 to 2021	2021
Outputs:				
Energy (GWh)	0.3%	-0.2%	0.5%	-0.1%
Ratcheted Max Demand (MVA)	1.4%	0.8%	1.7%	0.0%
Customer Numbers	1.0%	0.8%	1.2%	1.0%
Circuit Length (km)	-0.2%	-0.7%	0.1%	0.1%
CMOS	-1.1%	-2.9%	0.1%	-11.2%
Inputs:				
Real Opex ($'000 2006)	2.0%	9.3%	-2.9%	0.3%
O/H Sub-tran. Lines (MVA-kms)	3.4%	4.4%	2.7%	0.8%
O/H Distr. Lines (MVA-kms)	3.0%	3.4%	2.7%	4.4%
U/G Sub-tran. Lines (MVA-kms)	4.1%	-1.3%	7.8%	1.7%
U/G Sub-tran. Lines (MVA-kms)	4.2%	3.2%	4.8%	5.2%
Transformers (MVA)	2.2%	4.1%	1.0%	0.7%
All Capital inputs	2.8%	3.8%	2.1%	2.2%
Partial factor productivity:				
Output / Real Opex	-0.9%	-8.3%	4.0%	2.6%
Output / OH Sub-tran. Lines	-2.3%	-3.4%	-1.6%	2.1%
Output / OH Distr. Lines	-1.9%	-2.4%	-1.6%	-1.5%
Output / UG Sub-tran. Lines	-3.1%	2.3%	-6.7%	1.2%
Output / UG Distr. Lines	-3.1%	-2.2%	-3.8%	-2.3%
Output / Transformers	-1.2%	-3.1%	0.1%	2.2%
Output / Capital	-1.7%	-2.8%	-1.0%	0.7%

Table D.9 JEN's individual output, input and PFP growth rates

Year	2006 to 2021	2006 to 2012	2012 to 2021	2021
Outputs:				
Energy (GWh)	-0.3%	0.3%	-0.7%	0.1%
Ratcheted Max Demand (MVA)	1.6%	3.3%	0.3%	0.0%
Customer Numbers	1.6%	1.1%	2.0%	1.4%
Circuit Length (km)	1.1%	1.1%	1.2%	1.7%
CMOS	-1.2%	-4.2%	1.0%	-12.6%

Table D.9 (cont.)

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2021*
Inputs:				
Real Opex ($'000 2006)	-0.6%	3.3%	-3.4%	-33.1%
O/H Sub-tran. Lines (MVA-kms)	1.0%	1.0%	1.1%	-0.7%
O/H Distr. Lines (MVA-kms)	0.2%	-0.2%	0.4%	3.1%
U/G Sub-tran. Lines (MVA-kms)	3.2%	-0.4%	5.7%	11.3%
U/G Sub-tran. Lines (MVA-kms)	4.8%	4.8%	4.8%	4.0%
Transformers (MVA)	2.7%	3.3%	2.3%	-0.2%
All Capital inputs	1.3%	1.3%	1.4%	1.2%
Partial factor productivity:				
Output / Real Opex	2.1%	-1.0%	4.2%	35.0%
Output / OH Sub-tran. Lines	0.4%	1.4%	-0.2%	2.5%
Output / OH Distr. Lines	1.3%	2.5%	0.4%	-1.2%
Output / UG Sub-tran. Lines	-1.7%	2.7%	-4.9%	-9.4%
Output / UG Distr. Lines	-3.3%	-2.5%	-3.9%	-2.1%
Output / Transformers	-1.2%	-1.0%	-1.4%	2.0%
Output / Capital	0.1%	1.0%	-0.5%	0.6%

Table D.10 PCR's individual output, input and PFP growth rates

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2021*
Outputs:				
Energy (GWh)	0.4%	1.0%	0.0%	2.4%
Ratcheted Max Demand (MVA)	1.8%	3.3%	0.7%	0.0%
Customer Numbers	1.9%	1.9%	2.0%	3.3%
Circuit Length (km)	0.5%	0.4%	0.5%	0.6%
CMOS	0.7%	3.0%	-0.9%	-40.9%
Inputs:				
Real Opex ($'000 2006)	0.4%	2.6%	-1.2%	2.1%
O/H Sub-tran. Lines (MVA-kms)	0.1%	0.1%	0.1%	0.0%
O/H Distr. Lines (MVA-kms)	0.1%	0.1%	0.2%	0.1%
U/G Sub-tran. Lines (MVA-kms)	10.0%	5.9%	12.9%	14.8%
U/G Sub-tran. Lines (MVA-kms)	5.9%	5.9%	5.8%	5.8%
Transformers (MVA)	2.6%	3.0%	2.3%	-0.6%
All Capital inputs	2.1%	2.3%	2.1%	0.9%
Partial factor productivity:				
Output / Real Opex	0.9%	-1.2%	2.3%	5.8%
Output / OH Sub-tran. Lines	1.1%	1.3%	1.0%	7.9%
Output / OH Distr. Lines	1.1%	1.4%	0.9%	7.9%
Output / UG Sub-tran. Lines	-8.8%	-4.4%	-11.9%	-6.8%
Output / UG Distr. Lines	-4.6%	-4.5%	-4.7%	2.1%
Output / Transformers	-1.4%	-1.6%	-1.3%	8.5%
Output / Capital	-0.9%	-0.8%	-1.0%	7.1%

Table D.11 SAP's individual output, input and PFP growth rates

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2021*
Outputs:				
Energy (GWh)	-0.8%	0.1%	-1.5%	-1.9%
Ratcheted Max Demand (MVA)	1.0%	2.4%	0.0%	0.0%
Customer Numbers	1.1%	1.3%	1.0%	0.7%
Circuit Length (km)	0.4%	0.5%	0.2%	0.2%
CMOS	-0.3%	-1.7%	0.6%	6.0%
Inputs:				
Real Opex ($'000 2006)	2.3%	6.3%	-0.4%	1.9%
O/H Sub-tran. Lines (MVA-kms)	0.6%	0.5%	0.6%	2.5%
O/H Distr. Lines (MVA-kms)	-0.1%	0.0%	-0.1%	-0.2%
U/G Sub-tran. Lines (MVA-kms)	1.7%	2.1%	1.4%	0.2%
U/G Sub-tran. Lines (MVA-kms)	3.0%	3.3%	2.8%	11.0%
Transformers (MVA)	2.2%	3.6%	1.3%	1.1%
All Capital inputs	2.0%	2.7%	1.5%	3.5%
Partial factor productivity:				
Output / Real Opex	-1.5%	-4.5%	0.5%	-2.7%
Output / OH Sub-tran. Lines	0.2%	1.2%	-0.5%	-3.2%
Output / OH Distr. Lines	0.8%	1.8%	0.1%	-0.5%
Output / UG Sub-tran. Lines	-1.0%	-0.4%	-1.4%	-1.0%
Output / UG Distr. Lines	-2.3%	-1.5%	-2.8%	-11.8%
Output / Transformers	-1.4%	-1.8%	-1.2%	-1.9%
Output / Capital	-1.2%	-1.0%	-1.4%	-4.2%

Table D.12 AND's individual output, input and PFP growth rates

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2021*
Outputs:				
Energy (GWh)	0.1%	0.4%	-0.2%	0.1%
Ratcheted Max Demand (MVA)	1.9%	3.0%	1.0%	0.0%
Customer Numbers	1.8%	1.7%	1.9%	1.9%
Circuit Length (km)	0.7%	0.9%	0.6%	0.6%
CMOS	-1.0%	-5.2%	2.0%	-60.4%
Inputs:				
Real Opex ($'000 2006)	4.1%	7.5%	1.8%	1.6%
O/H Sub-tran. Lines (MVA-kms)	0.8%	1.2%	0.6%	0.4%
O/H Distr. Lines (MVA-kms)	0.0%	0.4%	-0.2%	-0.4%
U/G Sub-tran. Lines (MVA-kms)	8.2%	2.3%	12.3%	0.0%
U/G Sub-tran. Lines (MVA-kms)	5.1%	5.3%	5.0%	4.1%
Transformers (MVA)	2.5%	3.7%	1.7%	2.0%
All Capital inputs	2.0%	2.6%	1.5%	1.5%

Table D.12 (cont.)

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2021*
Partial factor productivity:				
Output / Real Opex	-2.5%	-4.6%	-1.1%	7.3%
Output / OH Sub-tran. Lines	0.8%	1.7%	0.2%	8.4%
Output / OH Distr. Lines	1.6%	2.5%	1.0%	9.3%
Output / UG Sub-tran. Lines	-6.6%	0.6%	-11.6%	8.9%
Output / UG Distr. Lines	-3.5%	-2.4%	-4.2%	4.7%
Output / Transformers	-0.9%	-0.9%	-1.0%	6.9%
Output / Capital	-0.4%	0.2%	-0.8%	7.3%

Table D.13 TND's individual output, input and PFP growth rates

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2021*
Outputs:				
Energy (GWh)	0.1%	-0.5%	0.4%	1.8%
Ratcheted Max Demand (MVA)	0.5%	1.4%	0.0%	0.0%
Customer Numbers	1.1%	1.8%	0.7%	1.3%
Circuit Length (km)	0.4%	0.8%	0.2%	-1.1%
CMOS	2.5%	5.0%	0.8%	7.6%
Inputs:				
Real Opex ($'000 2006)	1.4%	5.6%	-1.5%	7.1%
O/H Sub-tran. Lines (MVA-kms)	-0.2%	0.1%	-0.3%	-1.9%
O/H Distr. Lines (MVA-kms)	0.7%	0.6%	0.7%	0.3%
U/G Sub-tran. Lines (MVA-kms)	4.9%	9.2%	1.9%	-1.5%
U/G Sub-tran. Lines (MVA-kms)	1.2%	1.6%	0.9%	-0.2%
Transformers (MVA)	2.4%	4.0%	1.3%	1.3%
All Capital inputs	1.4%	2.2%	1.0%	0.5%
Partial factor productivity:				
Output / Real Opex	-1.2%	-5.3%	1.6%	-8.6%
Output / OH Sub-tran. Lines	0.4%	0.2%	0.5%	0.4%
Output / OH Distr. Lines	-0.5%	-0.3%	-0.6%	-1.8%
Output / UG Sub-tran. Lines	-4.7%	-9.0%	-1.8%	0.0%
Output / UG Distr. Lines	-1.0%	-1.3%	-0.8%	-1.3%
Output / Transformers	-2.2%	-3.7%	-1.2%	-2.8%
Output / Capital	-1.3%	-1.9%	-0.8%	-2.0%

Table D.14 UED's individual output, input and PFP growth rates

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2021*
Outputs:				
Energy (GWh)	-0.4%	0.4%	-1.0%	-0.4%
Ratcheted Max Demand (MVA)	1.5%	3.6%	0.0%	0.0%
Customer Numbers	1.0%	0.9%	1.0%	0.6%
Circuit Length (km)	0.6%	0.6%	0.6%	0.4%
CMOS	-3.6%	8.3%	-12.0%	-48.0%

Table D.14 (cont.)

Year	*2006 to 2021*	*2006 to 2012*	*2012 to 2021*	*2021*
Inputs:				
Real Opex ($'000 2006)	-0.2%	3.6%	-2.9%	-0.9%
O/H Sub-tran. Lines (MVA-kms)	1.5%	2.8%	0.6%	0.1%
O/H Distr. Lines (MVA-kms)	0.3%	0.7%	0.0%	0.4%
U/G Sub-tran. Lines (MVA-kms)	1.4%	7.7%	-3.1%	1.5%
U/G Sub-tran. Lines (MVA-kms)	2.9%	3.4%	2.6%	1.3%
Transformers (MVA)	2.5%	3.4%	1.9%	6.5%
All Capital inputs	1.7%	2.7%	1.0%	2.6%
Partial factor productivity:				
Output / Real Opex	1.4%	-2.6%	4.2%	3.8%
Output / OH Sub-tran. Lines	-0.4%	-1.9%	0.7%	2.8%
Output / OH Distr. Lines	0.8%	0.2%	1.3%	2.5%
Output / UG Sub-tran. Lines	-0.3%	-6.8%	4.3%	1.4%
Output / UG Distr. Lines	-1.8%	-2.4%	-1.3%	1.6%
Output / Transformers	-1.4%	-2.4%	-0.7%	-3.6%
Output / Capital	-0.6%	-1.7%	0.2%	0.3%

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