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QUANTITATIVE ECONOMICS

Economic Benchmarking Results for the Australian Energy Regulator's 2025 DNSP Annual Benchmarking Report

Report prepared for Australian Energy Regulator

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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
CCO	Capitalised corporate overheads
CMOS	Customer minutes off supply
DNSP	Distribution network service provider
EBRIN	Economic Benchmarking Regulatory Information Notice
kV	kilovolt
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 2024 DNSP Benchmarking Report (Quantonomics 2024).

This annual update closely follows the methods used previously by Economic Insights (2021) and Quantonomics 2023a; 2024). It includes data for the 2023–24 financial year reported by the Australian 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 19-year period from 2006 to 2024,[1] and for the 13–year period from 2012 to 2024. This follows previous analyses by Economic Insights (2014; 2015b; 2015a; 2017; 2018; 2019; 2020; 2021) and Quantonomics 2023a; 2024).

1.1 Updates to Productivity Measurement Methods

The methods of analysis used in this report are the same as those used in Quantonomics 2024) with one important refinement. This year, we updated the output index weights for non-reliability outputs, while maintaining the methodological approach originally developed by Denis Lawrence and Erwin Diewert (2006). This approach was first applied to benchmarking Australian energy networks in Economic Insights (2014), and the output weights were subsequently revised in Economic Insights (2020, 124–125) and most recently in Quantonomics (2025).

In updating the non-reliability output index weights, attention was given to the findings of the 2024 independent review of output weights by the University of Queensland's Centre for Efficiency and Productivity Analysis (Peyrache 2024). The review found the Lawrence-Diewert method is substantially correct, whilst suggesting some alternatives. The two main alternative suggested methods have been estimated as cross-checks to the standard method. A reasonable degree of consistency was found between the methods, providing confidence in the reliability of the results from the standard method.

[1] For Ontario, data from 2005 to 2023 are used due to differences in calendar year reporting.

1.2 Updates to data for the 2025 report

The updates to output and input variables data have been few and immaterial in terms of impact. In regard to output variables the key revision is:

- A change to SA Power Networks' 2022 and 2023 circuit length to include 0.09 km of underground circuit in the "other" category which was previously rounded to zero. This update changed circuit length by only 0.0001 per cent in each year.

In regard to input variables the revisions are:

- This year's analysis includes the correction of a previous minor error in the treatment of expected inflation, which had been incorrectly lagged by an additional year. This affected the values of the Annual User Cost (AUC) variables. It also corrects the AUC for VIC DNSPs, where calendar year WACC was mistakenly applied for all years in ABR24 instead of transitioning to financial year WACC from 2021.
- Changes to opex for AusNet (2022 and 2023) and Ausgrid (2023), reflecting data corrections. The average sizes of the changes in the relevant years are 1.3 per cent for AusNet and –0.1 per cent for Ausgrid.
- A change to SA Power Networks' 2022 and 2023 underground distribution lines to include 0.09 km of underground circuit in the "other" category which was previously rounded to zero. This update changed underground distribution lines by only 0.05 per cent in each year.

Regarding the international data, several minor revisions were made. Most notably, the opex price indexes for New Zealand and Ontario were updated after identifying inconsistencies in the calculations. On average, this affected New Zealand's opex price by –0.4 per cent and Ontario's by 0.01 per cent.

1.3 Supporting Information

This report summarises the key results and insights from the benchmarking analysis of DNSPs. The programs and spreadsheets used to produce the results, tables and charts are available in the accompanying zip file of supporting materials. More detailed tables and charts are also provided in the accompanying supporting file. These include the State level productivity index results, which are not presented in this report.

For guidance on how to navigate and interpret the supporting material, we recommend referring to the document *Guide to DNSP Economic Benchmarking Files*, which outlines the structure and content of the programs and spreadsheets.

1.4 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 1.4.4.

1.4.1 Productivity Index Numbers

We use total factor productivity (TFP) indexes and partial factor productivity (PFP) indexes to measure productivity growth of electricity distribution at the Australian industry 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 combined time–series and cross–sectional (or panel data) comparisons of productivity levels. This indexing method 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 presents the comparative productivity analysis that compares productivity level of DNSPs. The industry and DNSP analyses in Chapters 2 and 5 respectively, examine patterns of output, input, and productivity over time. Individual output and input contributions to productivity change are also examined.

1.4.2 Defining Outputs

The output index for DNSPs is defined to include five outputs. Outputs (a) to (d) are referred to as the 'non–reliability outputs', and output (e) is the 'reliability' output. The weights of the non-reliability outputs are based on an econometric analysis of cost causation applied to total revenue, and the weight of the reliability output is based on the cost to consumers of non-reliability. Section A3.2 in Appendix A explains the derivation of the output weights for the non-reliability outputs and the reliability output. The outputs are:

(a) Energy throughput in GWh (accounting for 12.4 per cent of total revenue on average[2]),

(b) Ratcheted maximum demand (RMD) in Megawatts (MW) (accounting for 55.1 per cent of total revenue on average),

(c) Customer numbers (accounting for 17.5 per cent of total revenue on average),

(d) Circuit length in kms (accounting for 30.1 per cent of total revenue on average), and

(e) (minus) Customer Minutes Off–supply (CMOS) (with the weight based on current AER estimated value of customer reliability (VCR), accounting for –15.2 per cent of total revenue on average).[3]

The outputs are all directly reported by the DNSPs. In the case of RMD, they 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 carried out by Economic Insights (2020) and in this review has been updated by Quantonomics (2025). The method is described in Appendix A.

1.4.3 Defining Inputs

The DNSP MTFP measures include six inputs:

(a) Opex (network services opex plus capitalised corporate overheads,[4] deflated by a composite labour, materials and services price index), making up 42.3 per cent of total costs on average,[5]

(b) Overhead subtransmission lines (quantity proxied by overhead subtransmission MVAkms), making up 4.3 per cent of total costs on average,

(c) Overhead distribution lines (quantity proxied by overhead distribution MVAkms), making up 14.2 per cent of total costs on average,

[2] This is the average across years for the aggregated industry, as per the last column of Table A.2 of Appendix A. This differs from the average across all observations (DNSPs and years) shown in Table A.1 of Appendix A. Table A.1, in section A3.2, assists in explaining the derivation of the output weights for the non-reliability outputs and the reliability output.

[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] As per the decision on capitalisations practices in AER (2023)

[5] See the last column of Table A.3 in Appendix A.

(d) Underground subtransmission cables (quantity proxied by underground subtransmission MVAkms), making up 2.1 per cent of total costs on average,

(e) Underground distribution cables (quantity proxied by underground distribution MVAkms), making up 10.6 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 26.4 per cent of total costs on average.

These inputs are grouped into two broader categories: input (a) is the 'non–capital inputs', or 'opex input', whilst inputs (b) to (f) are together the 'capital inputs'. The capital 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 AUC is taken to be the return on capital, the return of capital and the benchmark tax liability. These are calculated using the method set out in section A5 of Appendix A. Since 2024, the return on capital is measured by the real cost of capital, calculated consistently with AER guidelines, and the return of capital is straight-line depreciation calculated in the same way as used in the building blocks calculation. The AUC is calculated by asset class for each year using asset value data reported by DNSPs. The calculation of the WACC for 2020 to 2023 reflects the AER's *Rate of Return Instrument 2018* (AER 2018). For 2024, the AER's *Rate of Return Instrument 2022* (AER 2023) applies.[6] For earlier years (2006 to 2019), the AUC calculations broadly reflect the 2013 rate of return guideline (AER 2013). See Appendix A (section A3) for further discussion of the input weights.

1.4.4 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

[6] The 2018 Rate of return Instrument is applied in full, that is: Risk free rate – Yield from 10-year CGS; MRP – 6.1%; Equity beta – 0.6; Gamma – 0.585; Return on debt – Weighted average of A and BBB curves from RBA, Bloomberg and Thomson Reuters. For 2022, it is: Risk free rate – Yield from 10-year CGS; MRP – 6.2%; Equity beta – 0.6; Gamma – 0.57; Return on debt – Weighted average of A and BBB curves from RBA, Bloomberg and Refinitiv.

opex efficiency assessment is a key component of implementing building blocks regulation, which involves separate efficiency assessments of, and determinations on, DNSPs' 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 is 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, Least Squares Econometrics (LSE),[7] uses a variant of ordinary least squares regression, incorporating dummy variables for the Australian DNSPs.[8] 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

[7] The LSE model can also be considered a type of stochastic frontier analysis. For simplicity, we adopt distinct terminology to differentiate the two models.

[8] Technically, 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.

period from 2006 to 2024 and the sample period from 2012 to 2024. The results of this analysis are presented in chapter 4 and Appendix D.

1.5 Limitations

This study uses EBRIN data, which is generally of high quality. The main limitation of the benchmarking analysis is that the DNSPs included in the sample may not be fully comparable as they operate in different operating environments which can influence the ability of an efficient DNSP to transform inputs into outputs, and these differences are not fully controlled for. Whilst the TFP and PFP index analysis presented in this report does not explicitly take account of operating environment factors (OEFs), it does to some extent indirectly account for some OEFs. Firstly, the functional output specification that includes a range of output measures allows for differences in customer density and energy density across DNSPs as part of the output specification (Economic Insights 2020, 29). Secondly, in the multilateral index method the weights applied to inputs vary between DNSPs, reflecting both their own cost shares as well as industry average cost shares and DNSPs' own cost shares will vary in part due to OEFs. The econometric analysis of opex likewise accounts for differences in network density and additionally takes account of differences in the degree of undergrounding and implicitly accounts for some other OEFs (for a discussion see Quantonomics 2023b). The AER also applies a range of post-modelling OEF adjustments in the context of its opex efficiency analysis.

1.6 DNSPs comments on draft report and our response

Consistent with past practice, the AER released a draft version of this report to DNSPs for comment. The AER also circulated the Quantonomics memo *Nonreliability Output Index Weights ABR25* (17/06/2025). Several DNSPs provided feedback on key elements of the benchmarking framework.

1.6.1 Comments on the Update of the No-Reliability Output Weights

Three DNSPs — Jemena, Ergon and Energex — expressed support for adopting the updated non-reliability output weights. Jemena recommended updating the weights every five years, while Ergon and Energex preferred annual updates.

In contrast, three other DNSPs—AusNet, Evoenergy, and SA Power Networks —expressed strong concerns about the updated weights. AusNet expressed concern about the magnitude of the changes in the output weights, arguing that these changes did not reflect genuine shifts in the industry and the methodologies failed to produce stable values. It also noted that the new weights have an adverse effect on the measured productivity of DNSPs operating in regional or complex environments. AusNet recommended exploring approaches that deliver more stable weights over time, including the use of smoothing techniques.

Evoenergy supported updating the weights but noted that the 2024 data had not been included and recommended that the most recent data be used. Evoenergy endorsed Frontier Economics' findings discussed below.

SA Power Networks strongly criticised the updated weights, arguing that the Leontief models used in the estimation process were mis-specified and produced unreliable and spurious results that undermine the credibility of benchmarking. Further, the models failed to include relevant outputs driving distribution expenditure, such as the delivery of Consumer Energy Resources (CER) services. SA Power Networks stated that the estimated individual Leontief models were economically meaningless and inconsistent with the results of the AER's benchmarking models. It recommended retaining the previous set of weights or, at a minimum, publishing results under both the old and new weights, with a clear warning that the new weights should not be relied upon until the issues have been properly investigated and resolved.

Frontier Economics, on behalf of Evoenergy and SA Power Networks, also argued that some of the output weights had been mis-estimated. They attributed this to the choice of starting values, which in certain models did not minimise the sum of squared residuals. Both Evoenergy and SA Power Networks called for a review of the process used to estimate the output weights.

In light of these concerns, we undertook further analysis to test the claims of mis-estimation and to examine the drivers of the observed changes. Our findings and responses to the DNSPs' criticisms are presented in the memo *Nonreliability Output Index Weights ABR25 – Supplementary Analysis* (11/11/2025) and summarised in Appendix A, section A.3.6. This memo shows that the changes in output weights between 2020 and 2025 were mainly driven by revisions to data definitions and the inclusion of five years of additional data. The large increase in the RMD weight was driven by both the data definition changes and the additional data. The large decrease in the circuit length weight is due to the additional data. The data for 2020 and 2021 had a particularly marked impact on estimated output weights. There is no evidence that these changes were caused by model mis-estimation or instability. Appendix B presents the pooled MTFP and MPFP indexes under the old weights.

1.6.2 Comments on Shifts in Productivity Rankings

SA Power Networks raised concerns that the update to the non-reliability output weights led to a sharp decline in its productivity rankings. It argued that sudden changes in the indexes, such as those caused by revised output weights, can give the impression of a sudden fall in a DNSP's relative efficiency. This, in turn, may cause reputational harm, particularly among stakeholders.

Essential Energy, while not objecting directly to the weight changes, highlighted that benchmarking methodological refinements continue to cause significant shifts in both current and historical productivity rankings. Frequent rebasing, it argued, would reduce the value of these rankings to industry, as movements may reflect external factors rather than genuine efficiency gains.

We note that when several DNSPs have similar MTFP levels, rankings regularly shift from year to year, and even small changes in methodology or revised historical data, can also shift rankings. As noted earlier, the material changes in output weights have been data-driven, and these have contributed to the observed changes in rankings.

To highlight the effects of the change in non-reliability output weights on rankings, Table 1.1 presents the MTFP rankings using alternative weights by comparing the rankings for 2023 and 2024, had the previous (2020) output weights continued to apply (see Table B.1, Appendix B) against those with the new output weights (Table 3.1, section 3.1).

The results show variations in rankings due to changes in output weights in each of the two years. The results show that three DNSPs (EVO, AGD and JEN) moved up significantly in MTFP rankings, while four DNSPs (ESS, ERG, PCR and SAP) moved down considerably, due to the changes in output weights.

Table 1.1 Comparison of MTFP Index Rankings using Alternative Weights

	Comparison of 2023 rankings			*Comparison of 2024 rankings*		
	2023 Ranking using 2020 weights	*2023 Ranking using 2025 weights*	*Difference*	*2024 Ranking using 2020 weights*	*2024 Ranking using 2025 weights*	*Difference*
EVO	10	5	5	9	6	3
AGD	12	8	4	11	8	3
CIT	2	1	1	3	1	2
END	4	3	1	2	2	0
ENX	8	7	1	8	7	1
ERG	7	10	-3	10	13	-3
ESS	6	13	-7	6	10	-4
JEN	9	6	3	7	5	2
PCR	5	9	-4	5	9	-4
SAP	1	4	-3	1	4	-3
AND	11	12	-1	12	11	1
TND	12	11	1	13	12	1
UED	3	2	1	4	3	1

Updating output weights has been a longstanding request from many DNSPs and stakeholders, and other refinements, such as adjustments to opex allocation methods, have been subject to consultation. As benchmarking methodologies are inherently evolving, some degree of change is unavoidable. The overarching objective of these refinements is to enhance the robustness and relevance of the framework over time.

1.6.3 Comments on the Data Sample

Regarding issues with data sample, Energex and Ergon identified an inconsistency in the dataset spreadsheet calculation of Energex underground sub-transmission and distribution lines. We acknowledge there was a formula inconsistency, but note it did not affect the benchmarking dataset, because the cells concerned had zero values. The formulas in the relevant cells have been corrected.

SA Power Networks observed that the benchmarking dataset does not include SA Power Networks' amended 2024 revenue. We note that the corrected revenue data are only 0.66 per cent higher than the data used, and our analysis confirms these are immaterial to the productivity analysis. Accordingly, the correction will be applied in the next benchmarking analysis.

1.6.4 Comments on Benchmarking Development Program

Regarding benchmarking development, Ergon and Energex supported the AER's consultation on monotonicity violations in the econometric models, stressing the need to preserve methodological integrity and transparency. AusNet recommended that the AER undertake a holistic review of the benchmarking framework to ensure that the methodology reflects current network realities and regulatory obligations. Similarly, Ausgrid raised broader concerns about output specification, arguing that outputs and their weights have not evolved in line with industry changes, such as the inclusion of solar exports, electric vehicle charging management, and demand-side initiatives like energy efficiency. Essential Energy also commented that the impact of the energy transition remains insufficiently captured in the benchmarking. AusNet and Essential Energy recommended the inclusion of additional OEFs.

Evoenergy encouraged the AER to continue its development program and to include a further review the non-reliability output weights methods,[9] including the specification of models to account for time-varying inefficiency and additional relevant outputs. Evoenergy also recommended that the AER examine the procedures for estimating capital and total cost weights and assess whether the Leontief cost function remains fit for purpose. Both Essential Energy and SA Power Networks noted that while the AER intends to conduct a review in 2027 into the adequacy of existing output specifications in the context of changing energy network functions, this timeline is too distant given the immediate concerns raised by the updated weights and the impact of the energy transition.

All matters concerning the benchmarking development program are discussed in the AER's benchmarking report.

[9] Noting the review by CEPA in 2024.

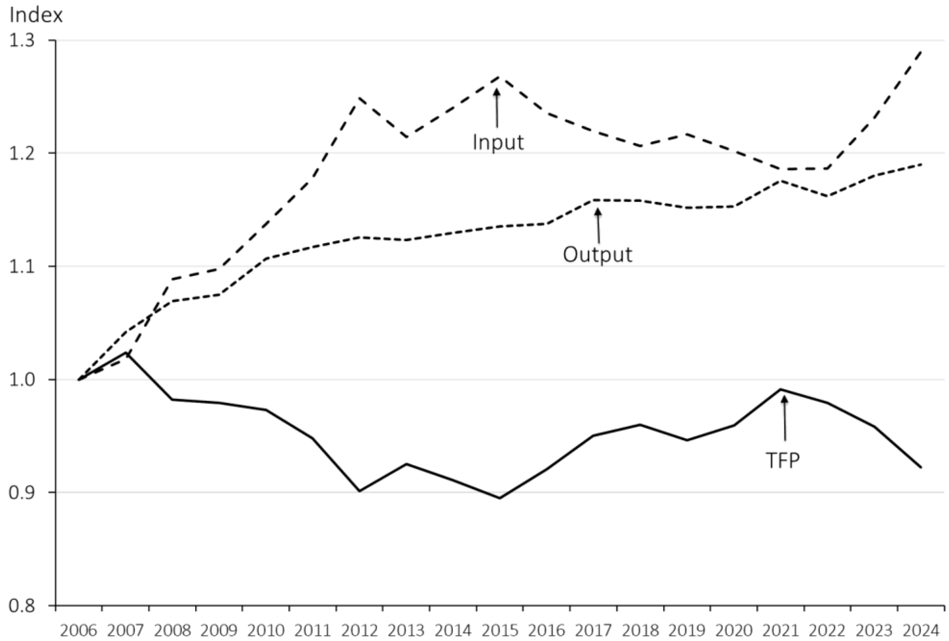
2 Industry–level Distribution Productivity Results

This chapter presents productivity results for the electricity distribution industry across the National Electricity Market (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.[10] Opex and capital partial factor productivity indexes are also presented in Table 2.1.

Figure 2.1 DNSP industry output, input and TFP indexes, 2006–2024



Over the 19-year period 2006 to 2024, industry level TFP *declined* at an average annual rate of 0.5 per cent.[11] Although total output increased at an average annual rate of 1.0 per cent, total input use increased faster at a rate of 1.4 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.

[10] Unlike the TNSP report, the TFP results in Figure 2.1 do not present alternative results excluding the reliability output. In the case of TNSPs, which typically operate at very high levels of reliability, even small changes in in reliability can result in large percentage changes, affecting the TFP results. In contrast, this issue does not arise for DNSPs to the same extent. As a result, the analysis excluding the impact of the CMOS output variable is not presented in this report.

[11] 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).

Although the long–run average TFP change was negative, TFP change was positive in 2007, 2013, 2016–2018 and 2020–2021. As shown in Figure 2.1, industry-wide TFP thus steadily improved in the period from 2015 to 2021 after declining in the period from 2006 to 2015. However, it has been deteriorating since 2022.

Table 2.1 shows that over the period 2006 to 2012, TFP *decreased* at an average annual rate of 1.7 per cent. From 2012 to 2024, TFP increased at an average annual rate of 0.2 per cent. TFP *decreased* 2.2 per cent in 2023 and 3.8 per cent in 2024.

Table 2.1 DNSP industry output, input, TFP and PFP indexes, 2006–2024

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	1.042	1.018	1.023	1.041	1.011
2008	1.069	1.089	0.982	0.938	1.017
2009	1.075	1.098	0.980	0.961	0.992
2010	1.107	1.137	0.973	0.946	0.992
2011	1.117	1.178	0.948	0.901	0.981
2012	1.126	1.248	0.902	0.819	0.966
2013	1.123	1.214	0.925	0.897	0.946
2014	1.130	1.240	0.911	0.886	0.930
2015	1.135	1.268	0.895	0.863	0.920
2016	1.137	1.235	0.921	0.937	0.909
2017	1.159	1.220	0.950	0.996	0.918
2018	1.158	1.206	0.960	1.037	0.908
2019	1.152	1.217	0.947	1.024	0.894
2020	1.153	1.202	0.959	1.070	0.884
2021	1.176	1.186	0.991	1.136	0.893
2022	1.162	1.187	0.979	1.131	0.877
2023	1.180	1.232	0.958	1.071	0.882
2024	1.190	1.290	0.923	0.983	0.882
Growth Rate 2006–2024	1.0%	1.4%	-0.5%	-0.1%	-0.7%
Growth Rate 2006–2012	2.0%	3.7%	-1.7%	-3.3%	-0.6%
Growth Rate 2012–2024	0.5%	0.3%	0.2%	1.5%	-0.8%
Growth Rate 2024	0.8%	4.6%	-3.8%	-8.6%	0.0%

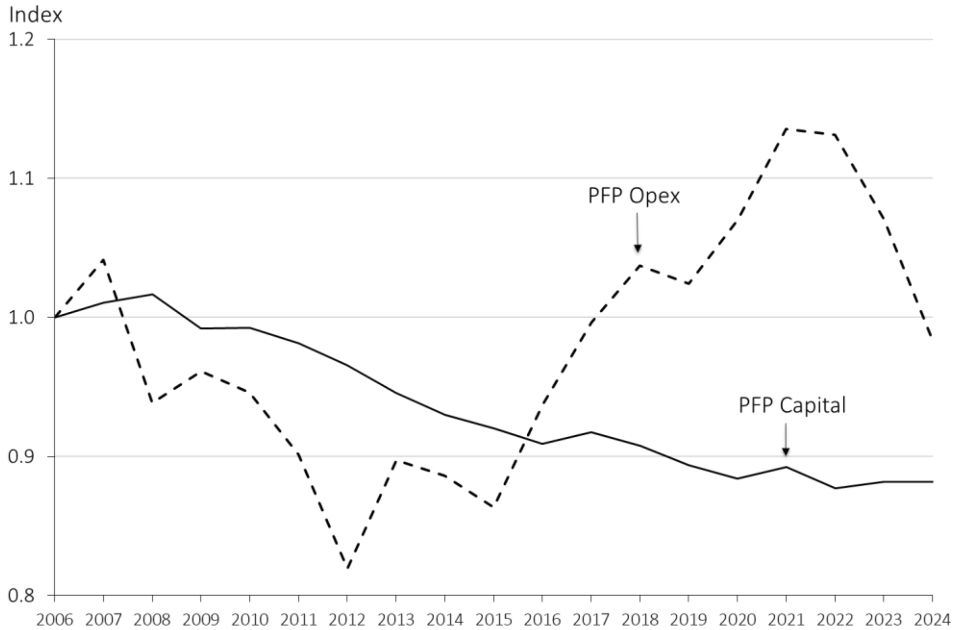
2.2 Partial factor productivity trends

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.

Opex PFP declined through to 2012 but has generally improved since then until 2021, as opex input trended down. However, in 2023 and 2024, the PFP of opex inputs *decreased* sharply. Over the 19-year period, opex PFP *declined* by an average of 0.1 per cent per year. In 2023, it *decreased* by 5.5 per cent, followed by a *decrease* of 8.6 per cent in 2024. By 2024, opex PFP was 1.7 per cent *below* its 2006 level.

Movements in the aggregate capital PFP index *declined* reasonably steadily over the sample period, at an average annual rate of –0.7 per cent. It follows an essentially inverse pattern to capital input quantities since, as Figure 2.1 shows, the total output index has a reasonably stable upward trend. In 2024, capital PFP did not change compared to 2023.

Figure 2.2 DNSP industry partial factor productivity indexes, 2006–2024



2.3 Distribution industry output and input quantity changes & contributions to TFP change

This section considers the changes in the quantities of the five separate outputs comprising the output index, and the six inputs comprising the input index. We also present results that show the contributions of each output and each input to TFP change. These changes reflect both the change in each component's quantity over time and its weight in forming the TFP index.

Quantity indexes for individual outputs (with 2006 = 1.0) are shown in Figure 2.3, and their growth rates in the first panel of Table 2.2. Individual input indexes (2006 = 1.0) are plotted in Figure 2.4 and their growth rates are in the second panel of Table 2.2. The third panel of this table shows partial productivity growth rates for individual inputs, which can assist to interpret TFP trends. Although we do not discuss these results here, they may be useful to the reader.

The following discussion of the movements in individual outputs and inputs for the DNSP industry, also addresses their contributions to overall TFP movements. Table 2.3 shows the percentage point contributions of each output and each input to the average annual rate of TFP change across four periods: 2006-2024, 2006-2012, 2012-2024 and 2024. Figure 2.5 depicts the output and input percentage point contributions to average annual TFP change for the distribution industry over 2006–2024.

Table 2.2 Industry individual output, input and PFP growth rates

	2006-2024	*2006-2012*	*2012-2024*	*2023-2024*
Outputs:				
Energy (GWh)	-0.1%	0.1%	-0.2%	1.3%
Ratcheted Max Demand (MVA)	1.1%	2.3%	0.5%	1.4%
Customer Numbers	1.3%	1.3%	1.3%	1.0%
Circuit Length (km)	0.3%	0.3%	0.3%	0.3%
CMOS	-0.1%	-1.9%	0.9%	2.6%
Inputs:				
Real Opex ($'000 2006)	1.1%	5.3%	-1.1%	9.4%
O/H Sub-tran. Lines (MVA-kms)	0.4%	0.8%	0.2%	-0.2%
O/H Distr. Lines (MVA-kms)	0.2%	0.1%	0.3%	0.5%
U/G Sub-tran. Lines (MVA-kms)	1.8%	2.9%	1.2%	1.7%
U/G Dist. Lines (MVA-kms)	3.2%	4.0%	2.7%	2.5%
Transformers (MVA)	2.1%	3.6%	1.3%	0.5%
All Capital inputs	1.7%	2.6%	1.2%	0.8%
Partial productivity:				
Output / Real Opex	-0.1%	-3.3%	1.5%	-8.6%
Output / OH Sub-tran. Lines	0.6%	1.2%	0.3%	1.0%
Output / OH Distr. Lines	0.8%	1.9%	0.2%	0.3%
Output / UG Sub-tran. Lines	-0.8%	-0.9%	-0.8%	-0.9%
Output / UG Distr. Lines	-2.2%	-2.0%	-2.3%	-1.7%
Output / Transformers	-1.1%	-1.6%	-0.9%	0.3%
Output / Capital	-0.7%	-0.6%	-0.8%	0.0%

2.3.1 Output movements and contributions

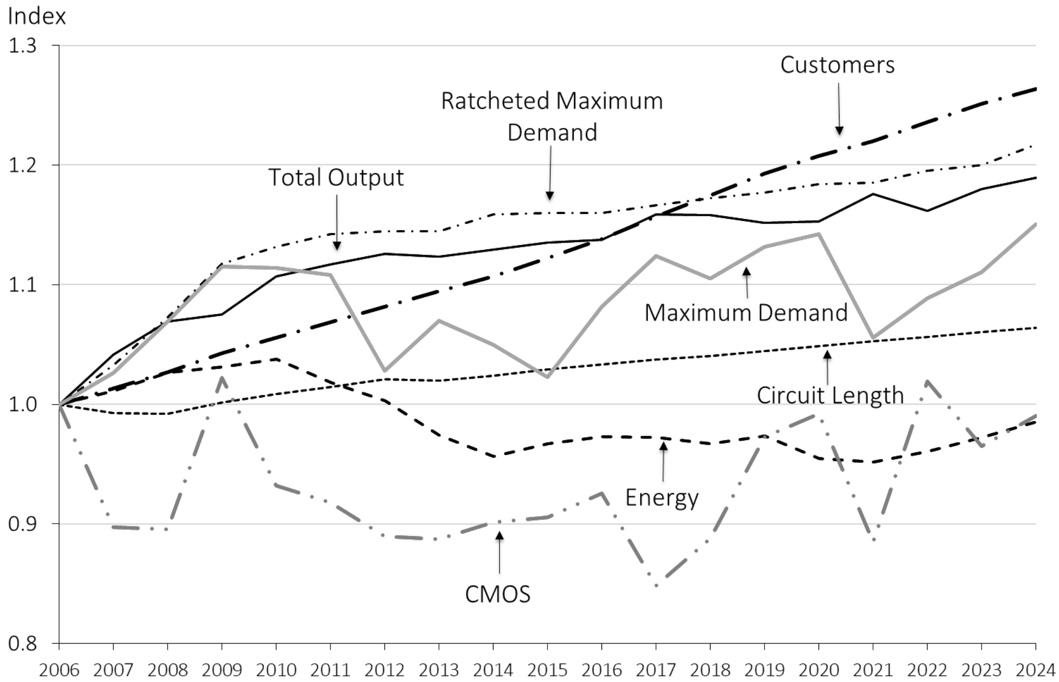
Over the 2006–2024 period, the DNSP industry's output with the highest growth rate is customer numbers, which increased steadily over the period and in 2024 was 26.3 per cent higher than in 2006.[12] Customer numbers have the third largest weight of the output components at 17.5 per cent on average, and as shown in Table 2.3, it contributed 0.23 percentage points to TFP change over the period 19-year period. In 2024 customer numbers increased by 1.0 per cent and contributed 0.17 percentage points to the industry's 2024 TFP change.

Energy throughput *decreased* by 0.1 per cent on average per year over the 19-year period and in 2024 was 1.5 per cent below its 2006 level. This broadly reflects the increasing impact of

[12] This steady increase is to be expected as the number of electricity customers will increase roughly in line with growth in the population.

energy conservation initiatives and more energy–efficient buildings and appliances, more than offsetting the effect of customer growth. Energy throughput made a marginal negative contribution to TFP of –0.01 percentage points in the 2006-2024 period, reflecting is small decline and relatively low average weight of 12.4 per cent in the output index. In 2024 energy throughput increased by 1.3 per cent and contributed to 0.17 percentage points of the industry's TFP change.

Figure 2.3 DNSP industry output quantity indexes, 2006–2024



Ratcheted maximum demand (RMD) is used as a measure of the capacity supplied to users.[13] It increased at an average rate of 1.1 per cent from 2006 to 2024 and by 2024 was 21.7 per cent higher than in 2006. RMD increased faster in the first half period, and more slowly since then, even though energy throughput declined after 2010. Over the whole period to 2024, the ratio between RMD and energy use increased more steadily and by 2024 was 23.5 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. RMD has the highest weight in forming the output index at 55.1 per cent, and in the 2006-2024 period it contributed 0.62 percentage points to the rate of TFP change. In 2024, RMD increased by 1.4 per cent and contributed 0.77 percentage points to the industry's TFP change.

[13] RMD is the sum of ratcheted maximum demands across the 13 DNSPs (rather than first summing the maximum demands and then calculating the ratcheted quantity). 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.

Circuit length increased at an average annual rate of only 0.3 per cent per year over the entire period. However, it receives an average weight of 30.1 per cent in the output index, and so made the third highest contribution to TFP change at 0.11 percentage points. In 2024, circuit length also increased by 0.3 per cent and contributed to 0.10 percentage points to the industry's TFP change. The slower growth in circuit length compared to customer numbers indicates that most of the increase in customer numbers over the period has been through 'in fill' development (ie, new dwellings which could be supplied off the existing network), hence not requiring large increases in network length. This would suggest that 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.

Customer minutes off–supply (CMOS) 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. By 2024, CMOS was 1.0 per cent *below* the 2006 level, representing an average annual change of –0.1 per cent. It receives a weight of –15.2 per cent on average in the output index and made a marginal positive contribution to TFP of 0.02 percentage points over the entire period. In 2024, CMOS increased by 2.6 per cent and contributed to –0.40 percentage points to the industry's TFP change.

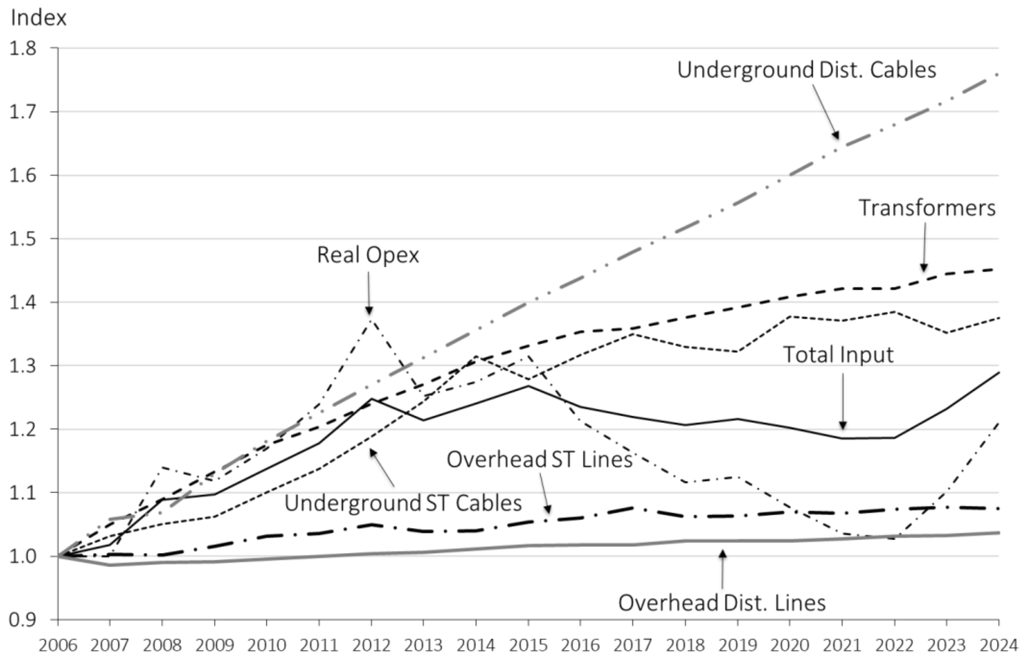
2.3.2 Input movements and contributions

Turning to the input side, as shown in Table 2.2 and Figure 2.4, the quantity of opex (ie, opex in constant 2006 prices) increased sharply between 2006 and 2012, at 5.3 per cent per year. It then *decreased* at 1.1 per cent per year in the 2012-2024 period. The decrease was more substantial in the 2012 to 2022 period, but in 2023 and 2024 real opex increased considerably, by 7.0 and 9.4 per cent respectively. Opex has the largest average share in total costs at 42.3 per 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). Over the 2006-2024 period, it contributed to –0.45 percentage points of TFP change. In 2024, it contributed –3.94 percentage points to TFP change.

Another input with a large weight is transformers, which accounts for 26.4 per cent of total cost for the industry. The quantity of transformers increased at 2.1 per cent per year over the period and by 2024 was 45.2 per cent above its 2006 level. Using more or larger transformers in zone substations and on the existing network, a DNSPs can accommodate ongoing increases in customer numbers with only small increases in their overall network length. Transformers make the largest negative contribution to TFP change in the 2006-2024 period at –0.55 percentage points. In 2024, it contributed –0.16 percentage points to TFP change.

The next inputs are the quantities of overhead distribution and overhead subtransmission lines (measured in MVAkm).[14] These two input quantities have increased over the period from 2006 to 2024 in total by 3.7 and 7.5 per cent. Overhead distribution and subtransmission lines together account for 18.5 per cent of total DNSP costs on average and combined made a contribution of –0.05 percentage points to TFP change in 2006-2024 period and –0.09 percentage points in 2024.

Figure 2.4 DNSP industry input quantity indexes, 2006–2024



The fastest growing input quantity is that of underground distribution cables whose quantity was 76.0 per cent higher in 2024 than it was in 2006. However, this growth starts from a 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 increased faster than underground subtransmission quantity (which increased by 37.5 per cent over the period). The length of overhead lines for the electricity distribution industry in 2024 is still approximately seven times the length of underground cables, reflecting that underground cables are considerably more expensive to install per kilometre. Consequently, despite their relatively short length, underground distribution and subtransmission cables have a combined average share in total costs of 12.7 per cent. Together, these inputs contributed –0.38 percentage points to TFP change in 2006-2024 period and –0.40 percentage points in 2024.

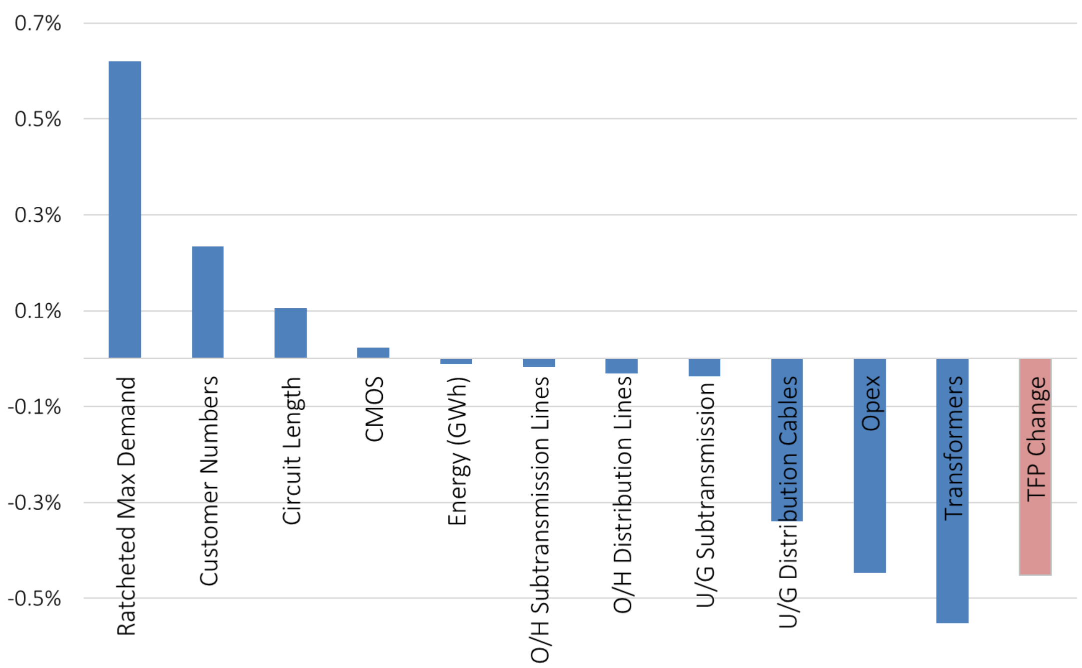
[14] Overhead line input quantities take account of both the length of lines (in km) and the overall 'carrying capacity' of the lines (in MVA

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 are added together, the sum will equal the red bar of TFP change at the far right.

Table 2.3 Distribution industry output and input percentage point contributions to average annual TFP change: Various periods

Year	*2006 to 2024*	*2006 to 2012*	*2012 to 2024*	*2024*
Energy (GWh)	-0.01%	0.01%	-0.02%	0.17%
Ratcheted Max Demand	0.62%	1.28%	0.29%	0.77%
Customer Numbers	0.23%	0.24%	0.23%	0.17%
Circuit Length	0.11%	0.11%	0.10%	0.10%
CMOS	0.02%	0.33%	-0.13%	-0.40%
Opex	-0.45%	-2.22%	0.45%	-3.94%
O/H Subtransmission Lines	-0.02%	-0.04%	-0.01%	0.00%
O/H Distribution Lines	-0.03%	-0.01%	-0.04%	-0.09%
U/G Subtransmission	-0.04%	-0.06%	-0.03%	-0.04%
U/G Distribution Cables	-0.34%	-0.43%	-0.29%	-0.36%
Transformers	-0.55%	-0.94%	-0.35%	-0.16%
TFP Change	-0.45%	-1.73%	0.19%	-3.79%

Figure 2.5 Distribution industry output and input percentage point contributions to average annual TFP change, 2006–2024



3 DNSP multilateral total and partial factor productivity analysis

As outlined in chapter 1, MTFP and MPFP indexes can yield comparisons of productivity levels between DNSPs, as well as comparative productivity growth rates, when a pooled group of DNSPs is included in the index analysis. This chapter presents a summary of MTFP and MPFP results for each DNSP using the pooled analysis.

3.1 Pooled Multilateral TFP Indexes

MTFP indexes for each DNSP over the period 2006 to 2024 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 1. The results are invariant to which observation is used as the base.

In 2006 the average MTFP index (relative to EVO in 2006) was 1.18, and it reduced to 1.09 in 2024, reflecting the average industry decrease in TFP over the intervening period. There was also a slightly narrowing of MTFP scores, in that the difference between the highest and lowest MTFP indexes decreased from 0.80 in 2006 to 0.67 in 2024.

Figure 3.1 DNSP multilateral total factor productivity indexes, 2006–2024

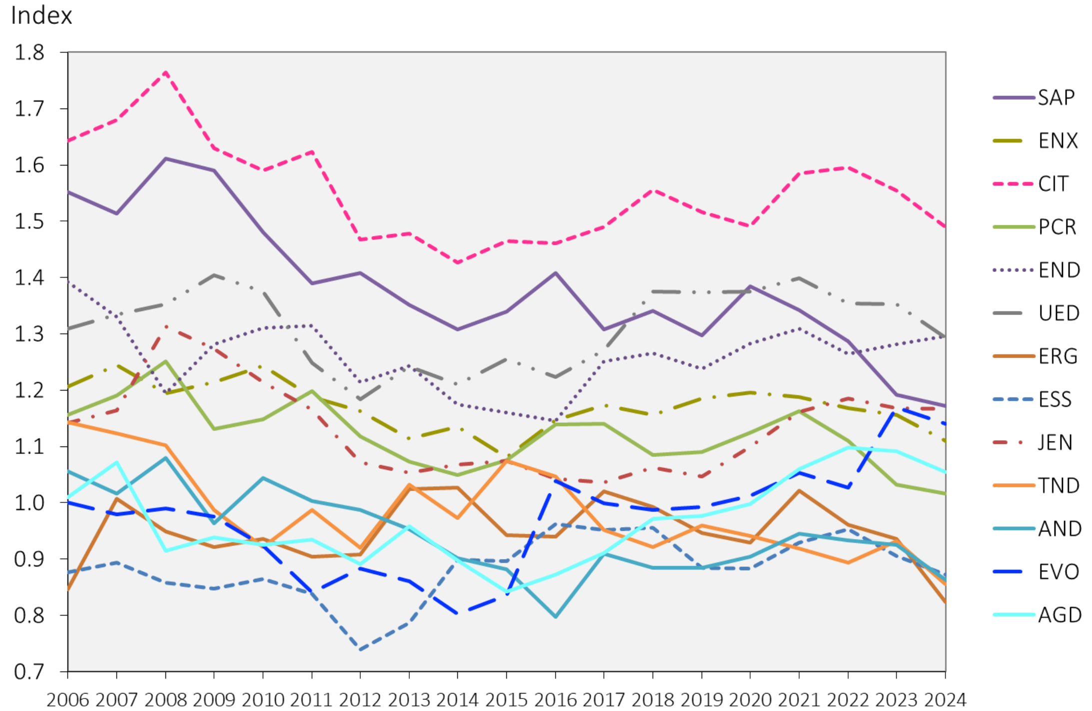


Table 3.1 DNSP multilateral total factor productivity indexes, 2006–2024

Year	EVO	AGD	CIT	END	ENX	ERG	ESS
2006	1.000	1.010	1.642	1.393	1.206	0.846	0.877
2007	0.980	1.071	1.679	1.331	1.245	1.007	0.893
2008	0.991	0.915	1.764	1.194	1.195	0.949	0.858
2009	0.976	0.939	1.629	1.282	1.214	0.921	0.847
2010	0.924	0.925	1.591	1.311	1.243	0.936	0.865
2011	0.841	0.934	1.623	1.314	1.188	0.905	0.838
2012	0.884	0.892	1.467	1.214	1.163	0.908	0.739
2013	0.860	0.958	1.478	1.243	1.114	1.024	0.787
2014	0.802	0.897	1.426	1.175	1.135	1.027	0.899
2015	0.836	0.842	1.465	1.160	1.081	0.942	0.896
2016	1.039	0.873	1.461	1.145	1.146	0.940	0.962
2017	0.999	0.911	1.490	1.252	1.173	1.020	0.951
2018	0.987	0.972	1.556	1.266	1.157	0.992	0.955
2019	0.992	0.977	1.517	1.239	1.185	0.946	0.885
2020	1.013	0.998	1.491	1.282	1.196	0.929	0.884
2021	1.053	1.060	1.585	1.309	1.187	1.022	0.930
2022	1.027	1.098	1.596	1.264	1.168	0.962	0.953
2023	1.169	1.092	1.554	1.281	1.157	0.936	0.906
2024	1.140	1.054	1.490	1.297	1.110	0.824	0.873

Table 3.1 (cont.)

Year	JEN	PCR	SAP	AND	TND	UED	AVG
2006	1.141	1.156	1.552	1.055	1.143	1.309	1.179
2007	1.164	1.191	1.514	1.016	1.123	1.334	1.196
2008	1.313	1.251	1.611	1.079	1.102	1.352	1.198
2009	1.274	1.132	1.591	0.964	0.988	1.404	1.166
2010	1.214	1.148	1.480	1.044	0.921	1.375	1.152
2011	1.165	1.199	1.390	1.004	0.987	1.248	1.126
2012	1.071	1.118	1.408	0.987	0.920	1.184	1.073
2013	1.053	1.073	1.352	0.953	1.032	1.241	1.090
2014	1.068	1.049	1.308	0.902	0.973	1.210	1.067
2015	1.075	1.076	1.340	0.881	1.074	1.256	1.071
2016	1.042	1.140	1.408	0.797	1.047	1.224	1.094
2017	1.037	1.140	1.307	0.910	0.952	1.272	1.109
2018	1.063	1.085	1.341	0.885	0.922	1.375	1.120
2019	1.047	1.090	1.297	0.885	0.960	1.374	1.107
2020	1.100	1.125	1.384	0.904	0.941	1.375	1.125
2021	1.162	1.163	1.343	0.945	0.919	1.398	1.160
2022	1.185	1.111	1.287	0.934	0.894	1.355	1.141
2023	1.168	1.032	1.192	0.925	0.932	1.353	1.131
2024	1.167	1.017	1.172	0.863	0.856	1.293	1.089

Comparing MTFP levels in 2024:

- CIT has the highest MTFP level followed by END and UED. ERG ranks lowest in terms of MTFP followed by TND and AND;
- The DNSPs with above–average MTFP indexes were CIT (with an MTFP index of 1.49), END (1.30), UED (1.29), SAP (1.17), JEN (1.17), EVO (1.14) and ENX (1.11);
- Those with below–average MTFP indexes were (from smallest to largest) ERG (0.82), TND (0.86), AND (0.86), ESS (0.87), PCR (1.02), and AGD (1.05).

Total factor productivity declined in 2024 across all DNSPs except for END, which increased its productivity by 1.2 per cent in 2024. The largest declines in MTFP change in 2024 were observed for ERG (–12.7 per cent), TND (–8.5 per cent), AND (–6.9 per cent), UED (–4.5 per cent), CIT (–4.2 per cent) and ENX (–4.1 per cent).

Comparing the rankings of MTFP levels in 2024 to those in 2023, ESS had the largest increase in its ranking, from 13th to 10th. It was followed by JEN, which increased from 6th to 5th, AND which increased from 12th to 11th and END, which increased from 3rd to 2nd. On the other hand, the DNSPs whose ranking decreased were ERG from 10th to 13th, TND from 11th to 12th, EVO from 5th to 6th and UED from 2nd to 3rd. AGD, CIT, ENX, PCR and SAP did not experience changes in their ranking positions from 2023 to 2024.[15]

Comparing the rankings of MTFP levels in 2024 to those in 2006, EVO had the largest increase in its rankings from 11th to 6th. JEN increased by three places, from 8th to 5th. AGD and ESS increased by two places, from 10th to 8th and from 13th to 10th, respectively. Other increases in ranking included END, from 3rd to 2nd and UED from 4th to 3rd. TND is the DNSP with the largest decreases in rankings between 2006 and 2024, from 7th to 12th. PCR decreased by three places, from 6th to 9th. DNSPs that decreased by two places included AND (from 9th to 11th), SAP (from 2nd to 4th) and ENX (from 5th to 7th). The MTFP rankings of CIT, and ERG in 2024 were unchanged from their 2006 rankings.

3.2 Multilateral PFP Indexes

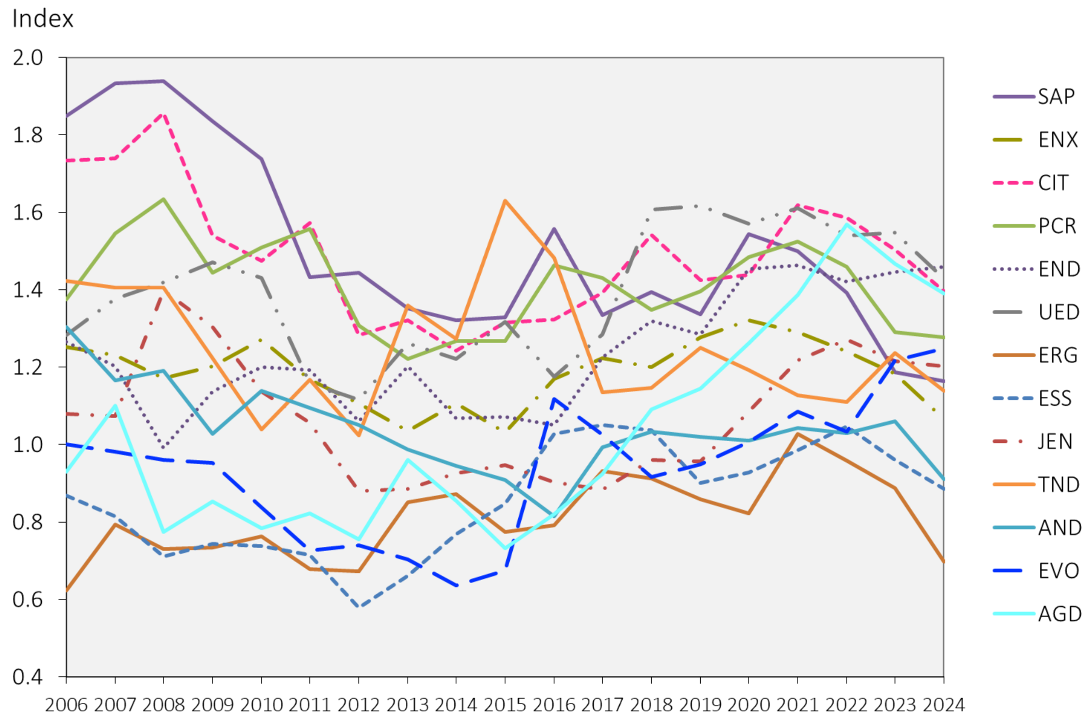
MTFP levels are an amalgam of Opex MPFP and Capital MPFP levels. Updated Opex MPFP indexes are presented in Figure 3.2 and Table 3.2 while updated Capital MPFP indexes are presented in Figure 3.3 and Table 3.3.

From Figure 3.2 and Table 3.2 we see that, on average, Opex MPFP levels decreased in the period from 2006 to 2012, but this trend was mostly reversed in the period 2013 to 2021. However, from 2022 to 2024, Opex MPFP has shown a further downtrend across DNSPs.

[15] Note that the output weights were updated in this year's report. As a result, the 2023 rankings shown in the 2024 report may differ from those presented for 2023 in the current report.

Only two DNSPs increased Opex MPFP levels in 2024, namely EVO (2.6 per cent) and END (0.9 per cent). The Opex MPFP levels of eleven DNSPs decreased in 2024, including ERG (–24.0 per cent), AND (–15.2 per cent), ENX (–10.3 per cent), TND, ESS and UED (all –8.1 per cent), CIT (–7.4 per cent), AGD (–5.3 per cent), SAP (–2.0 per cent), JEN (–1.2 per cent), and PCR (–1.0 per cent).[16] END ranked highest in terms of Opex MPFP levels in 2024 followed by UED and CIT. ERG ranked lowest in terms of Opex MPFP levels in 2024, followed by ESS, and AND.

Figure 3.2 DNSP multilateral opex partial factor productivity indexes, 2006–2024



Comparing rankings in 2024 with 2006, five DNSPs improved their Opex PFP ranking: AGD (from 11th to 4th), END (from 7th to 1st), EVO (from 10th to 6th), UED (from 6th to 2nd) and JEN (from 9th to 7th). Other six DNSPs decreased their Opex MPFP rankings in 2024 compared to 2006: SAP (from 1st to 8th), TND (from 3rd to 9th), AND (from 5th to 11th), ENX (from 8th to 10th, PCR (from 4th to 5th) and CIT (from 2nd to 3rd). The remaining DNSPs (ERG and ESS), had the same ranking in 2024 as in 2006.

Compared to 2023, END improved its Opex MPFP ranking by three places in 2024 (from 4th to 1st). Other improved rankings included EVO (from 7th to 6th place), JEN (from 8th to 7th) and SAP (from 9th to 8th). The DNSPs that decreased their Opex MPFP rankings in 2024 compared to 2023 were UED (from 1st to 2nd), CIT (from 2nd to 3rd), AGD (from 3rd to 4th) and TND

[16] As previously noted, annual growth rates are calculated using the log–difference method. See Appendix A (section A1.4) for further details.

(from 6th to 9th place). AND, ENX, ERG, ESS and PCR did not experience changes in their ranking positions from 2023 to 2024.

Table 3.2 DNSP multilateral opex partial factor productivity indexes, 2006–2024

Year	EVO	AGD	CIT	END	ENX	ERG	ESS
2006	1.000	0.930	1.733	1.265	1.251	0.624	0.869
2007	0.981	1.101	1.739	1.202	1.232	0.794	0.815
2008	0.960	0.775	1.857	0.990	1.171	0.731	0.712
2009	0.953	0.852	1.541	1.137	1.202	0.735	0.744
2010	0.839	0.784	1.474	1.200	1.271	0.764	0.737
2011	0.727	0.822	1.572	1.192	1.168	0.678	0.715
2012	0.741	0.755	1.282	1.061	1.107	0.673	0.578
2013	0.703	0.961	1.322	1.203	1.035	0.852	0.662
2014	0.637	0.854	1.243	1.068	1.106	0.872	0.769
2015	0.675	0.733	1.316	1.073	1.032	0.774	0.847
2016	1.118	0.820	1.324	1.051	1.169	0.792	1.029
2017	1.027	0.924	1.392	1.225	1.224	0.933	1.050
2018	0.916	1.092	1.543	1.319	1.200	0.912	1.037
2019	0.949	1.145	1.425	1.285	1.277	0.860	0.902
2020	1.007	1.261	1.439	1.453	1.322	0.822	0.927
2021	1.085	1.386	1.618	1.463	1.291	1.027	0.985
2022	1.034	1.569	1.586	1.421	1.241	0.959	1.046
2023	1.217	1.466	1.503	1.447	1.183	0.887	0.961
2024	1.249	1.390	1.396	1.459	1.067	0.698	0.886

Table 3.2 (cont.)

Year	JEN	PCR	SAP	AND	TND	UED	AVG
2006	1.079	1.376	1.849	1.303	1.423	1.283	1.230
2007	1.073	1.547	1.933	1.166	1.405	1.377	1.259
2008	1.398	1.634	1.938	1.190	1.407	1.420	1.245
2009	1.304	1.445	1.836	1.027	1.223	1.471	1.190
2010	1.136	1.509	1.738	1.139	1.039	1.430	1.158
2011	1.057	1.557	1.432	1.096	1.168	1.157	1.103
2012	0.881	1.309	1.443	1.051	1.024	1.115	1.002
2013	0.886	1.222	1.353	0.987	1.360	1.262	1.062
2014	0.926	1.267	1.321	0.945	1.273	1.222	1.039
2015	0.946	1.267	1.330	0.909	1.630	1.318	1.065
2016	0.903	1.463	1.557	0.815	1.482	1.175	1.131
2017	0.883	1.430	1.335	0.992	1.135	1.286	1.141
2018	0.960	1.347	1.395	1.034	1.146	1.608	1.193
2019	0.957	1.395	1.336	1.020	1.250	1.616	1.186
2020	1.085	1.485	1.543	1.010	1.192	1.571	1.240
2021	1.218	1.525	1.500	1.043	1.127	1.610	1.298
2022	1.272	1.459	1.393	1.029	1.110	1.539	1.281
2023	1.217	1.290	1.187	1.060	1.236	1.548	1.246
2024	1.202	1.277	1.164	0.910	1.139	1.428	1.174

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

In 2024, five DNSPs improved their Capital MPFP levels compared to 2023, namely END (2.9 per cent), ENX (1.6 per cent), PCR and JEN (both 0.8 per cent), and ESS (0.6 per cent). The DNSPs with reductions in capital MPFP levels in 2024 were: TND (–6.1 per cent), EVO (– 5.1 per cent), ERG (–3.8 per cent), UED (–1.5 per cent), SAP (–1.4 per cent), CIT (–1.3 per cent) and AND (–1.0 per cent). AGD's Capital MPFP was unchanged.

The highest ranked DNSPs in terms of capital productivity in 2024 were CIT followed by UED, END, and SAP (in that order), while TND ranked lowest followed by AND, PCR, and ESS. Comparing rankings in 2024 with 2006, four DNSPs improved their Capital PFP ranking: ESS (from 13th to 10th), EVO (from 9th to 7th), UED (from 4th to 2nd) and ENX (from 6th to 5th). The largest decline in ranking was TND (10th to 13th), while AGD, END, ERG, JEN and SAP had minor reductions in ranking. The remaining DNSPs (AND, PCR and CIT), had the same ranking in 2024 as in 2006.

Figure 3.3 DNSP multilateral capital partial factor productivity indexes, 2006–2024

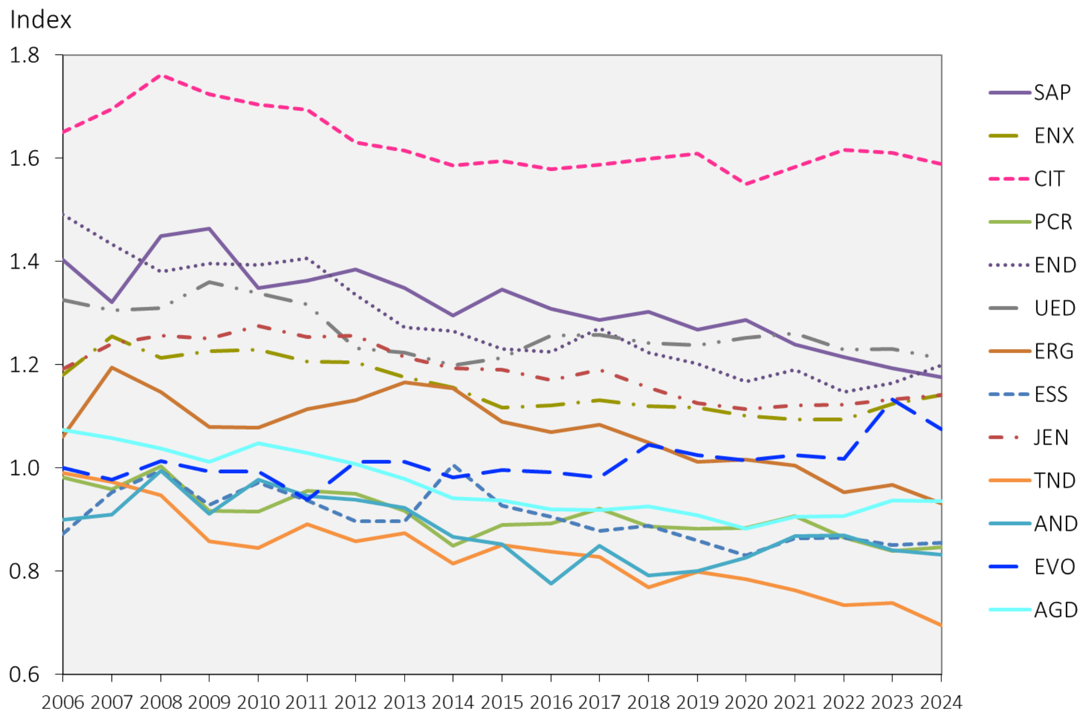


Table 3.3 DNSP multilateral capital partial factor productivity indexes, 2006–2024

Year	EVO	AGD	CIT	END	ENX	ERG	ESS
2006	1.000	1.073	1.651	1.492	1.181	1.060	0.873
2007	0.977	1.057	1.695	1.434	1.255	1.195	0.953
2008	1.013	1.038	1.762	1.380	1.214	1.147	0.994
2009	0.994	1.013	1.724	1.396	1.226	1.080	0.929
2010	0.994	1.047	1.704	1.393	1.230	1.078	0.971
2011	0.939	1.029	1.695	1.406	1.207	1.113	0.937
2012	1.012	1.007	1.631	1.336	1.205	1.131	0.897
2013	1.012	0.979	1.615	1.272	1.176	1.165	0.897
2014	0.982	0.941	1.586	1.265	1.155	1.155	1.007
2015	0.997	0.936	1.594	1.231	1.117	1.089	0.927
2016	0.992	0.920	1.578	1.226	1.122	1.069	0.905
2017	0.982	0.919	1.587	1.271	1.131	1.084	0.878
2018	1.045	0.925	1.598	1.224	1.119	1.050	0.889
2019	1.025	0.908	1.609	1.201	1.116	1.011	0.859
2020	1.015	0.882	1.549	1.168	1.102	1.017	0.831
2021	1.024	0.905	1.584	1.190	1.094	1.005	0.864
2022	1.017	0.907	1.616	1.147	1.095	0.953	0.866
2023	1.132	0.937	1.610	1.165	1.124	0.967	0.851
2024	1.075	0.936	1.589	1.199	1.142	0.931	0.855

Table 3.3 (cont.)

Year	JEN	PCR	SAP	AND	TND	UED	AVG
2006	1.191	0.982	1.403	0.899	0.990	1.325	1.163
2007	1.240	0.959	1.322	0.910	0.974	1.305	1.175
2008	1.256	1.004	1.449	0.995	0.947	1.309	1.193
2009	1.251	0.916	1.464	0.911	0.859	1.361	1.163
2010	1.275	0.916	1.349	0.977	0.845	1.339	1.163
2011	1.254	0.956	1.363	0.946	0.891	1.317	1.158
2012	1.256	0.950	1.385	0.939	0.858	1.232	1.142
2013	1.214	0.917	1.349	0.923	0.873	1.224	1.124
2014	1.194	0.849	1.296	0.866	0.815	1.199	1.101
2015	1.190	0.890	1.345	0.852	0.852	1.213	1.095
2016	1.170	0.892	1.308	0.775	0.837	1.256	1.081
2017	1.191	0.921	1.287	0.849	0.827	1.258	1.091
2018	1.156	0.886	1.303	0.792	0.769	1.242	1.077
2019	1.125	0.883	1.269	0.800	0.799	1.238	1.065
2020	1.114	0.883	1.286	0.827	0.785	1.252	1.055
2021	1.122	0.907	1.240	0.868	0.763	1.261	1.064
2022	1.123	0.865	1.215	0.870	0.734	1.230	1.049
2023	1.133	0.840	1.193	0.841	0.739	1.231	1.059
2024	1.142	0.847	1.176	0.833	0.696	1.213	1.049

4 Econometric opex cost function analysis

This chapter presents the update of the econometric opex cost function models. This analysis includes data for the 13 Australian DNSPs, together with 19 New Zealand DNSPs and 29 Ontario DNSPs. Opex for Australian DNSPs incorporates capitalised corporate overheads (CCOs).

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 allow the direct inclusion of adjustments for operating environment factors. In this section we update the models in Economic Insights (2020, 2021) and Quantonomics (2022; 2023a; 2024) to include data for the year ending June 2024 for the Australian DNSPs, the year ending March 2024 for New Zealand DNSPs and calendar year 2023 data for the Ontario DNSPs.[17]

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 specifications are used:

- 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),[18]
- a stochastic frontier analysis model using the Cobb–Douglas functional form (SFACD), and
- a stochastic frontier analysis model using the Translog functional form (SFATLG).

These models are estimated for two sample periods: 2006 to 2024 and 2012 to 2024. Detailed regression results are presented in Appendix D. In this section, we present summary information on the monotonicity performance and the average opex efficiency scores.

4.1 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.

[17] Throughout this section and Appendix D, when a sample is described as 2006 to 2024, it includes Ontario data for 2005 to 2023; and a sample described as 2012 to 2024 includes Ontario data for 2011 to 2023.

[18] The two least–squares models are estimated with panel–corrected standard errors.

Cobb-Douglas models have 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 (equal to the output's elasticity at the mean of the sample, which is used for normalisation), but also the estimated output elasticity for each observation because these models have varying output elasticities.

In previous benchmarking studies the SFATLG and LSETLG models have produced some monotonicity violations (Economic Insights 2019; 2020; 2021; Quantonomics 2022; 2023a; 2024). The practice has been to calculate the average efficiency score for each DNSP after excluding either the SFATLG or LSETLG models (or both) if they 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 D. The average efficiency scores for each DNSP in Table 4.1 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.

For the models applied to the full data sample from 2006 to 2024 (see Tables D.6 and D.7 of Appendix D) the LSETLG model has monotonicity violations in 7.7 per cent of the observations on Australian DNSPs. These violations specifically relate to the output customer numbers. Monotonicity violations occurred in half or more of the observations for one Australian DNSP (CIT) and for this reason, the LSETLG model is not included in its average efficiency scores for the 2006 to 2024 period.

For the models applied to the shorter sample period from 2012 to 2024 (see Table D.14 and D.15 of Appendix D), the LSETLG model has monotonicity violations in 46.2 per cent of Australian DNSP observations, with all violations relating to the customer number variable. Six Australian DNSPs (AGD, CIT, END, ENX, JEN, and UED) had monotonicity violations for more than half of the observations. For these six DNSPs, the LSETLG model is not included in the average efficiency scores for the 2012 to 2024 period.

The SFATLG truncated normal model did not converge in both the long and short sample.[19] Non-convergence implies that the parameter estimates, cost elasticities and inefficiency scores can be unreliable. Hence, the SFATLG models for both the long and short-sample periods have been omitted.

While the frequency monotonicity violations observed for the LSETLG models in both long and short period in this study are slightly lower than those reported in the 2024 study, they remain at a high level and represent a significant deterioration in the monotonicity

[19] See Section D3 for further discussion.

performance of the Translog models in the long sample period when compared to the results reported in 2023 and 2022. The non-convergence of the SFATLG model in the long sample period represents a deterioration in performance compared to previous years.

In the 2024 study the LSETLG model had excessive monotonicity violations for three Australian DNSPs in the long period and for six in the short period. The SFATLG long period model had excessive monotonicity violations for 11 Australian DNSPs and in the short period, the SFATLG model did not converge. In the 2023 study, the LSETLG model showed excessive monotonicity violations for one Australian DNSPs in the long period and for seven Australian DNSPs in the short period. The SFATLG model has excessive monotonicity violations for five of the Australian DNSPs in the long period and for ten in the short period. In the 2022 results, neither the LSETLG nor the SFATLG model had any monotonicity violations for Australian DNSPs when estimated using the full sample period. For the short period, LSETLG and SFATLG models had excessive monotonicity violations for five and nine Australian DNSPs, respectively. [20]

4.2 Summary results for the sample period 2006–2024

Opex efficiency scores for each of the 13 NEM DNSPs across the 19-year period 2006 to 2024 for the four opex cost function models and, for comparison, opex MPFP are presented in Table 4.1 and in Figure 4.1 (the latter excluding the SFATLG model due to non-convergence and LSETLG models as necessary). The same average opex efficiency scores across all models, and for the econometric models only, are presented in Figure 4.2.

The last two columns of Table 4.1 show averages of efficiency scores:

(a) across all models including Opex PFP (but excluding the SFATLG model for all DNSPs due to non-convergence, and excluding the LSETLG model for CIT as a result of monotonicity violations); and

(b) across only the econometric model estimates (with the same exclusions).

The opex efficiency scores averaged over all methods indicate:

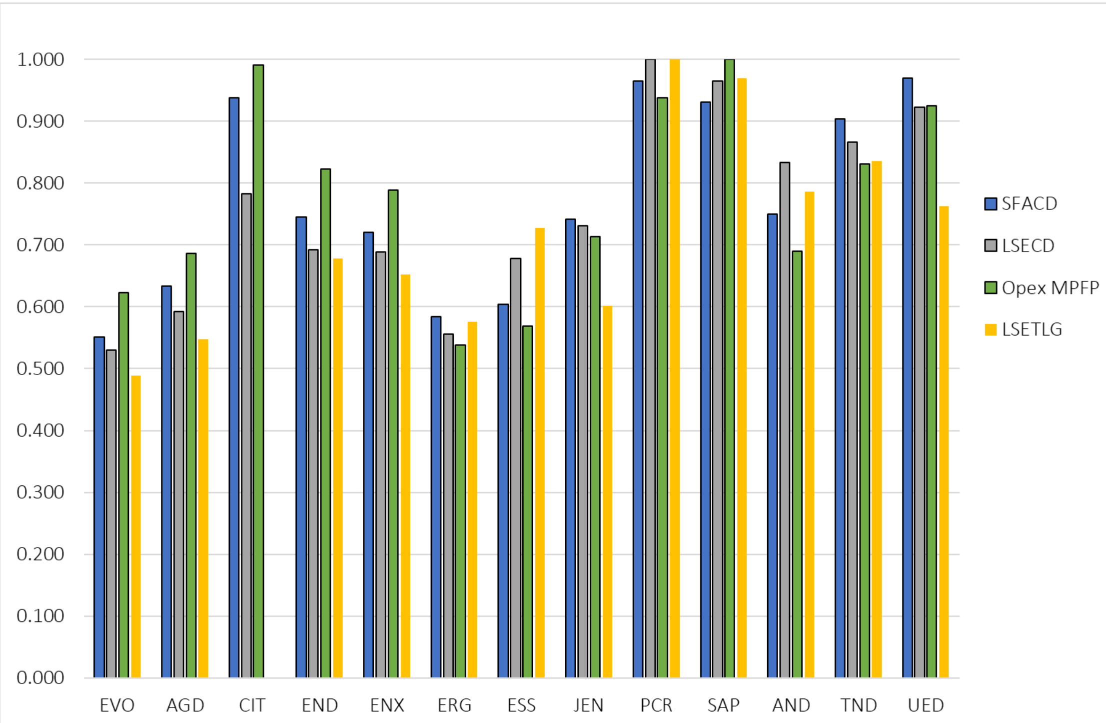
- PCR and SAP have the highest average efficiency scores (0.976 and 0.966 respectively);
- CIT, UED and TND also had non-trivially above-average efficiency scores (0.904, 0.895 and 0.859 respectively);
- The sample average opex efficiency score is 0.760, and the DNSP with opex efficiency closest to the average is AND (0.765);

[20] Note that the results of this present study, as well as those in the 2024 and 2023 studies, were obtained using opex including CCO. In contrast, the results of 2022 study were obtained using opex excluding CCOs.

- Several DNSPs are somewhat below average in terms of opex efficiency. These are END (0.734), ENX (0.713), JEN (0.697) and ESS (0.645);
- The three DNSPs with lowest opex efficiency are EVO (0.548), ERG (0.563) and AGD (0.515).

These rankings are similar to those in Quantonomics (2024).[21] The overall average efficiency scores are also broadly similar between models. The SFACD model has an average efficiency score of 0.772, while the LSECD and LSETLG models have average efficiency scores of 0.757 and 0.719, respectively. Table 4.1 also compares the average of the econometric efficiency scores 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 0.778, which is broadly similar to the econometric analysis.

Figure 4.1 DNSP opex cost efficiency scores, 2006–2024



Compared to the results in the 2024 report, and using the average of five methods, the efficiency scores of five DNSPs *decreased*: ESS (–3.6 per cent), ERG (–3.4 per cent), AND (–0.5 per cent), SAP (–0.2 per cent) and PCR (–0.1 per cent). The other eight DNSPs' average efficiency scores improved, specifically: CIT (11.6 per cent), EVO (8.3 per cent), END (7.1 per cent), AGD (6.7 per cent), JEN (6.5 per cent), ENX (4.7 per cent), UED (2.0 per cent) and TND (1.8 per cent)

[21] In the 2024 study, the efficiency ranking from highest to lowest is: PCR, SAP, UED, TND, CIT, AND, END, ENX, ESS, JEN, ERG, AGD, and EVO.

Table 4.1 DNSP average opex cost efficiency scores, 2006–2024

DNSP	*SFACD* (1)	*SFATLG* (2)[22]	*LSECD* (3)	*LSETLG* (4)	*Opex* (5)	*Average Methods***	*Average Models***
EVO	0.552	na	0.530	0.489	0.623	0.548	0.523
AGD	0.634	na	0.593	0.548	0.686	0.615	0.591
CIT	0.938	na	0.783	0.720	0.990	0.904*	0.860*
END	0.746	na	0.692	0.678	0.823	0.734	0.705
ENX	0.720	na	0.689	0.653	0.789	0.713	0.687
ERG	0.584	na	0.555	0.576	0.538	0.563	0.572
ESS	0.604	na	0.679	0.728	0.569	0.645	0.670
JEN	0.742	na	0.731	0.601	0.713	0.697	0.691
PCR	0.965	na	1.000	1.000	0.938	0.976	0.988
SAP	0.931	na	0.965	0.970	1.000	0.966	0.955
AND	0.749	na	0.833	0.786	0.690	0.765	0.790
TND	0.904	na	0.866	0.835	0.832	0.859	0.868
UED	0.970	na	0.923	0.763	0.925	0.895	0.885
AVG$^{(1)}$	0.772	na	0.757	0.719	0.778	0.760	0.753

Note: * Excludes LSETLG; ** Excludes SFATLG; (1) Excludes scores affected by monotonicity violations.

Table 4.2 summarises 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 4.2 Average DNSP output elasticities by country and overall, 2006–2024

Sub–sample	*Customer numbers*	*Circuit length*	*RMD*	*Total*
LSECD model				
All	0.518	0.229	0.216	0.963
LSETLG model				
Australia	0.279	0.300	0.412	0.991
New Zealand	0.653	0.237	0.055	0.946
Ontario	0.200	0.200	0.544	0.944
Full sample	0.358	0.233	0.364	0.955
SFACD model				
All	0.242	0.139	0.583	0.965

Table 4.2 shows averages of these elasticities by country and over the full sample (ie, including overseas DNSPs). The average cost–output elasticities differ across models. In the LSECD model, customer numbers have the highest elasticity, while circuit length and RMD follow with similar values. In the SFACD model, RMD ranks highest, followed by customer

[22] The SFATLG model is excluded due to non-convergence. See section D3 in Appendix D.

numbers, with circuit length showing the lowest elasticity. The LSETLG model, using the full sample, also assigns the highest elasticity to RMD, with customer numbers slightly lower and circuit length again the lowest. For the Australian sub-sample, RMD remains highest (0.412), followed by circuit length (0.300) and customer numbers (0.279).

Figure 4.2 shows the average efficiency scores of all models (including opex PFP), and for the econometric models only. The results are broadly similar whichever of these two averaging approaches is used.

Figure 4.2 DNSP opex cost efficiency scores, 2006–2024, average of models

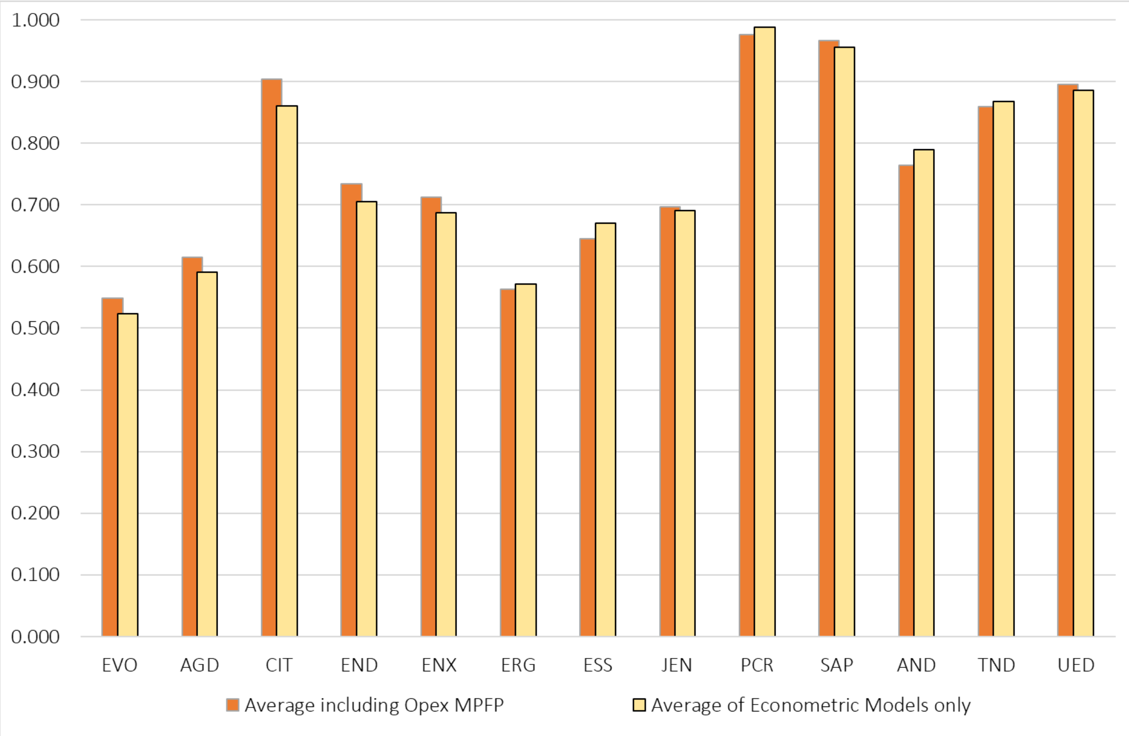
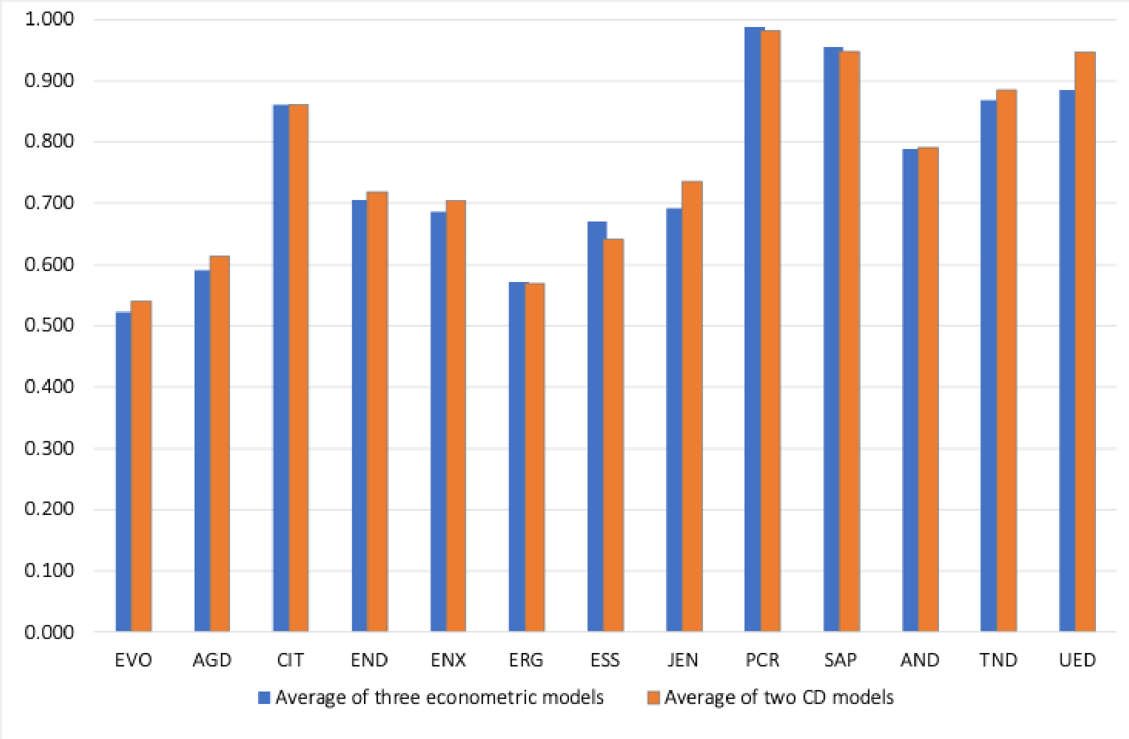


Figure 4.3 compares the average efficiency scores using all the valid econometric models (excluding the SFATLG or LSETLG models when necessary) against the average efficiency scores using only the two Cobb–Douglas models, SFACD and LSECD. This shows that whether the average of all valid econometric models is used, or whether the average of only the Cobb–Douglas models is used, the resulting efficiency scores are broadly similar.

Figure 4.3 DNSP opex cost efficiency scores, 2006–2024, average of three econometric models compared to the average of CD models



4.3 Summary results for the sample period 2012–2024

We turn now to the opex efficiency scores based on the more recent period, 2012 to 2024. Opex efficiency scores are presented in Figure 4.4 and Table 4.3 for each of the 13 NEM DNSPs. Table 4.3 shows the results from three opex cost function models and opex MPFP, with the SFATLG model excluded due to non-convergence.[23] For each DNSP, opex efficiency scores are averaged across econometric benchmarking models where feasible (with the SFATLG model excluded in all cases, and the LSETLG model also excluded for six of the 13 DNSPs), and also averaged over all methods (ie, the same econometric models plus opex PFP).

Figure 4.4 shows the efficiency score result for each DNSP using each of the included methods. Figure 4.5 compares the efficiency scores averaged over all methods (including opex PFP) compared to the average over the included econometric models.

[23] See section D3 in Appendix D.

Figure 4.4 DNSP opex cost efficiency scores, 2012–2024

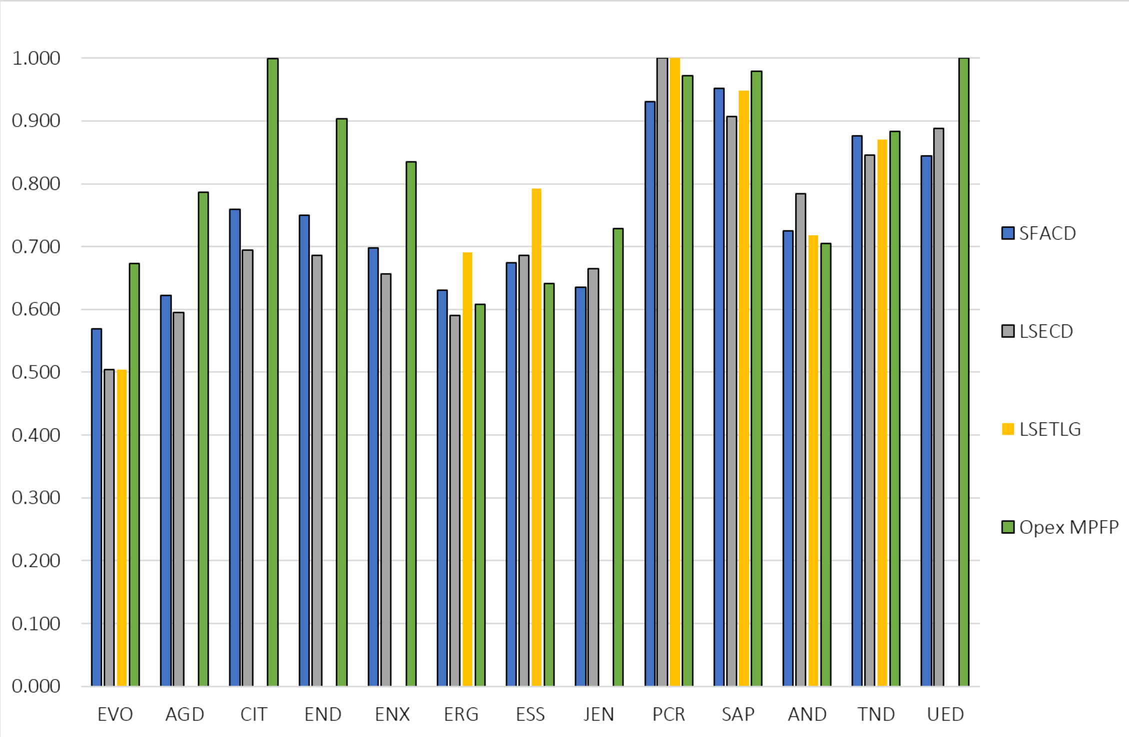


Table 4.3 DNSP average opex cost efficiency scores, 2012–2024

DNSP	*SFACD* (1)	*SFATLG* (2)[24]	*LSECD* (3)	*LSETLG* (4)	*Opex* (5)	*Average methods***	*Average Models***
EVO	0.568	na	0.504	0.504	0.673	0.562	0.525
AGD	0.622	na	0.595	0.546	0.786	0.668*	0.609*
CIT	0.760	na	0.695	0.709	0.999	0.818*	0.727*
END	0.750	na	0.686	0.697	0.904	0.780*	0.718*
ENX	0.698	na	0.656	0.619	0.834	0.730*	0.677*
ERG	0.631	na	0.591	0.691	0.607	0.630	0.638
ESS	0.674	na	0.686	0.792	0.642	0.698	0.717
JEN	0.635	na	0.665	0.560	0.729	0.676*	0.650*
PCR	0.931	na	1.000	1.000	0.972	0.976	0.977
SAP	0.952	na	0.907	0.948	0.979	0.946	0.936
AND	0.724	na	0.784	0.718	0.704	0.733	0.742
TND	0.877	na	0.846	0.871	0.884	0.869	0.864
UED	0.845	na	0.888	0.736	1.000	0.911*	0.867*
AVG(1)	0.744	na	0.731	0.789	0.824	0.769	0.724

Note: * Excludes LSETLG; ** Excludes SFATLG; (1) Excludes scores affected by monotonicity violations.

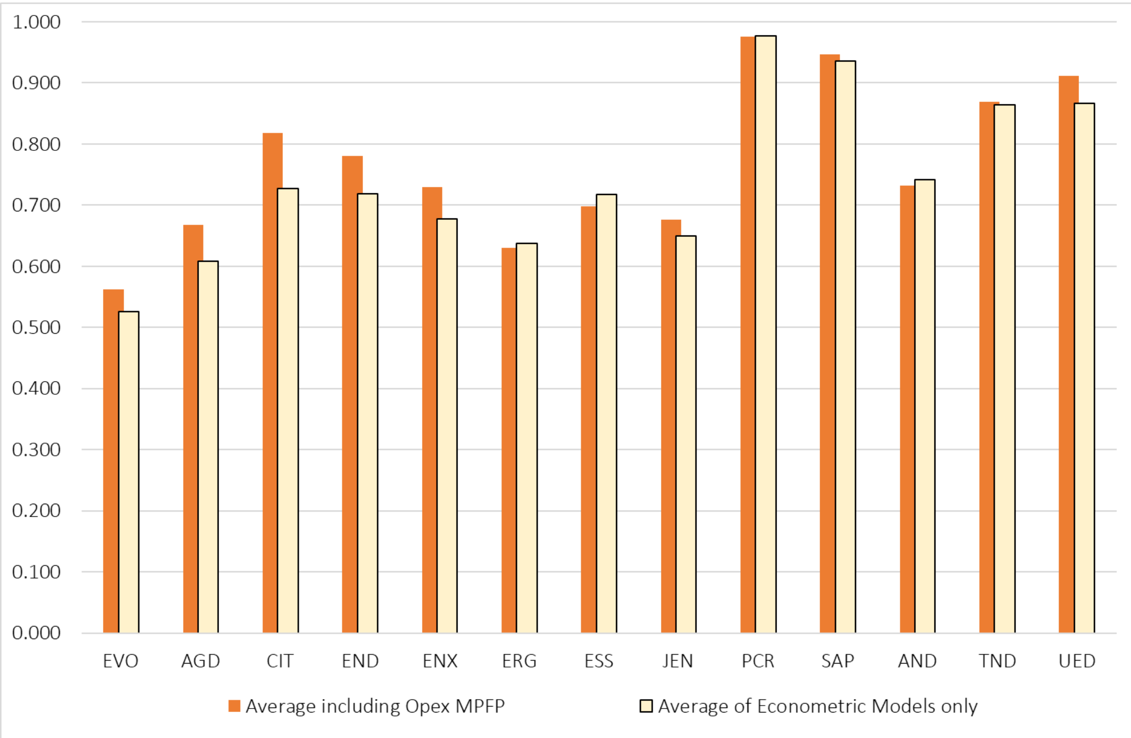
[24] The SFATLG model is excluded due to non-convergence. See section D2 in Appendix D.

From Figure 4.4 and Table 4.3 we see that the rankings are reasonably similar to the full sample period. Using the average of all methods, PCR and SAP have the highest opex efficiency measures, 0.976 and 0.946 respectively. The next highest ranked in terms of opex efficiency are UED (0.911) and TND (0.869). The two lowest ranked DNSPs in terms of opex efficiency are EVO (0.562) and ERG (0.630), the same as for the full sample. The average efficiency score for the Australian DNSPs (using the averages shown in the second last column of Table 4.3) for the period from 2012 to 2024 is 0.769, which similar to the average for the full period.[25]

Turning to the comparison between the models in terms of average scores for the post–2012 period, the SFACD model has an average efficiency score of 0.744 and the LSECD and LSETLG models have average efficiency scores of 0.731 and 0.789 respectively.

Figure 4.5 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 4.5 DNSP opex cost efficiency scores, 2012–2024, average of models



[25] In the 2024 study, the efficiency ranking from highest to lowest is: PCR, SAP, TND, UED, AND, CIT, ESS, END, ENX, ERG, JEN, AGD, and EVO.

5 DNSP Outputs, Inputs and Productivity Change

This chapter presents indexes for outputs, inputs and productivity for each of the 13 NEM DNSPs.

5.1 Evoenergy (EVO)

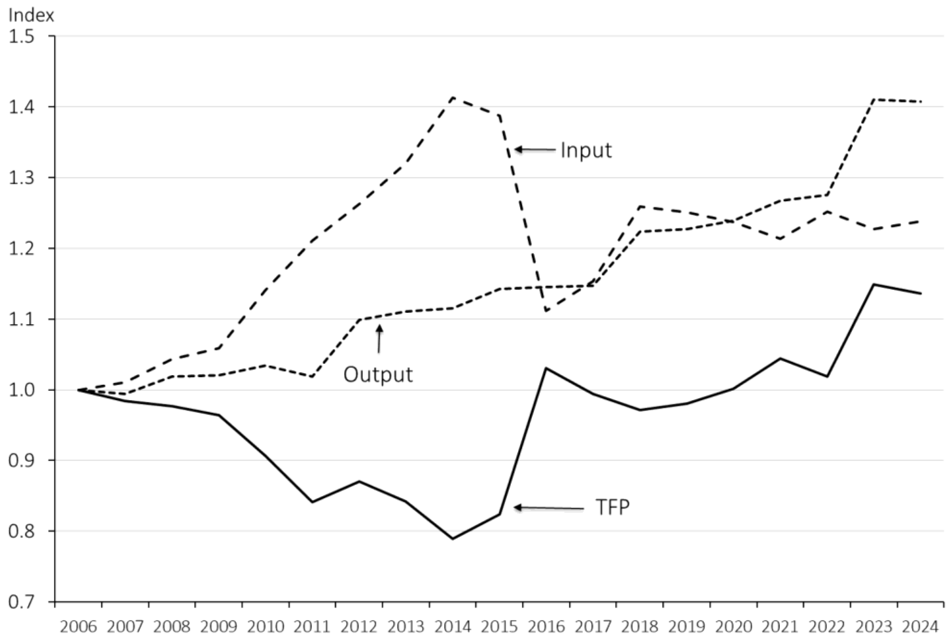
In 2024, EVO delivered 2,977 GWh to 225,475 customers over 5,816 circuit kilometres of lines and cables. EVO is the only energy distributor in the Australian Capital Territory (ACT), which is the smallest of the NEM jurisdictions in terms of customer numbers.

5.1.1 EVO's productivity performance

The EVO's total output, total input and TFP indexes are presented in Figure 5.1.1 and Table 5.1.1.

Over the 19-year period, from 2006 to 2024, EVO's average annual rate of TFP change was 0.7 per cent. Between 2006 and 2012, TFP *decreased* at an average annual rate of 2.3 per cent (more than 13 per cent in total). Then, from 2012 to 2024, the EVO's TFP increased at an average annual rate of 2.2 per cent and was almost 14 per cent above the 2006 level by 2024.

Figure 5.1.1 EVO output, input and TFP indexes, 2006–2024



Total output increased reasonably steadily over the period 2006 to 2024 at an average annual rate of 1.9 per cent, above the industry average rate of 1.0 per cent seen in chapter 3. In 2006–2012 period, output increased, on average by 1.6 per cent per year, below the industry average rate in this period of 2.0 per cent, and in 2012–2024 period output increased at 2.1 per cent per year, which is above the 0.5 per cent industry average annual growth for the same period. Total input use increased at an average rate of 3.9 per cent per year up to 2012, similar to the industry average rate in this period of 3.7 per cent. The average annual growth rate of input use was –0.2 between 2012 and 2024, below the industry average, which increased by 0.3 per cent per year over the same period.

In 2024, the EVO's TFP *decreased* by 1.1 per cent, driven by a 0.2 per cent *decrease* in output and a 0.9 per cent increase in input. This performance is better than the industry's TFP growth in 2024, which was –3.8 per cent.

Table 5.1.1 EVO output, input, TFP and PFP indexes, 2006–2024

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	0.994	1.010	0.984	0.988	0.981
2008	1.018	1.043	0.976	0.952	0.995
2009	1.021	1.058	0.964	0.951	0.976
2010	1.034	1.140	0.907	0.834	0.969
2011	1.019	1.211	0.841	0.739	0.934
2012	1.099	1.263	0.870	0.743	0.990
2013	1.111	1.320	0.842	0.703	0.983
2014	1.115	1.413	0.789	0.635	0.965
2015	1.142	1.387	0.824	0.676	0.978
2016	1.145	1.112	1.030	1.119	0.972
2017	1.147	1.153	0.994	1.033	0.967
2018	1.224	1.259	0.972	0.913	1.021
2019	1.227	1.251	0.981	0.951	1.004
2020	1.239	1.237	1.001	1.008	0.993
2021	1.267	1.214	1.044	1.091	1.002
2022	1.276	1.252	1.019	1.040	0.997
2023	1.410	1.227	1.149	1.211	1.098
2024	1.408	1.239	1.136	1.244	1.066
Growth Rate 2006–2024	1.9%	1.2%	0.7%	1.2%	0.4%
Growth Rate 2006–2012	1.6%	3.9%	-2.3%	-5.0%	-0.2%
Growth Rate 2012–2024	2.1%	-0.2%	2.2%	4.3%	0.6%
Growth Rate 2024	-0.2%	0.9%	-1.1%	2.6%	-3.0%

5.1.2 EVO's output and input quantity changes & contributions to TFP change

Average growth rates of quantity indexes for EVO's individual outputs and inputs, and rates of change in partial productivity indexes for individual inputs, are presented in Table 5.1.2. Table 5.1.3 shows the decomposition of EVO's average rates of TFP change into the contributions of the individual outputs and inputs for the whole 19-year period and for the periods up to and after 2012, and for 2024. Figure 5.1.2 shows the contributions of outputs and inputs to EVO's average rate of TFP change in 2024.

Over the 2006 to 2024 period, EVO's RMD increased at an average annual rate of 2.7 per cent, circuit length increased at 1.2 per cent, and customer numbers increased at 2.1 per cent. These rates are all above the corresponding the industry's annual growth rates of 1.1, 0.3 and 1.3 per cent respectively. These three outputs, which have the highest output weights, combined, accounted for 93.0 per cent of EVO's output cost share (see Appendix A, s.A3.3) and contributed 2.05 percentage points to EVO's total TFP change of 0.7 per cent over the 19-year period.

Energy delivered increased modestly at an average annual rate of 0.4 per cent (compared with a 0.1 per cent annual decline for the industry). It represented 11.2 per cent of EVO's output cost share and contributed 0.05 percentage points to EVO's TFP change over the 19-year period. CMOS increased at an average annual rate of 3.5 per cent (in contrast to a 0.1 per cent annual decrease for the industry). Given its negative output weight (–4.23 per cent), this increase had a negative effect on EVO's TFP of –0.19 percentage points.

Table 5.1.2 EVO individual output, input and PFP growth rates

	2006-2024	*2006-2012*	*2012-2024*	*2023-2024*
Outputs:				
Energy (GWh)	0.4%	0.8%	0.2%	-0.1%
Ratcheted Max Demand (MVA)	2.7%	1.8%	3.2%	0.0%
Customer Numbers	2.1%	1.9%	2.2%	1.8%
Circuit Length (km)	1.2%	1.2%	1.2%	1.3%
CMOS	3.5%	0.7%	5.0%	12.4%
Inputs:				
Real Opex ($'000 2006)	0.7%	6.5%	-2.2%	-2.8%
O/H Sub-tran. Lines (MVA-kms)	1.5%	1.8%	1.4%	0.8%
O/H Distr. Lines (MVA-kms)	-0.1%	-0.4%	0.0%	0.2%
U/G Sub-tran. Lines (MVA-kms)	15.6%	0.0%	23.4%	142.7%
U/G Dist. Lines (MVA-kms)	2.3%	2.7%	2.1%	2.6%
Transformers (MVA)	1.7%	2.0%	1.6%	3.8%
All Capital inputs	1.5%	1.7%	1.4%	2.8%
Partial productivity:				
Output / Real Opex	1.2%	-5.0%	4.3%	2.6%
Output / OH Sub-tran. Lines	0.4%	-0.3%	0.7%	-1.0%
Output / OH Distr. Lines	2.0%	2.0%	2.1%	-0.4%
Output / UG Sub-tran. Lines	-13.7%	1.6%	-21.3%	-142.9%
Output / UG Distr. Lines	-0.4%	-1.1%	0.0%	-2.8%
Output / Transformers	0.2%	-0.4%	0.5%	-4.0%
Output / Capital	0.4%	-0.2%	0.6%	-3.0%

Turning to the input side, over the 19-year period, opex increased at an average annual rate of 0.7 per cent (below the industry's annual growth rate of 1.1 per cent). Opex is the largest input cost share (at 45.1 per cent, see Appendix A, s.A3.4) and contributed –0.31 percentage points to EVO's TFP change over the period. By 2024, EVO's opex usage was 13.2 per cent higher than its 2006 level. Transformers increased at an average annual rate of 1.7 per cent (below the industry's annual growth rate of 2.1 per cent). It accounts for 24.5 per cent of EVO's input cost share and contributed –0.44 percentage points to EVO's TFP change in the 19-year period.

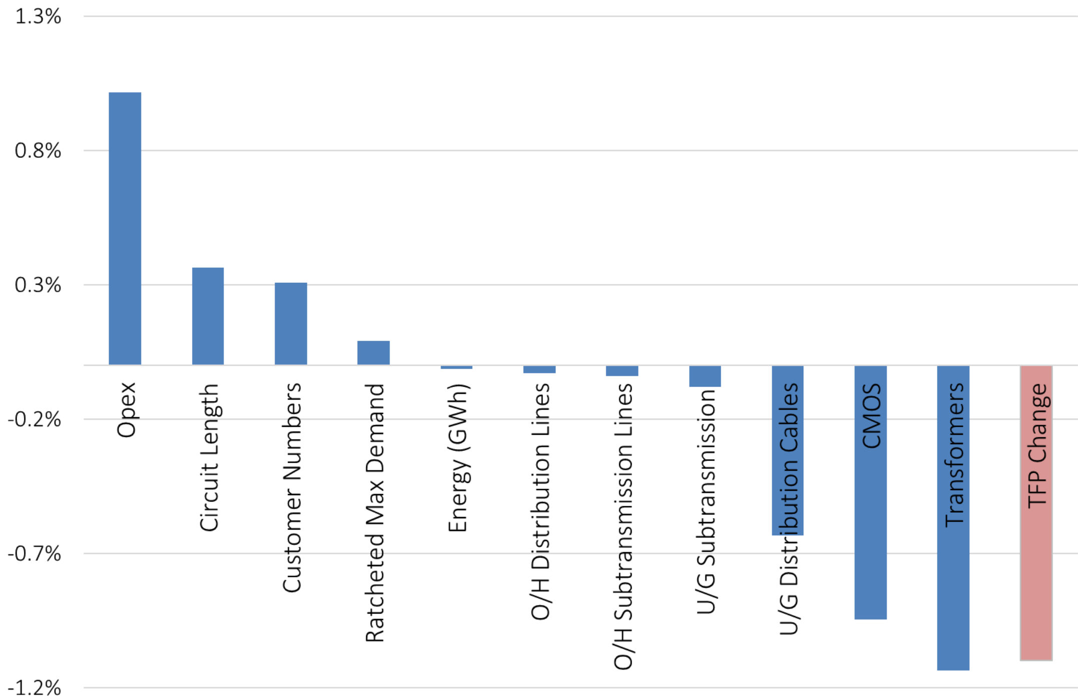
EVO's underground distribution and subtransmission cables increased by 2.3 and 15.6 per cent per year, respectively (compared to industry's annual rates of 3.2 and 1.8 per cent). Overhead distribution lines *decreased* at an average annual rate of 0.1 per cent (in contrast to the industry's annual rate increase of 0.2 per cent). Overhead subtransmission lines increased at 1.5 per cent per year, (above the industry's average annual increase of 0.4 per cent). Combined, these four inputs account for 30.4 per cent of EVO's input cost share and contributed –0.44 percentage points to TFP change over the 19-year period.

Table 5.1.3 EVO output and input percentage point contributions to average annual TFP change: various periods

Year	*2006 to 2024*	*2006 to 2012*	*2012 to 2024*	*2024*
Energy (GWh)	0.05%	0.09%	0.03%	-0.01%
Ratcheted Max Demand	1.38%	0.90%	1.61%	0.09%
Customer Numbers	0.34%	0.30%	0.35%	0.31%
Circuit Length	0.33%	0.32%	0.34%	0.36%
CMOS	-0.19%	-0.04%	-0.27%	-0.95%
Opex	-0.31%	-2.90%	0.99%	1.02%
O/H Subtransmission Lines	-0.05%	-0.06%	-0.04%	-0.04%
O/H Distribution Lines	0.01%	0.04%	0.00%	-0.03%
U/G Subtransmission Cables	-0.01%	0.00%	-0.01%	-0.08%
U/G Distribution Cables	-0.40%	-0.51%	-0.35%	-0.63%
Transformers	-0.44%	-0.47%	-0.42%	-1.14%
TFP Change	0.71%	-2.32%	2.23%	-1.10%

As shown in Figure 5.1.2, the component with the largest positive impact on EVO's TFP in 2024 was opex, which decreased by 2.8 per cent and contributed 1.02 percentage points. In contrast, transformers had the largest negative impact, contributing –1.14 percentage points due to a 3.8 per cent increase. CMOS also had a strong negative impact of –0.95 percentage points, given its 12.4 per cent increase in 2024. Despite the substantial increase of 142.7 per cent in underground subtransmission lines, its weight of just 0.1 per cent and small initial base meant it contributed only –0.04 percentage points to TFP in 2024.

Figure 5.1.2 EVO output and input percentage point contributions to TFP change, 2024



5.2 Ausgrid (AGD)

In 2024, AGD delivered 24,431 GWh to 1.80 million customers over 43,133 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.

5.2.1 AGD's productivity performance

AGD's total output, total input and TFP indexes are presented in Figure 5.2.1 and Table 5.2.1. Opex and capital PFP indexes are also presented in Table 5.2.1.

Over the 19-year period 2006 to 2024, AGD's TFP averaged an annual rate of change of 0.3 per cent, higher than 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 0.4 per cent. This is lower than the industry's average rate of growth in output of 1.0 per cent per annum. AGD's average annual rate of input use increase of 0.1 per cent was much lower than the rate of increase in total input use for the industry (1.4 per cent per year).

Over the period from 2006 to 2012, AGD's TFP increased in some years but overall, it *decreased* at an average rate of 2.1 per cent per year. From 2012 to 2024, TFP increased in most years, and on average TFP increased at an annual rate of 1.5 per cent. In 2024, AGD's TFP *decreased* by 2.5 per cent.

Figure 5.2.1 AGD output, input and total factor productivity indexes, 2006–2024

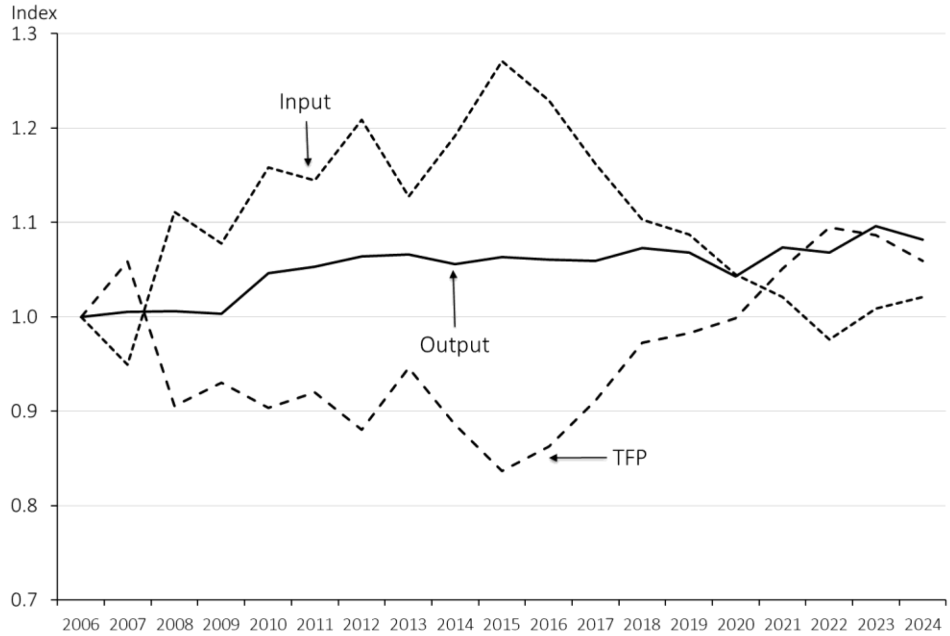


Table 5.2.1 AGD output, input, TFP and PFP indexes, 2006–2024

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	1.005	0.949	1.059	1.183	0.981
2008	1.006	1.111	0.905	0.835	0.958
2009	1.003	1.078	0.930	0.919	0.929
2010	1.046	1.158	0.903	0.842	0.940
2011	1.053	1.144	0.920	0.884	0.929
2012	1.064	1.209	0.880	0.811	0.910
2013	1.066	1.128	0.946	1.030	0.888
2014	1.056	1.192	0.886	0.918	0.857
2015	1.064	1.271	0.837	0.787	0.859
2016	1.060	1.229	0.863	0.881	0.844
2017	1.059	1.162	0.911	0.993	0.856
2018	1.073	1.103	0.972	1.172	0.865
2019	1.068	1.087	0.982	1.230	0.857
2020	1.043	1.045	0.998	1.360	0.831
2021	1.073	1.021	1.051	1.488	0.851
2022	1.068	0.976	1.095	1.686	0.856
2023	1.096	1.009	1.087	1.570	0.880
2024	1.082	1.021	1.059	1.492	0.880
Growth Rate 2006–2024	0.4%	0.1%	0.3%	2.2%	-0.7%
Growth Rate 2006–2012	1.0%	3.2%	-2.1%	-3.5%	-1.6%
Growth Rate 2012–2024	0.1%	-1.4%	1.5%	5.1%	-0.3%
Growth Rate 2024	-1.3%	1.2%	-2.5%	-5.1%	0.0%

5.2.2 AGD's output and input quantity changes & contributions to TFP change

Average growth rates of quantity indexes for AGD's individual outputs and for individual inputs are presented in Table 5.2.2. Table 5.1.3 shows the decomposition of AGD's average rates of TFP change into the contributions of the individual outputs and inputs for the whole 19-year period and for the periods up to and after 2012, and for 2024. Figure 5.2.2 shows the contributions of outputs and inputs to AGD's average rate of TFP change in 2024.

Table 5.2.2 AGD individual output, input and PFP growth rates

	2006-2024	*2006-2012*	*2012-2024*	*2023-2024*
Outputs:				
Energy (GWh)	-1.2%	-0.4%	-1.5%	-0.6%
Ratcheted Max Demand (MVA)	0.4%	1.2%	0.0%	0.0%
Customer Numbers	0.8%	0.8%	0.9%	0.5%
Circuit Length (km)	0.6%	0.8%	0.5%	0.5%
CMOS	-0.4%	-0.8%	-0.3%	15.3%
Inputs:				
Real Opex ($'000 2006)	-1.8%	4.5%	-4.9%	3.8%
O/H Sub-tran. Lines (MVA-kms)	-0.2%	0.1%	-0.3%	0.8%
O/H Distr. Lines (MVA-kms)	0.7%	-0.2%	1.1%	0.4%
U/G Sub-tran. Lines (MVA-kms)	0.1%	0.4%	0.0%	0.3%
U/G Dist. Lines (MVA-kms)	1.8%	2.6%	1.4%	1.2%
Transformers (MVA)	1.3%	3.9%	0.0%	-3.7%
All Capital inputs	1.1%	2.6%	0.4%	-1.3%
Partial productivity:				
Output / Real Opex	2.2%	-3.5%	5.1%	-5.1%
Output / OH Sub-tran. Lines	0.6%	1.0%	0.4%	-2.1%
Output / OH Distr. Lines	-0.3%	1.2%	-1.0%	-1.7%
Output / UG Sub-tran. Lines	0.3%	0.6%	0.2%	-1.6%
Output / UG Distr. Lines	-1.3%	-1.6%	-1.2%	-2.5%
Output / Transformers	-0.9%	-2.9%	0.2%	2.4%
Output / Capital	-0.7%	-1.6%	-0.3%	0.0%

Over the 2006 to 2024 period, AGD's RMD increased at an average annual rate of 0.4 per cent, circuit length increased at 0.6 per cent per year, and customer numbers increased at 0.8 per cent per year (compared to corresponding the industry's annual growth rates of 1.1, 0.3 and 1.3 per cent annually, respectively). These three outputs, which have the highest output weights, combined accounted for 98.5 per cent of AGD's output cost share (see Appendix A, s.A3.3) and contributed 0.53 percentage points to AGD's total TFP change of 0.3 per cent over the 19-year period.

Energy delivered decreased at an average annual rate of 1.2 per cent per year over the period, a larger decline than the industry's growth rate of –0.1 per cent per year. It represents 11.9 per cent of AGD's output cost share and contributed –0.14 percentage points to AGD's TFP over the 19-year period. By 2024, AGD's energy delivered was 18.9 per cent lower than in 2006.

Turning to the input side, over the 19-year period, opex *decreased* at an average annual rate of 1.8 per cent (in contrast with the industry's average increase of 1.1 per cent). Opex is the largest input cost share (at 36.5 per cent, see Appendix A, s.A3.4) and contributed 0.59 percentage points to AGD's TFP change over the period. By 2024, AGD's opex usage was 27.5 per cent *lower* than its 2006 level. Transformers increased at an average annual rate of 1.3 per cent (below the industry's annual growth rate of 2.1 per cent). It accounts for 32.6 per cent of AGD's input cost share and contributed –0.39 percentage points to TFP change in the 19-year period.

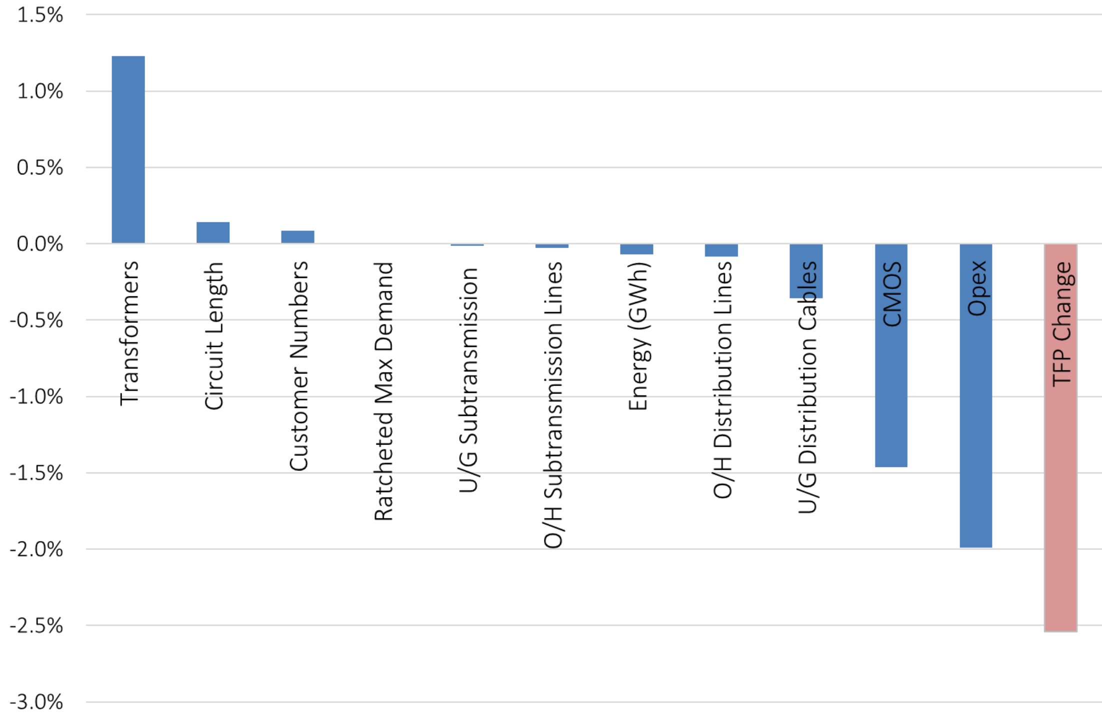
Over the same period, AGD's underground distribution and subtransmission cables increased by 1.8 and 0.1 per cent per year, respectively (below to the industry's annual growth rates of 3.2 and 1.8 per cent). Overhead distribution lines increased at an average annual rate of 0.7 per cent (above the industry's annual increase of 0.2 per cent). Overhead subtransmission lines *decreased* at 0.2 per cent per year, (in contrast with the industry's average annual increase of 0.4 per cent). Combined, these four inputs accounted for 30.9 per cent of AGD's input cost share and contributed –0.31 percentage points to TFP change over the 19-year period.

Table 5.2.3 AGD output and input percentage point contributions to average annual TFP change: various periods

Year	*2006 to 2024*	*2006 to 2012*	*2012 to 2024*	*2024*
Energy (GWh)	-0.14%	-0.06%	-0.18%	-0.07%
Ratcheted Max Demand	0.21%	0.63%	0.00%	0.00%
Customer Numbers	0.14%	0.14%	0.15%	0.09%
Circuit Length	0.17%	0.24%	0.14%	0.14%
CMOS	0.05%	0.08%	0.03%	-1.46%
Opex	0.59%	-1.62%	1.69%	-1.99%
O/H Subtransmission Lines	0.01%	0.00%	0.01%	-0.03%
O/H Distribution Lines	-0.05%	0.01%	-0.08%	-0.09%
U/G Subtransmission Cables	-0.01%	-0.02%	0.00%	-0.01%
U/G Distribution Cables	-0.27%	-0.35%	-0.23%	-0.36%
Transformers	-0.39%	-1.18%	0.00%	1.23%
TFP Change	0.32%	-2.13%	1.54%	-2.54%

As shown in Figure 5.2.2, in 2024 the component with the greatest positive impact on AGD's TFP was transformers, contributing 1.23 percentage points due to a 3.7 per cent *decrease* that year. In contrast, opex and CMOS had the largest negative impacts, due their increase by 3.8 per cent and 15.3 per cent, respectively. Combined, these two affected AGD's TFP by –3.45 percentage points in 2024.

Figure 5.2.2 AGD output and input percentage point contributions to TFP change, 2024



5.3 CitiPower (CIT)

In 2024, CIT delivered 5,459 GWh to 350,648 customers over 4,596 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.

5.3.1 CIT's productivity performance

CIT's total output, total input and TFP indexes are presented in Figure 5.3.1 and Table 5.3.1 Opex and capital PFP indexes are also presented in Table 5.3.1.

Over the 19-year period 2006 to 2024, CIT's TFP *decreased* at an average annual rate of 0.8 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 19-year period at an average annual rate of 0.8 per cent, which is aligned with the industry's increase of 1.0 per cent. CIT's average annual rate of increase in input use of 1.6 per cent was similar to the for the industry as a whole (1.4 per cent).

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 4.0 per cent increase per year over this period. TFP *decreased* at average annual rate of 2.8 per cent over this period. Input use stabilised in the period 2012 to 2024, with an average annual rate of change of 0.3 per cent, and average TFP growth in this period was 0.3 per cent per annum.

Figure 5.3.1 CIT's output, input and TFP indexes, 2006–2024

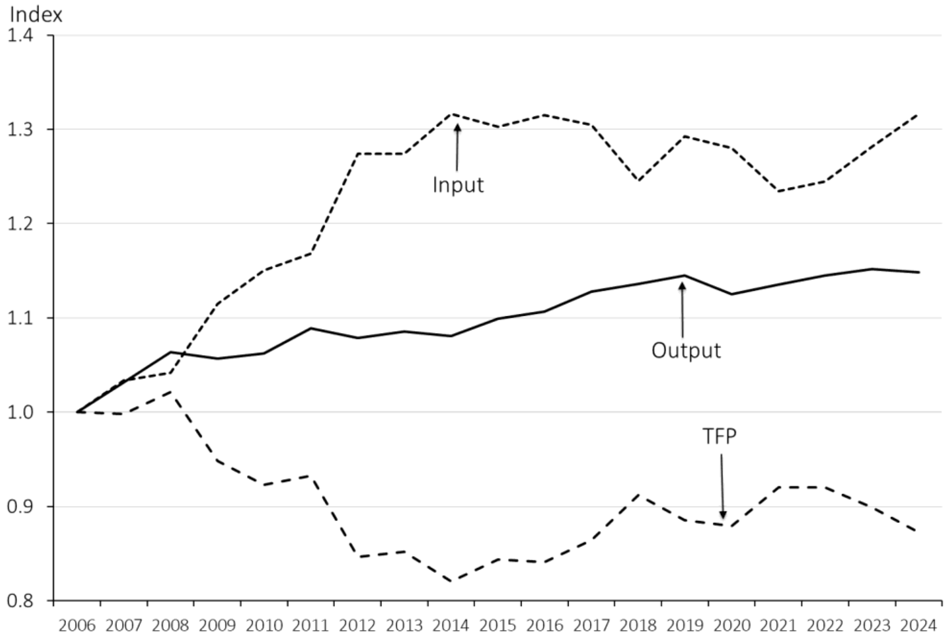


Table 5.3.1 CIT's output, input, TFP and PFP indexes, 2006–2024

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	1.031	1.033	0.998	1.000	0.996
2008	1.064	1.042	1.021	1.058	1.001
2009	1.057	1.115	0.948	0.890	0.979
2010	1.062	1.150	0.923	0.852	0.963
2011	1.089	1.168	0.932	0.901	0.947
2012	1.078	1.274	0.847	0.740	0.915
2013	1.086	1.274	0.852	0.764	0.908
2014	1.081	1.316	0.821	0.723	0.886
2015	1.099	1.302	0.844	0.763	0.894
2016	1.106	1.315	0.841	0.767	0.887
2017	1.128	1.305	0.864	0.802	0.900
2018	1.136	1.246	0.912	0.894	0.919
2019	1.145	1.293	0.886	0.823	0.921
2020	1.125	1.280	0.879	0.839	0.899
2021	1.136	1.234	0.920	0.936	0.904
2022	1.145	1.245	0.920	0.914	0.916
2023	1.152	1.282	0.899	0.864	0.914
2024	1.148	1.316	0.872	0.806	0.910
Growth Rate 2006–2024	0.8%	1.6%	-0.8%	-1.2%	-0.5%
Growth Rate 2006–2012	1.3%	4.0%	-2.8%	-5.0%	-1.5%
Growth Rate 2012–2024	0.5%	0.3%	0.3%	0.7%	0.0%
Growth Rate 2024	-0.3%	2.7%	-3.0%	-7.1%	-0.5%

The PFP of capital inputs has *declined* at an average rate of 0.5 per cent per year from 2006 to 2024. There was a strong rate of decline in the period up to 2012 and there was no change on average in the period after 2012. The PFP of opex input *declined* particularly strongly in the period up to 2012, at average annual rate of –5.0 per cent, whereas it increased at an average rate of 0.7 per cent per annum from 2012 to 2024.

5.3.2 CIT's output and input quantity changes & contributions to TFP change

Table 5.3.2 presents average growth rates of CIT's individual output and input quantity indexes and shows partial productivity growth rates for individual inputs. Table 5.3.3 decomposes CIT's average TFP growth into contributions from each output and input over the full 19-year period, the sub-periods before and after 2012, and for 2024. Figure 5.3.2 illustrates the contributions of outputs and inputs to CIT's TFP growth in 2024.

Table 5.3.2 CIT individual output, input and PFP growth rates

	2006-2024	*2006-2012*	*2012-2024*	*2023-2024*
Outputs:				
Energy (GWh)	-0.5%	0.3%	-0.9%	0.7%
Ratcheted Max Demand (MVA)	0.9%	1.7%	0.5%	0.0%
Customer Numbers	1.0%	1.3%	0.8%	0.3%
Circuit Length (km)	0.9%	1.4%	0.6%	0.0%
CMOS	0.0%	4.0%	-2.1%	13.5%
Inputs:				
Real Opex ($'000 2006)	2.0%	6.3%	-0.2%	6.7%
O/H Sub-tran. Lines (MVA-kms)	0.0%	-0.3%	0.2%	-1.4%
O/H Distr. Lines (MVA-kms)	-0.5%	-0.2%	-0.7%	0.2%
U/G Sub-tran. Lines (MVA-kms)	3.7%	5.0%	3.0%	0.9%
U/G Dist. Lines (MVA-kms)	1.2%	3.3%	0.0%	-1.2%
Transformers (MVA)	1.4%	2.1%	1.1%	1.8%
All Capital inputs	1.3%	2.7%	0.6%	0.2%
Partial productivity:				
Output / Real Opex	-1.2%	-5.0%	0.7%	-7.1%
Output / OH Sub-tran. Lines	0.8%	1.5%	0.4%	1.1%
Output / OH Distr. Lines	1.3%	1.5%	1.2%	-0.5%
Output / UG Sub-tran. Lines	-2.9%	-3.8%	-2.5%	-1.2%
Output / UG Distr. Lines	-0.4%	-2.1%	0.5%	0.9%
Output / Transformers	-0.6%	-0.8%	-0.5%	-2.2%
Output / Capital	-0.5%	-1.5%	0.0%	-0.5%

Over the 2006 to 2024 period, CIT's customer numbers increased at an average annual rate of 1.0 per cent per year (below the industry's annual growth rate of 1.3 per cent), circuit length and RMD both increased at 0.9 per cent per year (compared to the industry's annual growth rates of 0.3 per cent and 1.1 per cent respectively). These three outputs, which have the highest output weights, combined, represent 92.9 per cent of CIT's output cost weight (see Appendix

A, s.A3.3) and contributed 0.85 percentage points to CIT's TFP growth of –0.8 per cent over the 19-year period.

Energy delivered decreased modestly at an average annual rate of 0.5 per cent (compared with a 0.1 per cent annual decline for the industry). It represented 11.2 per cent of CIT's output cost share and contributed –0.06 percentage points to CIT's TFP change over the 19-year period.

Turning to the input side, over 19-year period, CIT's opex increased at an average annual rate of 2.0 per cent per year (above the industry's average of 1.1 per cent). Opex has the largest input cost share (at 37.7 per cent, see Appendix A, s.A3.4) and contributed –0.70 percentage points to CIT's TFP change over the period. By 2024, CIT's opex usage was 42.6 per cent higher than its 2006 level. Transformers increased at an average annual rate of 1.4 per cent per year (below the industry's average of 2.1 per cent). It accounts for 19.3 per cent of CIT's input cost share and contributed –0.32 percentage points to TFP change in the 19-year period.

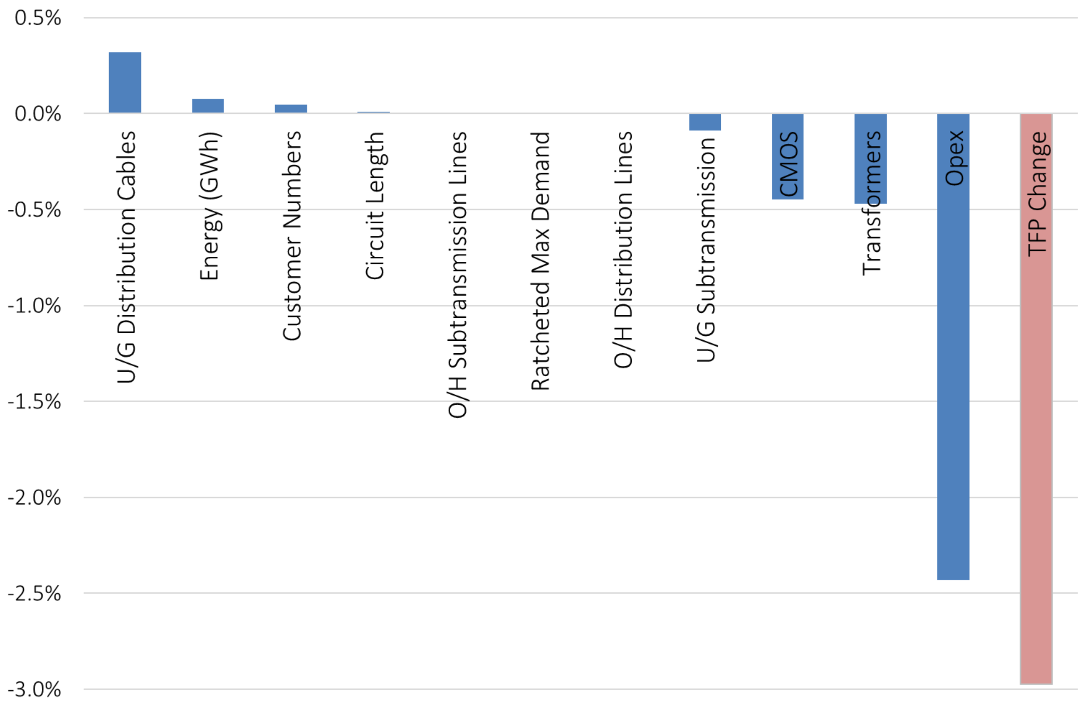
CIT's underground distribution cables increased at an average annual rate of 1.2 per cent per year and underground subtransmission cables of 3.7 per cent (compared to the industry's annual growth rate of 3.2 and 1.8 per cent). In contrast, overhead distribution lines *decreased* by 0.5 per cent per year (in contrast to the industry's average increase of 0.2 per cent), while overhead subtransmission lines increased zero per cent (compared to the industry's annual increase of 0.4 per cent). Combined, these four inputs represented 43.0 per cent of CIT's input cost share and contributed –0.55 percentage points to TFP change over the period.

Table 5.3.3 CIT's output and input percentage point contributions to average annual TFP change: various periods

Year	*2006 to 2024*	*2006 to 2012*	*2012 to 2024*	*2024*
Energy (GWh)	-0.06%	0.03%	-0.11%	0.08%
Ratcheted Max Demand	0.46%	0.82%	0.27%	0.01%
Customer Numbers	0.16%	0.20%	0.13%	0.05%
Circuit Length	0.23%	0.39%	0.16%	0.01%
CMOS	0.00%	-0.19%	0.09%	-0.45%
Opex	-0.70%	-2.21%	0.09%	-2.43%
O/H Subtransmission Lines	0.00%	0.00%	0.00%	0.01%
O/H Distribution Lines	0.03%	0.01%	0.04%	0.00%
U/G Subtransmission Cables	-0.22%	-0.30%	-0.18%	-0.09%
U/G Distribution Cables	-0.36%	-1.02%	-0.01%	0.32%
Transformers	-0.32%	-0.52%	-0.22%	-0.47%
TFP Change	-0.78%	-2.77%	0.26%	-2.97%

As shown in Figure 5.3.2, in 2024 the component with the greatest positive impact on CIT's TFP was underground distribution cables, contributing 0.32 percentage points due to 1.2 per cent *decrease* that year. In contrast, opex had the largest negative impact, due its increase at 6.7 per cent, contributing to CIT's TFP by –2.43 percentage points in 2024.

Figure 5.3.2 CIT's output and input percentage point contributions to TFP change, 2024



5.4 Endeavour Energy (END)

In 2024, END delivered 18,306 GWh to 1.11 million customers over 40,430 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.

5.4.1 END's productivity performance

END's total output, total input and TFP indexes are presented in Figure 5.4.1 and Table 5.4.1. Opex and capital PFP indexes are also presented in Table 5.4.1.

Over the 19-year period 2006 to 2024, END's TFP *decreased* at an average annual rate of 0.5 per cent, which is the same rate as for the industry. END's total output increased over the same period at an average annual rate of 1.1 per cent, which aligned with 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 1.6 per cent is also similar with the industry's rate of increase in total input use of 1.4 per cent per year. END's TFP had an overall declining trend up to 2016 but has since increased steadily. From 2006 to 2012, its average annual rate of TFP change was –2.5 per cent, and from 2012 to 2024 the average annual rate of TFP change was 0.6 per cent. Again, these trends are broadly similar to those for the industry as a whole.

Figure 5.4.1 END's output, input and TFP indexes, 2006–2024

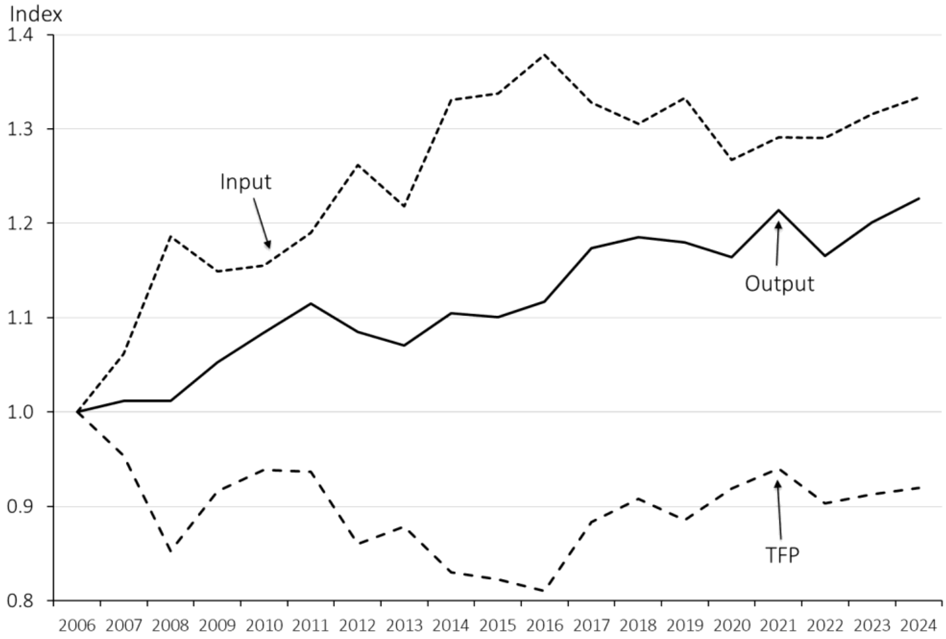


Table 5.4.1 END's output, input, TFP and PFP indexes, 2006–2024

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	1.012	1.061	0.953	0.950	0.958
2008	1.012	1.186	0.853	0.783	0.918
2009	1.053	1.149	0.916	0.900	0.927
2010	1.084	1.155	0.938	0.952	0.925
2011	1.115	1.190	0.937	0.947	0.926
2012	1.085	1.261	0.860	0.843	0.872
2013	1.070	1.218	0.879	0.954	0.826
2014	1.105	1.331	0.830	0.849	0.819
2015	1.101	1.338	0.823	0.852	0.804
2016	1.117	1.379	0.810	0.834	0.798
2017	1.173	1.328	0.883	0.973	0.821
2018	1.185	1.306	0.908	1.048	0.813
2019	1.180	1.333	0.885	1.020	0.794
2020	1.164	1.267	0.919	1.152	0.774
2021	1.214	1.291	0.940	1.162	0.794
2022	1.166	1.290	0.903	1.125	0.759
2023	1.201	1.316	0.913	1.147	0.765
2024	1.226	1.334	0.919	1.157	0.778
Growth Rate 2006–2024	1.1%	1.6%	-0.5%	0.8%	-1.4%
Growth Rate 2006–2012	1.4%	3.9%	-2.5%	-2.9%	-2.3%
Growth Rate 2012–2024	1.0%	0.5%	0.6%	2.6%	-0.9%
Growth Rate 2024	2.0%	1.3%	0.7%	0.8%	1.8%

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 3.9 per cent per year) than in the period 2012 to 2024 (averaging 0.5 per cent per year). The large change in input growth explains the turnaround in the TFP trend.

Capital PFP declined at an average rate of 1.4 per cent per year over the 19-year period. The rate of decline was greater in the period up to 2012 (–2.3 per cent) but there was further decline in the period after 2012 (–0.9 per cent). Opex PFP increased on average over the 19-year period (averaging 0.8 per cent per year), but this covers very different trends in the period up to 2012 (with an average annual rate of –2.9 per cent) and after 2012 (with an average increase of 2.6 per cent per annum).

5.4.2 END's output and input quantity changes & contribution to TFP change

Average growth rates of quantity indexes for END's individual outputs and individual inputs are presented in Table 5.4.2, together with rates of partial productivity change for individual inputs. Table 5.4.3 shows the decomposition of END's average rates of TFP change into the contributions of the individual outputs and inputs for the whole 19-year period and for the periods up to and after 2012, and for 2024. Figure 5.4.2 shows the contributions of outputs and inputs to END's average rate of TFP change in 2024.

Table 5.4.2 END individual output, input and PFP growth rates

	2006-2024	*2006-2012*	*2012-2024*	*2023-2024*
Outputs:				
Energy (GWh)	0.3%	-0.7%	0.9%	8.1%
Ratcheted Max Demand (MVA)	0.8%	1.6%	0.4%	0.0%
Customer Numbers	1.5%	1.0%	1.7%	1.2%
Circuit Length (km)	1.2%	1.1%	1.3%	1.0%
CMOS	-0.2%	0.0%	-0.2%	-3.8%
Inputs:				
Real Opex ($'000 2006)	0.3%	4.2%	-1.6%	1.2%
O/H Sub-tran. Lines (MVA-kms)	-0.1%	0.8%	-0.5%	0.0%
O/H Distr. Lines (MVA-kms)	-0.2%	0.0%	-0.3%	0.0%
U/G Sub-tran. Lines (MVA-kms)	4.8%	7.6%	3.4%	-1.4%
U/G Dist. Lines (MVA-kms)	4.9%	6.6%	4.1%	1.9%
Transformers (MVA)	2.3%	3.3%	1.8%	0.0%
All Capital inputs	2.5%	3.6%	2.0%	0.2%
Partial productivity:				
Output / Real Opex	0.8%	-2.9%	2.6%	0.8%
Output / OH Sub-tran. Lines	1.2%	0.6%	1.5%	2.0%
Output / OH Distr. Lines	1.3%	1.3%	1.3%	2.1%
Output / UG Sub-tran. Lines	-3.7%	-6.3%	-2.4%	3.5%
Output / UG Distr. Lines	-3.8%	-5.2%	-3.1%	0.2%
Output / Transformers	-1.2%	-2.0%	-0.8%	2.1%
Output / Capital	-1.4%	-2.3%	-0.9%	1.8%

Over the 2006–2024 period, END's customer numbers increased at an average annual rate of 1.5 per cent per year (similar to the industry's annual rate of 1.3 per cent), circuit length at 1.2 per cent (above the industry's average of 0.3 per cent), and RMD at 0.8 per cent (below the industry's average of 1.1 per cent). These three outputs, which have the highest output weights, combined, account for 101.5 per cent of END's output cost weight (see Appendix A, s.A3.3) and contributed 1.06 percentage points to its TFP change over the period.[26] Energy delivered increased modestly at an average annual rate of 0.3 per cent (compared with a 0.1 per cent annual *decline* for the industry). It represented 12.3 per cent of END's output cost share and contributed 0.04 percentage points to END's TFP change over the 19-year period.

Turning to the input side, over the 19-year period, opex increased at an average annual rate of 0.3 per cent per year (well below the industry's annual growth rate of 1.1 per cent). Opex is the largest input cost share (at 43.5 per cent, see Appendix A, s.A3.4) and contributed –0.15 percentage points to END's TFP change over the period. By 2024, END's opex usage was 6.0 per cent higher than its 2006 level. Transformers increased at an average annual rate of 2.3 per cent per year, slightly above the industry's growth rate of 2.1 per cent. It accounts for 26.8 per cent of END's input cost share and contributed –0.64 percentage points to TFP change over the period. By 2024, the quantity of transformers was 52.3 per cent higher than in 2006.

END's underground distribution cables increased by 4.9 per cent per year and underground subtransmission cables by 4.8 per cent (both above the industry's averages growth of 3.2 and 1.8 per cent, respectively). In contrast, overhead distribution and subtransmission lines *decreased* by 0.2 and 0.1 per cent per year, while the industry recorded increases of 0.2 and 0.4 per cent, respectively. Combined, these four inputs represent 29.7 per cent of END's input cost share and contributed –0.81 percentage points to its TFP change over the 2006–2024 period.

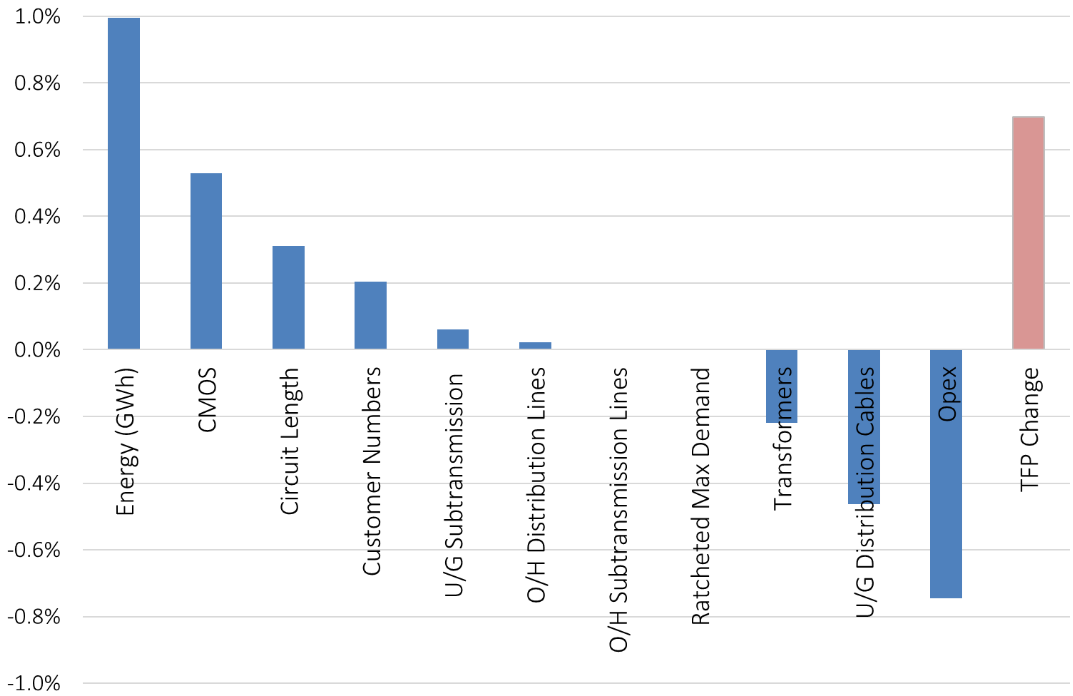
Table 5.4.3 END's output and input percentage point contributions to average annual TFP change: various periods

Year	*2006 to 2024*	*2006 to 2012*	*2012 to 2024*	*2024*
Energy (GWh)	0.04%	-0.08%	0.11%	1.00%
Ratcheted Max Demand	0.43%	0.90%	0.19%	0.00%
Customer Numbers	0.26%	0.19%	0.30%	0.20%
Circuit Length	0.37%	0.33%	0.39%	0.31%
CMOS	0.03%	0.02%	0.03%	0.53%
Opex	-0.15%	-1.80%	0.68%	-0.75%
O/H Subtransmission Lines	0.00%	-0.03%	0.02%	0.00%
O/H Distribution Lines	0.02%	0.00%	0.03%	0.02%
U/G Subtransmission Cables	-0.09%	-0.14%	-0.06%	0.06%
U/G Distribution Cables	-0.75%	-1.02%	-0.62%	-0.46%
Transformers	-0.64%	-0.89%	-0.52%	-0.22%
TFP Change	-0.47%	-2.51%	0.55%	0.70%

[26] CMOS has a negative output cost share weight, and the sum of the weights across all outputs equals 100 per cent.

As shown in Figure 5.4.2, the component with the greatest positive impact on END's TFP in 2024 was energy delivered, which contributed 1.0 percentage point due to an 8.1 per cent increase in the same year. CMOS and circuit length also contributed positively, at 0.53 and 0.31 percentage points, respectively, given a 3.8 per cent decrease in CMOS and a 1.0 per cent increase in circuit length. In contrast, opex had the largest negative impact, contributing –0.75 percentage points due to a 1.2 per cent increase in 2024. This was followed by underground distribution cables, which contributed –0.46 percentage points given a 1.9 per cent increase.

Figure 5.4.2 END's output and input percentage point contributions to TFP change, 2024



5.5 Energex (ENX)

In 2024, ENX delivered 22,364 GWh to 1.62 million customers over 56,798 circuit kilometres of lines and cables. ENX distributes electricity in Southeast 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.

5.5.1 ENX's productivity performance

ENX's total output, total input and TFP indexes are presented in Figure 5.5.1 and Table 5.5.1. Opex and capital PFP indexes are also presented in Table 5.5.1.

Over the whole period from 2006 to 2024, ENX's TFP *decreased* at an annual rate of 0.6 per cent similar to the industry's average annual change of –0.5 over the same period. As Figure

5.5.1 shows, ENX's TFP decreased from 2006 to 2012 on average by 0.7 per cent per year and further decreased from 2012 to 2024 on average by 0.5 per cent per year. This differs from the industry's 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, growth patterns on the input side were the major influence on 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 4.3 per cent per annum up to 2012, reducing to 0.7 per cent per annum after 2012. The average output growth of 1.9 per cent per annum over the whole 19-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 1.2 per cent per annum from 2012 to 2024. The average rate of increase in inputs of 2.5 per cent per annum over the 19-year period is also much higher than the industry's average input increase of 1.4 per cent per annum.

Capital PFP declined on average by 0.3 per cent per year from 2006 to 2024, 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 –2.1 per cent and at a rate of –0.3 per cent per annum after 2012. On average over the full period, Opex PFP averaged an annual rate of change of –0.9 per cent.

Figure 5.5.1 ENX's output, input and TFP indexes, 2006–2024

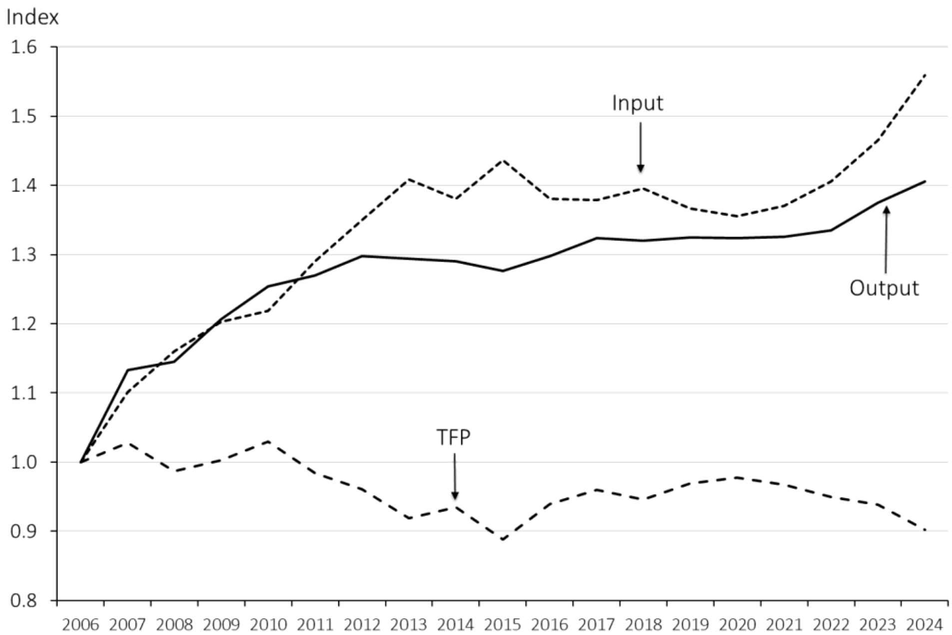


Table 5.5.1 ENX's output, input, TFP and PFP indexes, 2006–2024

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	1.133	1.102	1.028	0.983	1.061
2008	1.145	1.160	0.987	0.935	1.025
2009	1.206	1.203	1.003	0.960	1.033
2010	1.254	1.218	1.029	1.015	1.039
2011	1.270	1.290	0.984	0.932	1.020
2012	1.297	1.350	0.961	0.883	1.019
2013	1.294	1.408	0.919	0.826	0.994
2014	1.290	1.380	0.935	0.884	0.975
2015	1.276	1.436	0.889	0.827	0.938
2016	1.298	1.381	0.940	0.935	0.942
2017	1.324	1.379	0.960	0.977	0.946
2018	1.321	1.395	0.946	0.959	0.935
2019	1.325	1.367	0.969	1.019	0.930
2020	1.324	1.355	0.977	1.056	0.917
2021	1.326	1.371	0.967	1.031	0.911
2022	1.335	1.406	0.950	0.992	0.910
2023	1.375	1.465	0.938	0.944	0.930
2024	1.406	1.559	0.902	0.853	0.942
Growth Rate 2006–2024	1.9%	2.5%	-0.6%	-0.9%	-0.3%
Growth Rate 2006–2012	4.3%	5.0%	-0.7%	-2.1%	0.3%
Growth Rate 2012–2024	0.7%	1.2%	-0.5%	-0.3%	-0.7%
Growth Rate 2024	2.2%	6.2%	-4.0%	-10.2%	1.3%

5.5.2 ENX's output and input quantity changes & contributions to TFP change

Table 5.5.2 presents the average growth rates of ENX's individual output quantity indexes, individual input indexes and partial productivity indexes for individual inputs. Table 5.5.3 decomposes ENX's average TFP growth into the contributions of each output and input over the full 19-year period, the sub-periods before and after 2012, and for 2024. Figure 5.5.2 illustrates these contributions for 2024.

Over the 2006 to 2024, ENX's customer numbers increased at an average annual rate of 1.6 per cent (above the industry's annual growth rate of 1.3 per cent), circuit length at 1.1 per cent (above the industry's annual growth rate of 0.3 per cent), and RMD at 2.0 per cent (above the industry's annual growth rate of 1.1 per cent). These three outputs, which have the highest output weights, combined, accounted for 99.0 per cent of ENX's output cost weight (see Appendix A, s.A3.3) and contributed 1.69 percentage points to its TFP change over the period. Energy delivered increased modestly at an average annual rate of 0.5 per cent (compared with a 0.1 per cent annual *decline* for the industry). It represented 12.0 per cent of ENX's output cost share and contributed 0.06 percentage points to ENX's TFP change over the 19-year period.

Table 5.5.2 ENX individual output, input and PFP growth rates

	2006-2024	*2006-2012*	*2012-2024*	*2023-2024*
Outputs:				
Energy (GWh)	0.5%	0.5%	0.4%	2.9%
Ratcheted Max Demand (MVA)	2.0%	3.8%	1.0%	7.5%
Customer Numbers	1.6%	1.7%	1.5%	1.0%
Circuit Length (km)	1.1%	1.6%	0.8%	0.9%
CMOS	-0.5%	-9.8%	4.2%	20.9%
Inputs:				
Real Opex ($'000 2006)	2.8%	6.4%	1.0%	12.5%
O/H Sub-tran. Lines (MVA-kms)	1.3%	2.4%	0.7%	0.3%
O/H Distr. Lines (MVA-kms)	0.1%	0.4%	0.0%	-0.1%
U/G Sub-tran. Lines (MVA-kms)	3.8%	8.5%	1.4%	0.6%
U/G Dist. Lines (MVA-kms)	3.8%	6.3%	2.5%	2.5%
Transformers (MVA)	2.4%	4.2%	1.5%	1.0%
All Capital inputs	2.2%	4.0%	1.3%	1.0%
Partial productivity:				
Output / Real Opex	-0.9%	-2.1%	-0.3%	-10.2%
Output / OH Sub-tran. Lines	0.6%	1.9%	0.0%	2.0%
Output / OH Distr. Lines	1.7%	4.0%	0.6%	2.3%
Output / UG Sub-tran. Lines	-1.9%	-4.1%	-0.8%	1.6%
Output / UG Distr. Lines	-1.9%	-2.0%	-1.8%	-0.3%
Output / Transformers	-0.5%	0.2%	-0.8%	1.2%
Output / Capital	-0.3%	0.3%	-0.7%	1.3%

Turning to the input side, over the 19-year period, opex increased at an average annual rate of 2.8 per cent (above the industry's annual growth rate of 1.1 per cent). Opex is the largest input cost share (at 43.3 per cent, see Appendix A, s.A3.4) and contributed –1.17 percentage points to ENX's TFP change over the period. By 2024, ENX's opex usage was 64.9 per cent higher than its 2006 level. Transformers increased at an average rate of 2.4 per cent (similar to the industry's growth rate of 2.1 per cent). It accounts for 27.4 per cent of ENX's input cost share and contributed –0.68 percentage points to TFP change in the 19-year period.

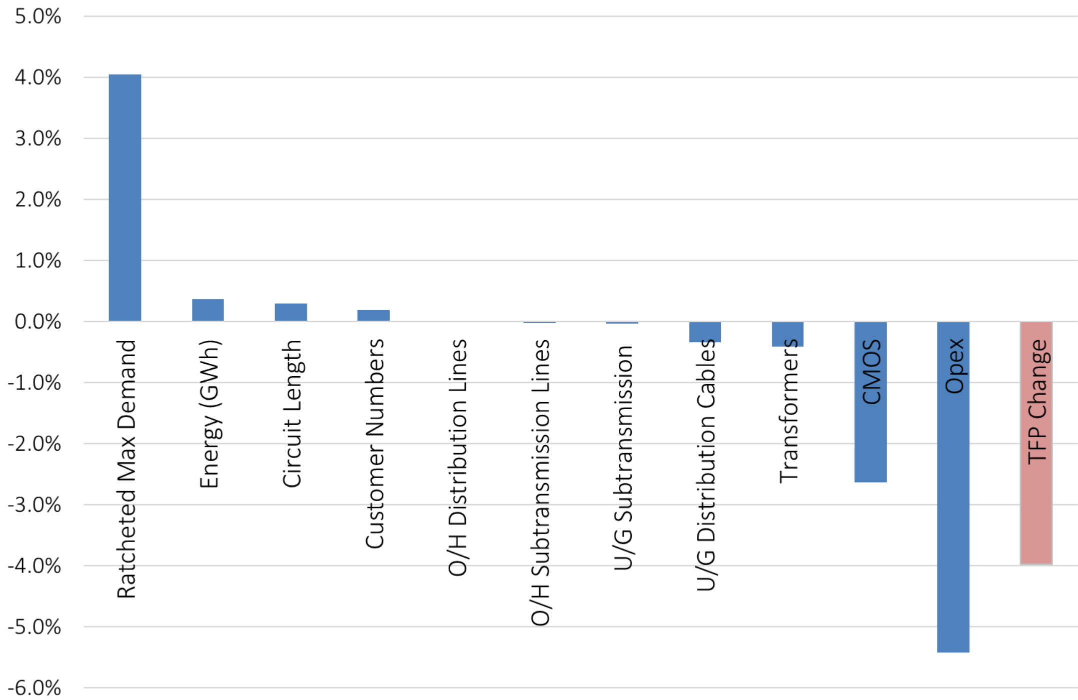
Over the same period, ENX's underground distribution and subtransmission cables each increased at an average rate of 3.8 per cent per year, above the industry's annual growth rates of 3.2 and 1.8 per cent, respectively. Overhead distribution lines increased at 0.1 per cent per year (compared to the industry's annual rate of 0.2 per cent), while overhead subtransmission lines increased by 1.3 per cent (versus the industry's average rate of 0.4 per cent). Combined, these four inputs accounted for 29.2 per cent of ENX's input cost share and contributed –0.62 percentage points to TFP change over the period.

Table 5.5.3 ENX's output and input percentage point contributions to average annual TFP change: various periods

Year	*2006 to 2024*	*2006 to 2012*	*2012 to 2024*	*2024*
Energy (GWh)	0.06%	0.06%	0.05%	0.36%
Ratcheted Max Demand	1.08%	2.10%	0.57%	4.04%
Customer Numbers	0.28%	0.32%	0.26%	0.19%
Circuit Length	0.33%	0.50%	0.25%	0.29%
CMOS	0.15%	1.36%	-0.46%	-2.64%
Opex	-1.17%	-2.58%	-0.46%	-5.42%
O/H Subtransmission Lines	-0.04%	-0.08%	-0.02%	-0.02%
O/H Distribution Lines	-0.02%	-0.04%	0.00%	0.00%
U/G Subtransmission Cables	-0.15%	-0.35%	-0.06%	-0.03%
U/G Distribution Cables	-0.41%	-0.71%	-0.26%	-0.34%
Transformers	-0.68%	-1.24%	-0.40%	-0.41%
TFP Change	-0.57%	-0.66%	-0.53%	-3.98%

As shown in Figure 5.5.2, the component with the greatest positive impact on ENX's TFP in 2024 was RMD, which contributed 4.04 percentage points given a 7.5 per cent increase in that year. In contrast, opex had the largest negative impact, contributing –5.42 percentage points due to a 12.5 per cent increase. This was followed by CMOS, which increased by 20.9 per cent and contributed –2.64 percentage points to ENX's TFP in 2024.

Figure 5.5.2 ENX's output and input percentage point contributions to TFP change in 2024



5.6 Ergon Energy (ERG)

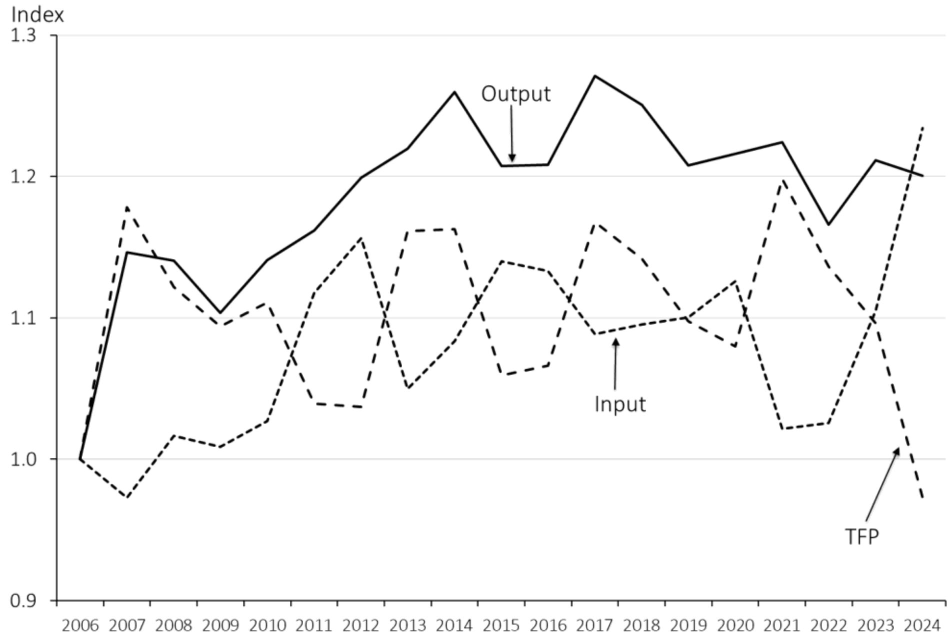
In 2024, ERG delivered 13,926 GWh to 792,127 customers over 154,426 circuit kilometres of lines and cables. ERG distributes electricity throughout regional Queensland, excluding South East Queensland. ERG is the seventh largest DNSP in the NEM in terms of customer numbers but is the second largest in terms of network length.

5.6.1 ERG's productivity performance

ERG's total output, total input and TFP indexes are presented in Figure 6.17 and Table 6.9. Opex and capital PFP indexes are also presented in Table 6.9. Over the 19-year period 2006 to 2024, ERG's TFP *decreased* at an average annual rate of 0.2 per cent, compared to the industry average annual TFP change of –0.5 per cent over the same period. As shown in Figure 5.6.1, in some years there have been large increases in ERG's TFP, and other years have seen substantial decreases, suggesting a zigzag pattern.

ERG's total output increased over the 19-year period at an average annual rate 1.0 per cent, which is the same as the industry's output growth rate. ERG's average annual rate of increase in input use of 1.2 per cent over the 19-year period is similar to the average rate of increase in industry total input use of 1.4 per cent per year.

Figure 5.6.1 ERG's output, input and total factor productivity indexes, 2006–2024



The rates of growth of output and input usage were both much higher in the period 2006 to 2012 (averaging 3.0 and 2.4 per cent per year respectively) than in the period 2012 to 2024 (where they averaged 0.0 and 0.5 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 2024 it averaged a decrease of 0.5 per cent per annum.

The PFP indexes in Table 5.6.1 show that Opex PFP has improved at an average annual rate of 0.5 per cent over the 19-year period. Capital PFP improved slightly in the period from 2006 to 2012 (at an average annual rate of 0.6 per cent) but deteriorated after 2012; with an average rate of change of –1.3 per cent per annum. The average trend growth rate in capital MPFP over the 19-year period was –0.7 per cent per annum.

Table 5.6.1 ERG's output, input, TFP and PFP indexes, 2006–2024

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	1.146	0.973	1.178	1.253	1.119
2008	1.141	1.017	1.122	1.157	1.093
2009	1.104	1.009	1.094	1.164	1.036
2010	1.141	1.027	1.111	1.208	1.034
2011	1.162	1.118	1.039	1.044	1.031
2012	1.199	1.156	1.037	1.030	1.039
2013	1.220	1.050	1.162	1.290	1.064
2014	1.260	1.083	1.163	1.318	1.049
2015	1.208	1.140	1.059	1.158	0.984
2016	1.208	1.133	1.066	1.201	0.966
2017	1.271	1.089	1.168	1.412	0.997
2018	1.251	1.095	1.142	1.388	0.970
2019	1.208	1.100	1.097	1.315	0.943
2020	1.216	1.126	1.080	1.258	0.949
2021	1.224	1.021	1.198	1.590	0.941
2022	1.166	1.026	1.136	1.499	0.899
2023	1.211	1.105	1.096	1.373	0.907
2024	1.201	1.234	0.973	1.086	0.888
Growth Rate 2006–2024	1.0%	1.2%	-0.2%	0.5%	-0.7%
Growth Rate 2006–2012	3.0%	2.4%	0.6%	0.5%	0.6%
Growth Rate 2012–2024	0.0%	0.5%	-0.5%	0.4%	-1.3%
Growth Rate 2024	-0.9%	11.1%	-12.0%	-23.4%	-2.1%

5.6.2 ERG's output and input quantity changes & contributions to TFP change

Table 5.6.2 presents the average growth rates of ERG's individual output and input quantity indexes, and for individual input partial productivity indexes. Table 5.6.3 decomposes ERG's average TFP growth into the contributions of each output and input over the full 19-year period, the sub-periods before and after 2012, and for 2024. Figure 5.6.2 illustrates these contributions for 2024.

Over the 2006 to 2024 period, ERG's customer numbers increased at an average annual rate of 1.3 per cent per year (in line with the industry's growth rate), circuit length at 0.2 per cent (slightly below the industry's growth rate of 0.3 per cent), and RMD at 0.8 per cent (below the industry's growth rate of 1.1 per cent). These three outputs, which have the highest output weights, combined, accounted for 113.6 per cent of ERG's output cost weight (see Appendix A, s.A3.3) and contributed 0.86 percentage points to its TFP change over the period.[27]

Energy delivered increased modestly at an average annual rate of 0.2 per cent (compared with a 0.1 per cent annual *decline* for the industry). It represented 13.7 per cent of ERG's output cost share and contributed 0.03 percentage points to ERG's TFP change over the 19-year period.

Table 5.6.2 ERG individual output, input and PFP growth rates

	2006-2024	*2006-2012*	*2012-2024*	*2023-2024*
Outputs:				
Energy (GWh)	0.2%	0.3%	0.1%	0.4%
Ratcheted Max Demand (MVA)	0.8%	2.4%	0.0%	0.0%
Customer Numbers	1.3%	1.9%	1.0%	0.7%
Circuit Length (km)	0.2%	0.6%	0.0%	0.0%
CMOS	-0.3%	-2.3%	0.8%	3.5%
Inputs:				
Real Opex ($'000 2006)	0.6%	2.5%	-0.4%	22.6%
O/H Sub-tran. Lines (MVA-kms)	0.1%	1.7%	-0.7%	-1.3%
O/H Distr. Lines (MVA-kms)	1.0%	1.1%	1.0%	2.0%
U/G Sub-tran. Lines (MVA-kms)	3.7%	6.3%	2.4%	10.8%
U/G Dist. Lines (MVA-kms)	4.3%	8.9%	2.0%	1.7%
Transformers (MVA)	2.4%	2.9%	2.1%	1.3%
All Capital inputs	1.7%	2.4%	1.3%	1.2%
Partial productivity:				
Output / Real Opex	0.5%	0.5%	0.4%	-23.4%
Output / OH Sub-tran. Lines	0.9%	1.4%	0.7%	0.4%
Output / OH Distr. Lines	0.0%	2.0%	-1.0%	-2.9%
Output / UG Sub-tran. Lines	-2.7%	-3.2%	-2.4%	-11.7%
Output / UG Distr. Lines	-3.3%	-5.9%	-2.0%	-2.6%
Output / Transformers	-1.4%	0.1%	-2.1%	-2.2%
Output / Capital	-0.7%	0.6%	-1.3%	-2.1%

Turning to the input side, over the 19-year period, opex increased at an average annual rate of 0.6 per cent (below the industry's annual growth rate of 1.1 per cent). Opex is the largest input cost share (at 45.3 per cent, see Appendix A, s.A3.4) and contributed –0.25 percentage points to ERG's TFP change over the period. By 2024, ERG's opex usage was 10.5 per cent higher than its 2006 level. Transformers increased at an average annual rate of 2.4 per cent (similar

[27] CMOS has a negative output cost share weight, and the sum of the weights across all outputs equals 100 per cent.

to the industry's annual growth rate of 2.1 per cent). It accounts for 24.4 per cent of ERG's input cost share and contributed –0.58 percentage points to TFP change in the 19-year period.

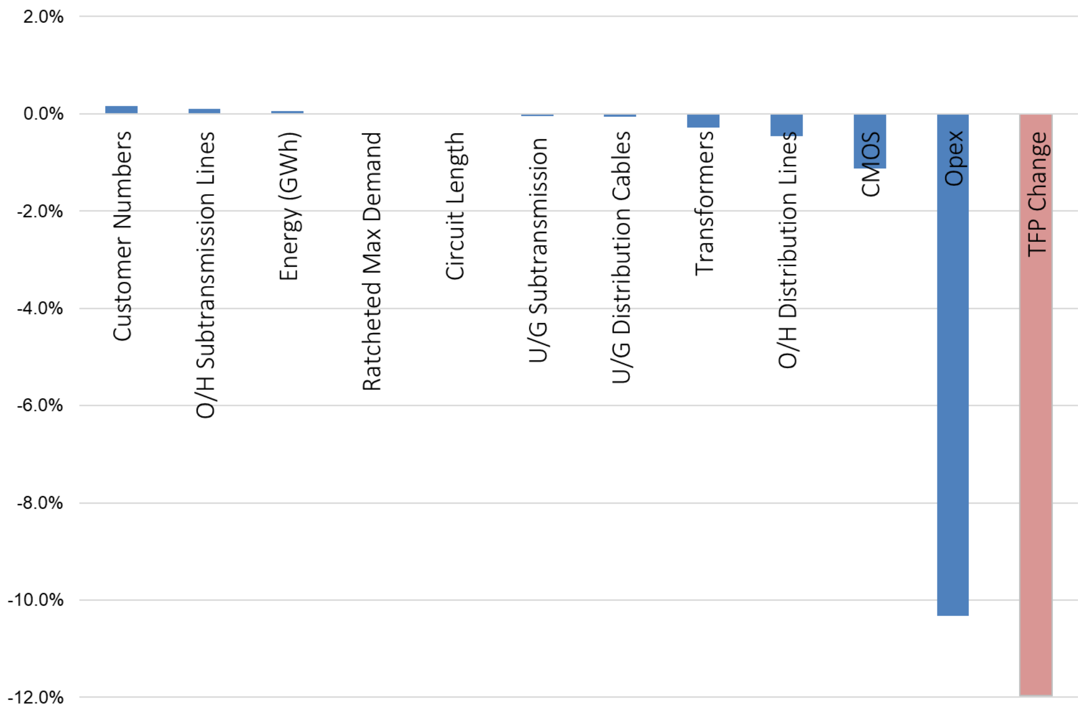
ERG's underground distribution and subtransmission cables increased at an average annual rate 4.3 and 3.7 per cent per year, respectively (both above the industry's growth rate of 3.2 and 1.8 per cent). Overhead distribution lines increased at 1.0 per cent per year (compared to the industry's annual growth rate of 0.2 per cent), while overhead subtransmission lines increased at 0.1 per cent (below the industry's growth rate of 0.4 per cent). Combined, these four inputs accounted for 30.3 per cent of ERG's input cost share and contributed –0.34 percentage points to TFP change over the period.

Table 5.6.3 ERG's output and input percentage point contributions to average annual TFP change: various sources

Year	*2006 to 2024*	*2006 to 2012*	*2012 to 2024*	*2024*
Energy (GWh)	0.03%	0.04%	0.02%	0.06%
Ratcheted Max Demand	0.52%	1.54%	0.00%	0.01%
Customer Numbers	0.27%	0.40%	0.20%	0.16%
Circuit Length	0.08%	0.21%	0.01%	0.00%
CMOS	0.13%	0.84%	-0.23%	-1.12%
Opex	-0.25%	-1.12%	0.18%	-10.33%
O/H Subtransmission Lines	-0.01%	-0.15%	0.06%	0.10%
O/H Distribution Lines	-0.20%	-0.21%	-0.20%	-0.46%
U/G Subtransmission Cables	-0.01%	-0.02%	-0.01%	-0.04%
U/G Distribution Cables	-0.12%	-0.24%	-0.06%	-0.06%
Transformers	-0.58%	-0.69%	-0.52%	-0.28%
TFP Change	-0.15%	0.61%	-0.53%	-11.96%

As shown in Figure 5.6.2, the components with a positive impact on ERG's TFP in 2024, customer numbers, overhead subtransmission lines, and energy delivered, each contributed less than 0.2 percentage points. In contrast, opex had the largest negative impact, contributing –10.33 percentage points due to a 22.6 per cent increase.

Figure 5.6.2 ERG's output and input percentage point contributions to TFP change, 2024



5.7 Essential Energy (ESS)

In 2024, ESS delivered 12,698 GWh to 956,776 customers over 193,437 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.

5.7.1 ESS's productivity performance

ESS's total output, total input and TFP indexes are presented in Figure 5.7.1 and Table 5.7.1. Opex and capital PFP indexes are also presented in Table 5.7.1.

Over the 19-year period 2006 to 2024, ESS's TFP average annual rate of change was 0.1 per cent. This compares favourably to the industry's average annual change of –0.5 per cent over the same period. ESS's TFP mostly declined in the period up to 2012, where the average rate of TFP change was –3.8 per cent per year. In the period 2012 to 2024, ESS's TFP increased at an average rate of 2.0 per cent per year. ESS's TFP in 2024 *decreased* by 3.3 per cent.

Figure 5.7.1 ESS's output, input and TFP indexes, 2006–2024

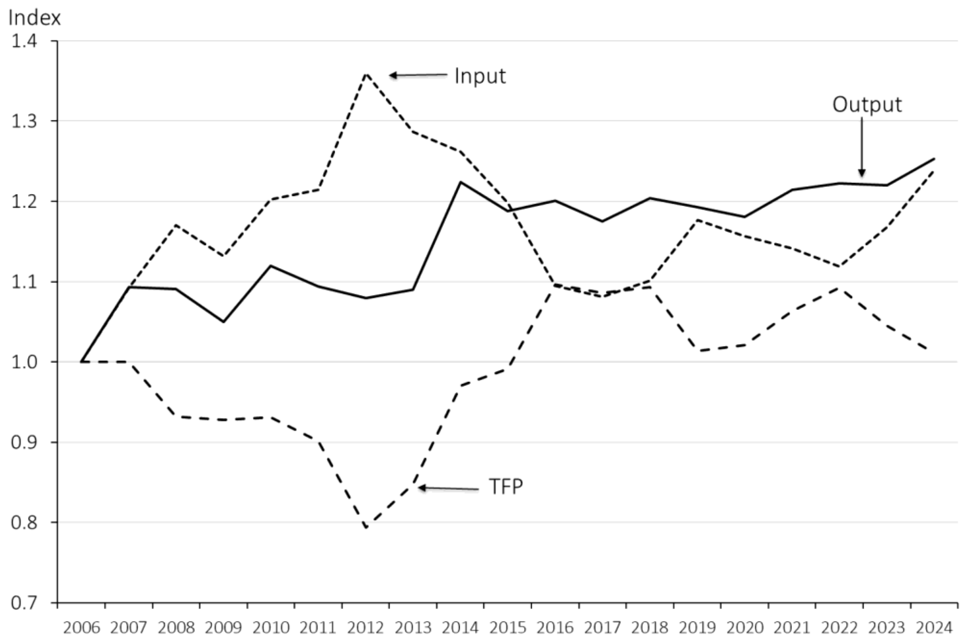


Table 5.7.1 ESS's output, input, TFP and PFP indexes, 2006–2024

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	1.093	1.093	1.000	0.924	1.081
2008	1.091	1.170	0.932	0.804	1.079
2009	1.050	1.131	0.928	0.842	1.014
2010	1.119	1.202	0.931	0.822	1.043
2011	1.094	1.214	0.901	0.794	1.006
2012	1.080	1.360	0.794	0.636	0.981
2013	1.090	1.287	0.847	0.725	0.979
2014	1.224	1.262	0.970	0.848	1.094
2015	1.188	1.198	0.992	0.935	1.046
2016	1.200	1.095	1.097	1.164	1.043
2017	1.175	1.081	1.086	1.184	1.015
2018	1.204	1.102	1.093	1.167	1.036
2019	1.192	1.177	1.013	1.019	1.008
2020	1.180	1.156	1.021	1.049	0.991
2021	1.214	1.142	1.064	1.111	1.013
2022	1.222	1.119	1.093	1.180	1.013
2023	1.220	1.167	1.045	1.091	1.003
2024	1.253	1.239	1.011	1.001	1.023
Growth Rate 2006–2024	1.3%	1.2%	0.1%	0.0%	0.1%
Growth Rate 2006–2012	1.3%	5.1%	-3.8%	-7.5%	-0.3%
Growth Rate 2012–2024	1.2%	-0.8%	2.0%	3.8%	0.3%
Growth Rate 2024	2.7%	5.9%	-3.3%	-8.6%	1.9%

ESS's total output increased over the 19-year period at an average annual rate of 1.3 per cent (compared with the 1.0 per cent for the industry's growth rate over the same period), and input use increased at an average rate of 1.2 per cent in the same period (compared to the industry's rate of increase in total input use of 1.4 per cent per year). Whereas output growth was at a reasonably steady rate, input use increased strongly in the period up to 2012 (at an average annual rate of 5.1 per cent) and then *decreased* at an average rate of 0.8 from 2012 to 2024.

Capital PFP increased at an average rate of 0.1 per cent per year from 2006 to 2024. The decline was greater in the period up to 2012, averaging –0.3 per cent per annum. After 2012, Capital PFP averaged 0.3 per cent per annum. Opex PFP declined rapidly in the period up to 2012, averaging –7.5 per cent per annum, whereas it increased at a rate of 3.8 per cent per annum after 2012. Over the full period, Opex PFP had zero growth.

5.7.2 ESS's output and input quantity changes & contributions to TFP change

Table 5.7.2 presents the average growth rates of ESS's individual output and input quantity indexes, and individual input partial factor productivity indexes. Table 5.7.3 decomposes ESS's average TFP growth into the contributions of each output and input over the full 19-year period, the sub-periods before and after 2012, and for 2024. Figure 5.7.2 illustrates these contributions for 2024.

Table 5.7.2 ESS individual output, input and PFP growth rates

	2006-2024	*2006-2012*	*2012-2024*	*2023-2024*
Outputs:				
Energy (GWh)	0.3%	-0.2%	0.6%	0.4%
Ratcheted Max Demand (MVA)	1.3%	0.8%	1.6%	1.5%
Customer Numbers	1.0%	0.8%	1.1%	0.9%
Circuit Length (km)	-0.2%	-0.7%	0.1%	0.0%
CMOS	-1.0%	-2.9%	-0.1%	-6.8%
Inputs:				
Real Opex ($'000 2006)	1.2%	8.8%	-2.5%	11.3%
O/H Sub-tran. Lines (MVA-kms)	0.7%	-0.3%	1.2%	0.7%
O/H Distr. Lines (MVA-kms)	-0.2%	-1.3%	0.3%	0.2%
U/G Sub-tran. Lines (MVA-kms)	2.6%	-3.6%	5.8%	0.8%
U/G Dist. Lines (MVA-kms)	2.0%	0.1%	3.0%	3.4%
Transformers (MVA)	2.1%	4.1%	1.0%	1.3%
All Capital inputs	1.1%	1.6%	0.9%	0.7%
Partial productivity:				
Output / Real Opex	0.0%	-7.5%	3.8%	-8.6%
Output / OH Sub-tran. Lines	0.6%	1.5%	0.1%	2.0%
Output / OH Distr. Lines	1.5%	2.5%	1.0%	2.4%
Output / UG Sub-tran. Lines	-1.4%	4.9%	-4.5%	1.9%
Output / UG Distr. Lines	-0.8%	1.1%	-1.8%	-0.8%
Output / Transformers	-0.8%	-2.8%	0.2%	1.4%
Output / Capital	0.1%	-0.3%	0.3%	1.9%

Over 2006–2024, ESS's customer numbers increased at an average annual rate of 1.0 per cent per year (below the industry's growth rate of 1.3 per cent), RMD at 1.3 per cent (above the industry's growth rate of 1.1 per cent), and circuit length *decreased* at 0.2 per cent (in contrast to the industry's growth rate of 0.3 per cent). These three outputs, which have the highest output weights, combined, accounted for 108.7 per cent of ESS's output cost share (see Appendix A, s.A3.3) and contributed 0.91 percentage points to its TFP change in the 19-year period.[28]

Energy delivered increased modestly at an average annual rate of 0.3 per cent (compared with a 0.1 per cent annual *decline* for the industry). It represented 13.1 per cent of ESS's output cost share and contributed 0.04 percentage points to ESS's TFP change over the 19-year period. CMOS *decreased* at an average annual rate of 1.0 per cent (compared to a 0.1 per cent *decrease* for the industry). Given its negative output weight (–21.8 per cent), this decrease had a positive effect on ESS's TFP of 0.29 percentage points.

Turning to the input side, over the 2006 to 2024 period, opex increased at 1.2 per cent per year, in line with the industry's 1.1 per cent. Opex is the largest input cost share (at 47.9 per cent, see Appendix A, s.A3.4) and contributed –0.60 percentage points to TFP change. By 2024, ESS's opex usage was 25.2 per cent higher than its 2006 level. Transformers increased at 2.1 per cent per year (same as the industry), accounted for 24.7 per cent of input cost share, and contributed –0.51 percentage points to ESS's TFP.

ESS's underground distribution and subtransmission cables increased by 2.0 and 2.6 per cent per year, respectively (compared to the industry's growth rates of 3.2 and 1.8 per cent). Overhead distribution lines *decreased* by 0.2 per cent per year (in line with the industry), while overhead subtransmission lines increased by 0.7 per cent (above the industry's 0.4 per cent). These four inputs accounted for 27.3 per cent of ESS's input cost share and contributed –0.08 percentage points to TFP change over the period.

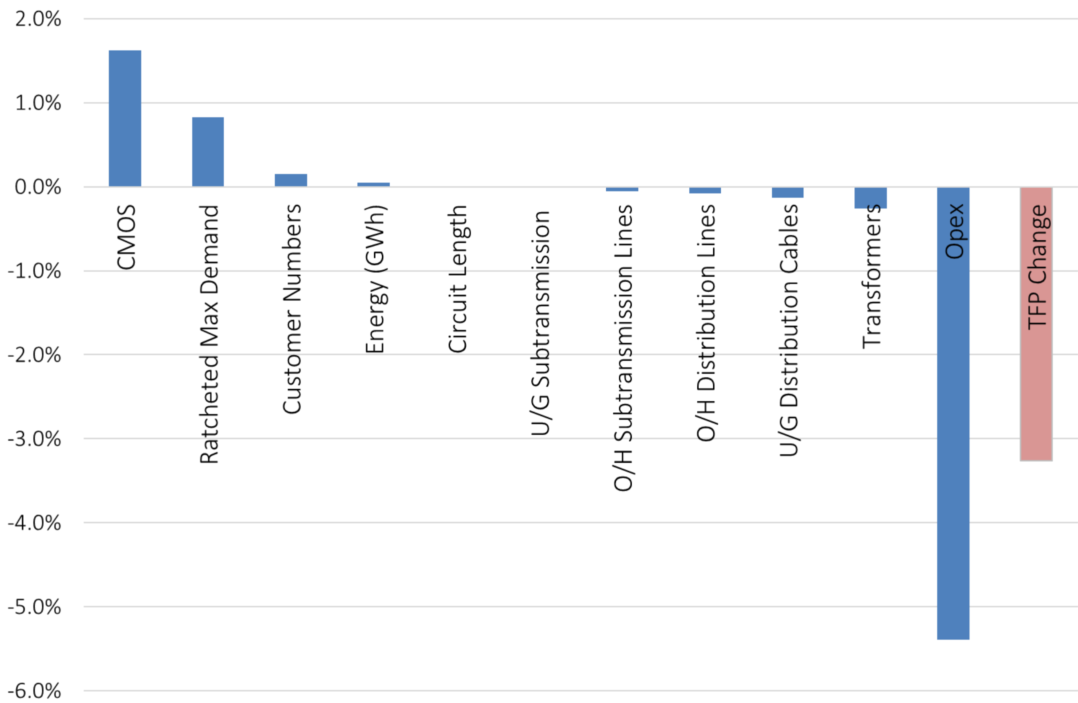
As shown in Figure 5.7.2, the components with a positive impact on ESS's TFP in 2024 were CMOS and RMD, reflecting a 6.8 per cent *decrease* in CMOS and a 1.5 per cent increase in RMD. Together, they contributed 2.45 percentage points to TFP in 2024. In contrast, opex had the largest negative impact, contributing –5.39 percentage points due to an 11.3 per cent increase in the same year.

[28] CMOS has a negative output cost share weight, and the sum of the weights across all outputs equals 100 per cent.

Table 5.7.3 ESS's output and input percentage point contributions to average annual TFP change: various periods

Year	*2006 to 2024*	*2006 to 2012*	*2012 to 2024*	*2024*
Energy (GWh)	0.04%	-0.02%	0.07%	0.05%
Ratcheted Max Demand	0.78%	0.53%	0.91%	0.83%
Customer Numbers	0.19%	0.17%	0.20%	0.15%
Circuit Length	-0.06%	-0.25%	0.04%	0.01%
CMOS	0.29%	0.85%	0.02%	1.63%
Opex	-0.60%	-4.29%	1.25%	-5.39%
O/H Subtransmission Lines	-0.04%	0.01%	-0.07%	-0.06%
O/H Distribution Lines	0.03%	0.21%	-0.05%	-0.08%
U/G Subtransmission Cables	0.00%	0.01%	-0.01%	-0.01%
U/G Distribution Cables	-0.06%	0.00%	-0.10%	-0.13%
Transformers	-0.51%	-1.06%	-0.24%	-0.26%
TFP Change	0.06%	-3.84%	2.02%	-3.26%

Figure 5.7.2 ESS's output and input percentage point contributions to TFP change, 2024



5.8 Jemena Electricity Networks (JEN)

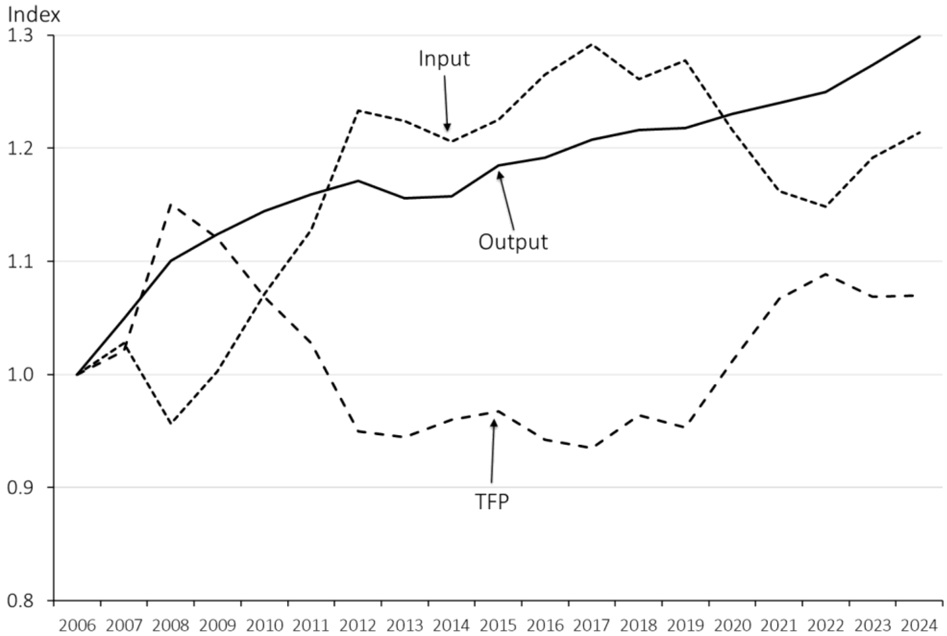
In 2024, JEN delivered 4,321 GWh to 383,818 customers over 7,014 circuit kilometres of lines and cables. JEN distributes electricity across 950 square kilometres of north–west greater Melbourne. JEN's network footprint incorporates a mix of major industrial areas, residential growth areas, established inner suburbs and Melbourne International Airport.

5.8.1 JEN's productivity performance

JEN's total output, total input and TFP indexes are presented in Figure 5.8.1 and Table 5.8.1. Opex and capital PFP indexes are also presented in Table 5.8.1.

Over the 19-year period 2006 to 2024, JEN's TFP increased at an average annual rate of change of 0.4 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 change in TFP was –0.9 per cent per annum, and in the period from 2012 to 2024, the rate of increase was 1.0 per cent per annum.

Figure 5.8.1 JEN's output, input, and TFP indexes, 2006–2024



JEN's total output increased over 19-year period at an average annual rate of 1.5 per cent, which is higher than the industry growth rate of growth in output of 1.0 per cent per annum. JEN's average annual rate of increase in input use of 1.1 per cent over the same period is below to the industry (1.4 per cent per year). JEN's rate of output growth was higher in the period up to 2012 (at 2.6 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 3.5 per cent per annum) than in the period after 2012 (at –0.1 per cent per annum).

Capital PFP increased at an average rate of 0.3 per cent per year from 2006 to 2024. In the period up to 2012, Capital PFP increased at a rate of 1.4 per cent per annum, whilst in the period after 2012, the rate of change in Capital PFP averaged –0.3 per cent per annum. Opex PFP increased on average at a rate of 0.6 per cent per annum from 2006 to 2024. In the period up to 2012, Opex PFP *decreased* by 3.5 per cent per annum on average, whereas it has increased at a rate of 2.7 per cent per annum after 2012.

Table 5.8.1 JEN's output, input, TFP and PFP indexes, 2006–2024

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	1.049	1.028	1.021	0.994	1.044
2008	1.101	0.957	1.151	1.291	1.062
2009	1.124	1.003	1.121	1.208	1.064
2010	1.145	1.071	1.069	1.049	1.086
2011	1.159	1.128	1.028	0.974	1.074
2012	1.171	1.233	0.950	0.810	1.086
2013	1.156	1.224	0.945	0.820	1.066
2014	1.158	1.206	0.960	0.858	1.054
2015	1.185	1.225	0.967	0.872	1.054
2016	1.192	1.265	0.942	0.832	1.046
2017	1.208	1.292	0.935	0.813	1.057
2018	1.216	1.261	0.964	0.884	1.037
2019	1.218	1.277	0.953	0.884	1.016
2020	1.230	1.216	1.012	1.003	1.019
2021	1.240	1.162	1.067	1.124	1.021
2022	1.250	1.148	1.088	1.174	1.022
2023	1.274	1.192	1.069	1.118	1.032
2024	1.299	1.214	1.070	1.108	1.047
Growth Rate 2006–2024	1.5%	1.1%	0.4%	0.6%	0.3%
Growth Rate 2006–2012	2.6%	3.5%	-0.9%	-3.5%	1.4%
Growth Rate 2012–2024	0.9%	-0.1%	1.0%	2.7%	-0.3%
Growth Rate 2024	2.0%	1.8%	0.1%	-0.9%	1.5%

5.8.2 JEN's output and input quantity changes & contributions to TFP change

Table 5.8.2 presents the average growth rates of JEN's individual output quantity and input quantity indexes, and of the individual input partial productivity indexes. Table 5.8.3 decomposes JEN's average TFP growth into the contributions of each output and input over the full 19-year period, the sub-periods before and after 2012, and for 2024. Figure 5.8.2 illustrates these contributions for 2024.

Over 2006–2024, JEN's RMD increased at an average annual rate of 1.6 per cent per year (above the industry's rate of 1.1 per cent), circuit length increased by 1.2 per cent per year (above the industry's 0.3 per cent), and customer numbers increased by 1.5 per cent per year (compared to 1.3 per cent for the industry). These three outputs, which have the highest output weights, combined, account for 96.0 per cent of JEN's output cost share (see Appendix A, s.A3.3) and contributed 1.40 percentage points to JEN's TFP change over the period.

Energy delivered increased modestly at an average annual rate of 0.1 per cent (compared with a 0.1 per cent annual *decline* for the industry). It represented 11.6 per cent of JEN's output cost share and contributed 0.01 percentage points to JEN's TFP change over the 19-year period.

Table 5.8.2 JEN individual output, input and PFP growth rates

	2006-2024	*2006-2012*	*2012-2024*	*2023-2024*
Outputs:				
Energy (GWh)	0.1%	0.3%	-0.1%	-1.2%
Ratcheted Max Demand (MVA)	1.6%	3.3%	0.7%	4.7%
Customer Numbers	1.5%	1.1%	1.8%	1.3%
Circuit Length (km)	1.2%	1.1%	1.2%	1.7%
CMOS	-0.9%	-4.2%	0.8%	14.8%
Inputs:				
Real Opex ($'000 2006)	0.9%	6.1%	-1.8%	2.9%
O/H Sub-tran. Lines (MVA-kms)	0.8%	1.0%	0.7%	-0.2%
O/H Distr. Lines (MVA-kms)	0.2%	-0.2%	0.4%	0.1%
U/G Sub-tran. Lines (MVA-kms)	3.2%	-0.4%	5.0%	3.5%
U/G Dist. Lines (MVA-kms)	4.9%	4.8%	4.9%	7.0%
Transformers (MVA)	2.5%	3.3%	2.0%	0.8%
All Capital inputs	1.2%	1.3%	1.2%	0.5%
Partial productivity:				
Output / Real Opex	0.6%	-3.5%	2.7%	-0.9%
Output / OH Sub-tran. Lines	0.7%	1.7%	0.2%	2.2%
Output / OH Distr. Lines	1.3%	2.8%	0.5%	1.8%
Output / UG Sub-tran. Lines	-1.7%	3.0%	-4.1%	-1.6%
Output / UG Distr. Lines	-3.4%	-2.2%	-4.0%	-5.0%
Output / Transformers	-1.0%	-0.6%	-1.1%	1.2%
Output / Capital	0.3%	1.4%	-0.3%	1.5%

Turning to the input side, over the 2006 to 2024 period, opex increased at an average annual rate of 0.9 per cent (below the industry average of 1.1 per cent). Opex is the largest input cost share (at 45.0 per cent, see Appendix A, s.A3.4) and contributed –0.42 percentage points to TFP change. By 2024, JEN's opex usage was 17.3 per cent higher than its 2006 level. Transformers increased at an average annual rate of 2.5 per cent (above the industry's rate of 2.1 per cent annually), accounted for 20.7 per cent of input cost share, and contributed –0.48 percentage points to TFP change.

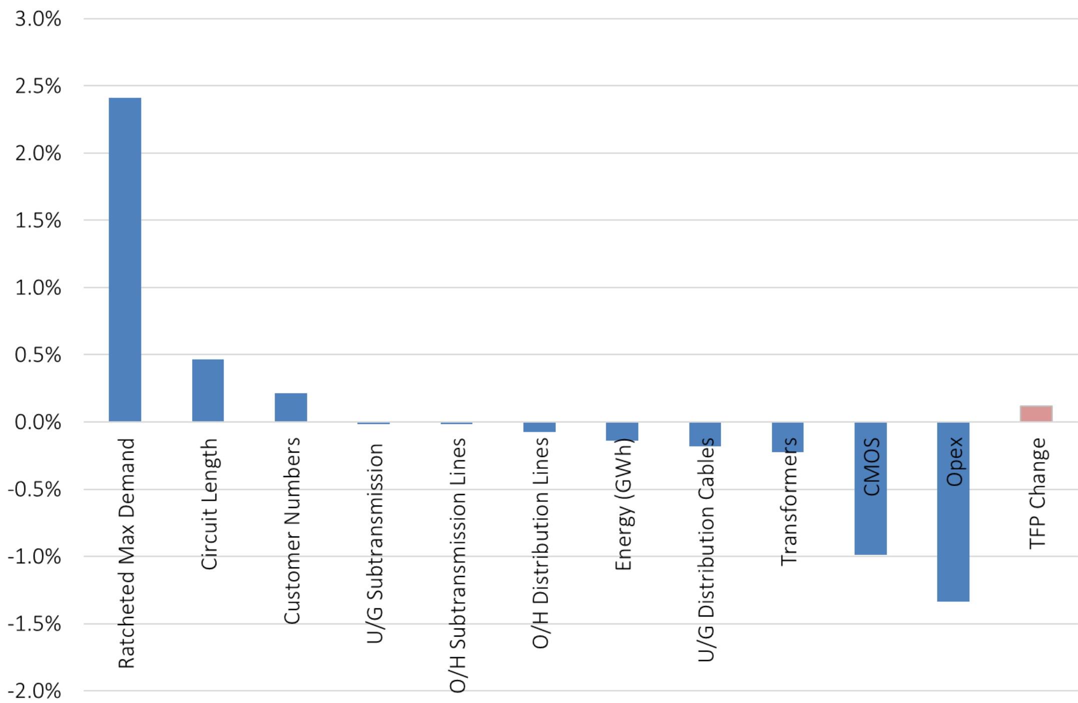
JEN's underground distribution and subtransmission cables increased 4.9 and 3.2 per cent per year, respectively, compared to industry's growth rates of 3.2 and 1.8 per cent. Overhead distribution lines increased by 0.2 per cent per year (in line with the industry), while overhead subtransmission lines increased by 0.8 per cent (above the industry's 0.4 per cent). These four inputs accounted for 34.3 per cent of JEN's input cost share and contributed –0.20 percentage points to TFP change over the period.

Table 5.8.3 JEN's output and input percentage point contributions to average annual TFP change: various points

Year	*2006 to 2024*	*2006 to 2012*	*2012 to 2024*	*2024*
Energy (GWh)	0.01%	0.04%	-0.01%	-0.14%
Ratcheted Max Demand	0.82%	1.73%	0.34%	2.41%
Customer Numbers	0.25%	0.18%	0.29%	0.21%
Circuit Length	0.33%	0.31%	0.34%	0.47%
CMOS	0.09%	0.37%	-0.06%	-0.99%
Opex	-0.42%	-2.81%	0.83%	-1.33%
O/H Subtransmission Lines	-0.04%	-0.04%	-0.04%	-0.02%
O/H Distribution Lines	-0.06%	0.05%	-0.11%	-0.07%
U/G Subtransmission Cables	-0.01%	0.00%	-0.01%	-0.02%
U/G Distribution Cables	-0.10%	-0.11%	-0.10%	-0.18%
Transformers	-0.48%	-0.59%	-0.43%	-0.22%
TFP Change	0.39%	-0.86%	1.04%	0.12%

As shown in Figure 5.8.2, the components with a positive impact on JEN's TFP in 2024 was RMD, reflecting a 4.7 per cent increase in that year and contributing 2.41 percentage points to TFP in 2024. In contrast, opex and CMOS had the largest negative impact, contributing together –2.32 percentage points due to 2.9 per cent increase in opex and 14.8 increase in CMOS the same year.

Figure 5.8.2 JEN's output and input percentage point contributions to TFP change, 2024



5.9 Powercor (PCR)

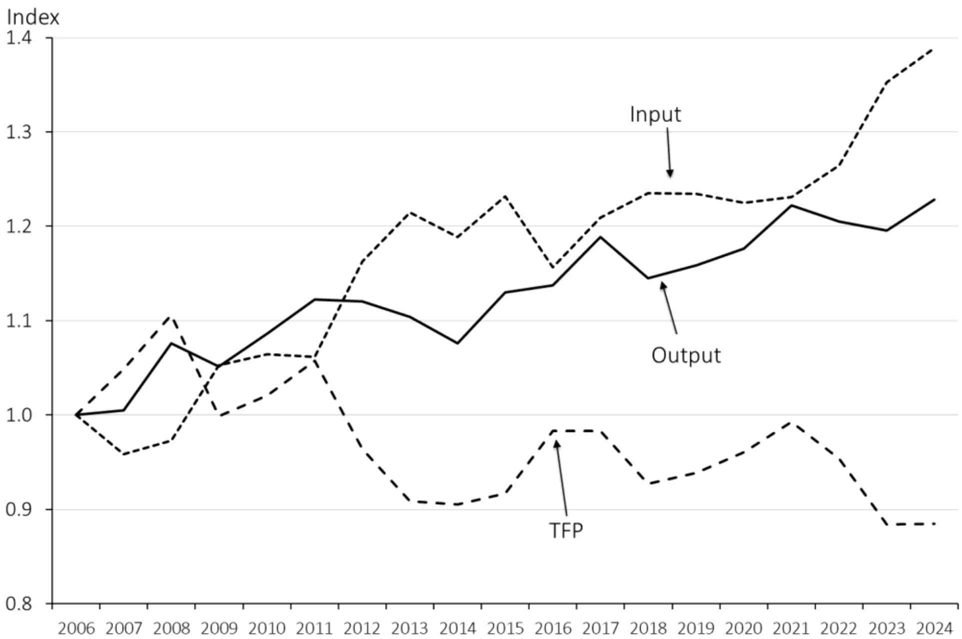
In 2024, PCR delivered 11,204 GWh to 936,897 customers over 77,747 circuit kilometres of lines and cables. PCR distributes electricity to the western half of Victoria, including the western suburbs of Melbourne and stretching west to the border of South Australia and north to New South Wales.

5.9.1 PCR's productivity performance

PCR's total output, total input and TFP indexes are presented in Figure 5.9.1 and Table 5.9.1. Opex and capital PFP indexes are also presented in Table 5.9.1.

Over the 19-year period PCR's TFP decreased, averaging an annual rate of change of –0.7 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 PCR's TFP *decline* at an average rate of 0.6 per cent per year, while in the period from 2012 to 2024, TFP again *decreased* at an average annual rate of 0.7 per cent.

Figure 5.9.1 PCR's output, input and TFP indexes, 2006–2024



PCR's total output increased over the 19-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 1.9 per cent over the same period was higher than for the industry (1.4 per cent per year). The average rate of growth of output for PCR in the period up to 2012 was 1.9 per cent per year, and in the period after 2012 it was 0.8 per cent per year. PCR's input usage increased at an average rate of 2.5 per cent per year from 2006 to 2012, and by 1.5 per cent per year after 2012.

Capital PFP decreased reasonably consistently, averaging an annual rate of change of –0.9 per cent per annum. Opex PFP *decreased* on average at a rate of 0.5 per cent per annum from 2006 to 2024. In the period up to 2012, Opex PFP *decreased* by 0.8 per cent per annum, on average, and *decreased* at a rate of 0.3 per cent per annum from 2012 to 2024.

Table 5.9.1 PCR's output, input, TFP and PFP indexes, 2006–2024

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	1.005	0.959	1.048	1.125	0.983
2008	1.076	0.973	1.106	1.190	1.034
2009	1.051	1.052	0.999	1.052	0.951
2010	1.086	1.064	1.021	1.100	0.953
2011	1.123	1.062	1.057	1.134	0.990
2012	1.120	1.163	0.964	0.952	0.978
2013	1.104	1.214	0.909	0.886	0.941
2014	1.076	1.189	0.905	0.917	0.899
2015	1.130	1.232	0.917	0.916	0.926
2016	1.137	1.157	0.983	1.059	0.916
2017	1.188	1.209	0.983	1.037	0.935
2018	1.145	1.235	0.927	0.975	0.885
2019	1.159	1.235	0.938	1.009	0.877
2020	1.176	1.225	0.961	1.072	0.867
2021	1.222	1.231	0.993	1.104	0.897
2022	1.205	1.264	0.953	1.055	0.866
2023	1.196	1.352	0.884	0.933	0.841
2024	1.228	1.388	0.885	0.924	0.849
Growth Rate 2006–2024	1.2%	1.9%	-0.7%	-0.5%	-0.9%
Growth Rate 2006–2012	1.9%	2.5%	-0.6%	-0.8%	-0.4%
Growth Rate 2012–2024	0.8%	1.5%	-0.7%	-0.3%	-1.2%
Growth Rate 2024	2.7%	2.6%	0.1%	-1.0%	1.0%

5.9.2 PCR's output and input quantity changes & contributions to TFP change

Table 5.9.2 presents the average growth rates of PCR's individual output and input quantity indexes, and for the partial productivity indexes for each input. Table 5.9.3 decomposes PCR's average TFP growth into the contributions of each output and input over the full 19-year period, the sub-periods before and after 2012, and for 2024. Figure 5.9.2 illustrates these contributions for 2024.

Over 2006–2024 period, PCR's RMD increased at an average annual rate of 1.5 per cent per year (above the industry's rate of 1.1 per cent), circuit length increased 0.5 per cent per year (similar to the industry's growth rate of 0.3 per cent), and customer numbers increased 2.0 per cent per year (above to 1.3 per cent annual increase for the industry). These three outputs, which have the highest output weights, combined, account for 105.6 per cent of PCR's output cost share (see Appendix A, s.A3.3) and contributed 1.33 percentage points to PCR's TFP change over the period.[29]

Energy delivered increased at an average annual rate of 0.6 per cent (compared with a 0.1 per cent annual *decline* for the industry). It represented 12.8 per cent of PCR's output cost share and contributed 0.07 percentage points to PCR's TFP change over the 19-year period. PCR's CMOS increased 1.2 per cent per year, in contrast to a 0.1 per cent *decrease* for the industry. Given its negative output weight (–18.4 per cent), this increase had a *negative* effect on TFP of –0.22 percentage points.

Table 5.9.2 PCR individual output, input and PFP growth rates

	2006-2024	*2006-2012*	*2012-2024*	*2023-2024*
Outputs:				
Energy (GWh)	0.6%	1.0%	0.4%	1.6%
Ratcheted Max Demand (MVA)	1.5%	3.3%	0.5%	0.0%
Customer Numbers	2.0%	1.9%	2.0%	1.8%
Circuit Length (km)	0.5%	0.4%	0.5%	0.4%
CMOS	1.2%	3.0%	0.2%	-12.3%
Inputs:				
Real Opex ($'000 2006)	1.6%	2.7%	1.1%	3.7%
O/H Sub-tran. Lines (MVA-kms)	0.2%	0.1%	0.2%	-0.3%
O/H Distr. Lines (MVA-kms)	0.1%	0.1%	0.1%	0.1%
U/G Sub-tran. Lines (MVA-kms)	8.8%	5.9%	10.3%	0.1%
U/G Dist. Lines (MVA-kms)	5.6%	5.9%	5.4%	4.1%
Transformers (MVA)	2.7%	3.0%	2.5%	2.4%
All Capital inputs	2.1%	2.3%	2.0%	1.7%
Partial productivity:				
Output / Real Opex	-0.5%	-0.8%	-0.3%	-1.0%
Output / OH Sub-tran. Lines	1.0%	1.8%	0.6%	3.0%
Output / OH Distr. Lines	1.1%	1.8%	0.7%	2.6%
Output / UG Sub-tran. Lines	-7.6%	-4.0%	-9.5%	2.6%
Output / UG Distr. Lines	-4.4%	-4.0%	-4.6%	-1.4%
Output / Transformers	-1.5%	-1.1%	-1.7%	0.3%
Output / Capital	-0.9%	-0.4%	-1.2%	1.0%

Turning to the input side, over the 2006 to 2024 period, opex increased at an average annual rate of 1.6 per cent per year (above the industry's average of 1.1 per cent). Opex is the largest input cost share (at 48.9 per cent, see Appendix A, s.A3.4) and contributed –0.77 percentage points to PCR's TFP change. By 2024, PCR's opex usage was 32.9 per cent higher than its 2006 level. Transformers increased 2.7 per cent per year (above the industry's rate of 2.1 per

[29] CMOS has a negative output cost share weight, and the sum of the weights across all outputs equals 100 per cent.

cent annually). It accounts for 18.1 per cent of input cost share, and contributed –0.51 percentage points to PCR's TFP.

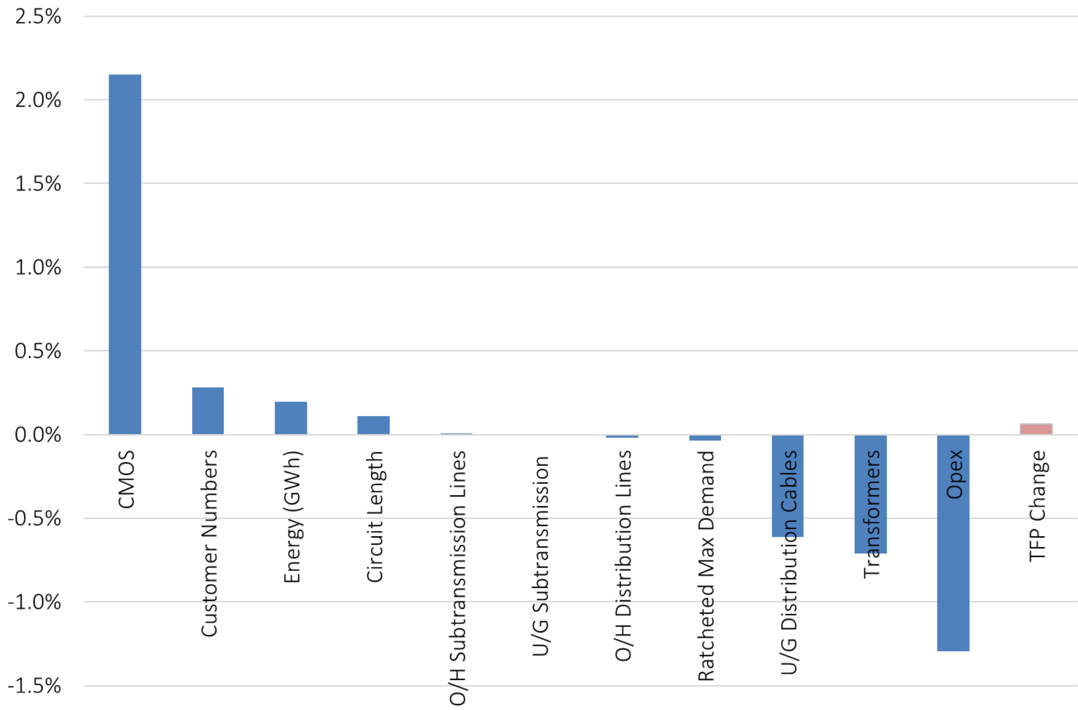
PCR's underground distribution and subtransmission cables increased 5.6 and 8.8 per cent per year, respectively, well above to industry averages of 3.2 and 1.8 per cent. Overhead distribution lines increased 0.1 per cent per year (in line with the industry), while overhead subtransmission lines increased by 0.2 per cent (below the industry's 0.4 per cent). These four inputs accounted for 33.0 per cent of PCR's input cost share and contributed –0.60 percentage points to TFP change over the period.

Table 5.9.3 PCR's output and input percentage point contributions to average annual TFP change: various periods

Year	*2006 to 2024*	*2006 to 2012*	*2012 to 2024*	*2024*
Energy (GWh)	0.07%	0.12%	0.05%	0.20%
Ratcheted Max Demand	0.83%	1.85%	0.30%	-0.04%
Customer Numbers	0.35%	0.34%	0.36%	0.28%
Circuit Length	0.14%	0.14%	0.15%	0.11%
CMOS	-0.22%	-0.55%	-0.05%	2.15%
Opex	-0.77%	-1.33%	-0.48%	-1.29%
O/H Sub-transmission Lines	-0.01%	0.00%	-0.01%	0.01%
O/H Distribution Lines	-0.02%	-0.02%	-0.02%	-0.02%
U/G Sub-transmission Cables	-0.01%	-0.01%	-0.01%	0.00%
U/G Distribution Cables	-0.57%	-0.62%	-0.54%	-0.61%
Transformers	-0.51%	-0.54%	-0.49%	-0.71%
TFP Change	-0.70%	-0.62%	-0.74%	0.06%

As shown in Figure 5.9.2, the largest positive impact on PCR's TFP in 2024 was from CMOS, reflecting its 12.3 per cent *decrease* in that year and contributing 2.15 percentage points to TFP in 2024. In contrast, opex and transformers had the largest negative impact, contributing together –2.01 percentage points due to 3.7 per cent increase in opex and 2.4 per cent increase in transformers.

Figure 5.9.2 PCR's output and input percentage point contributions to TFP change, 2024



5.10 SA Power Networks (SAP)

In 2024, SA Power Networks (SAP) delivered 9,730 GWh to 945,709 customers over 90,576 circuit kilometres of lines and cables. SAP is the only energy distributor in the South Australia (SA).

5.10.1 SAP's DNSP productivity performance

SAP's total output, total input and TFP indexes are presented in Figure 5.10.1 and Table 5.10.1. Opex and capital PFP indexes are also presented in Table 5.10.1.

Over the 19-year period 2006 to 2024, the SAP's TFP *decreased* at an average annual rate of 1.7 per cent. While total output increased by an average annual rate of 0.6 per cent, total input use increased faster, at a rate of 2.3 per cent. SAP thus had slower 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 4.0 per cent and increased more slowly from 2012 to 2024 at an annual average rate of 1.5 per cent. Although the rate of output growth was also lower after 2012 (–0.1 per cent per year compared to an average rate of 2.0 per cent before 2012), the flattening of the input index led to a slightly slower decline in TFP after 2012. Whereas SAP's average annual TFP growth rate before 2012 was –1.9 per cent, from 2012 to 2024 it averaged –1.6 per cent. In 2024 SAP's TFP *decreased* 1.3 per cent.

Figure 5.10.1 SA DNSP output, input and total factor productivity indexes, 2006–2024

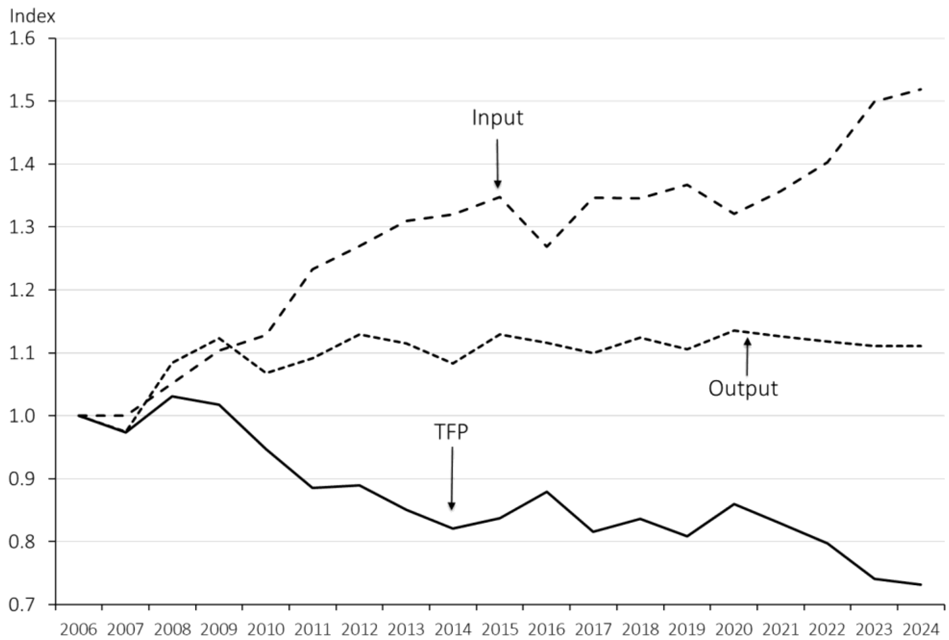


Table 5.10.1 SA DNSP output, input, TFP and PFP indexes, 2006–2024

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	1.001	0.974	1.049	0.940
2008	1.084	1.051	1.031	1.046	1.023
2009	1.124	1.104	1.018	0.991	1.031
2010	1.068	1.128	0.947	0.941	0.949
2011	1.092	1.233	0.886	0.772	0.951
2012	1.130	1.270	0.890	0.773	0.958
2013	1.115	1.310	0.851	0.725	0.930
2014	1.083	1.320	0.820	0.707	0.890
2015	1.129	1.348	0.838	0.710	0.917
2016	1.116	1.268	0.880	0.836	0.897
2017	1.099	1.347	0.816	0.716	0.876
2018	1.124	1.345	0.836	0.747	0.887
2019	1.105	1.367	0.809	0.716	0.863
2020	1.136	1.321	0.860	0.825	0.874
2021	1.126	1.357	0.830	0.802	0.838
2022	1.118	1.402	0.797	0.746	0.822
2023	1.110	1.499	0.741	0.637	0.808
2024	1.111	1.519	0.731	0.625	0.798
Growth Rate 2006–2024	0.6%	2.3%	-1.7%	-2.6%	-1.3%
Growth Rate 2006–2012	2.0%	4.0%	-1.9%	-4.3%	-0.7%
Growth Rate 2012–2024	-0.1%	1.5%	-1.6%	-1.8%	-1.5%
Growth Rate 2024	0.1%	1.3%	-1.3%	-1.9%	-1.3%

5.10.2 SAP's DNSP output and input quantity changes & contributions to TFP change

Table 5.10.2 presents the average growth rates of SAP's individual output and input quantity indexes, and the growth rates of individual input partial productivity indexes. Table 5.10.3 decomposes SAP's average TFP growth into the contributions of each output and input over the full 19-year period, the sub-periods before and after 2012, and for 2024. Figure 5.10.2 illustrates these contributions for 2024.

Table 5.10.2 SAP individual output, input and PFP growth rates

	2006-2024	*2006-2012*	*2012-2024*	*2023-2024*
Outputs:				
Energy (GWh)	-0.7%	0.1%	-1.0%	-0.8%
Ratcheted Max Demand (MVA)	0.8%	2.4%	0.0%	0.0%
Customer Numbers	1.1%	1.3%	0.9%	1.0%
Circuit Length (km)	0.4%	0.5%	0.3%	0.3%
CMOS	0.5%	-1.7%	1.7%	0.5%
Inputs:				
Real Opex ($'000 2006)	3.2%	6.3%	1.6%	2.0%
O/H Sub-tran. Lines (MVA-kms)	0.4%	0.5%	0.4%	-0.5%
O/H Distr. Lines (MVA-kms)	-0.1%	0.0%	-0.1%	-0.2%
U/G Sub-tran. Lines (MVA-kms)	1.6%	2.1%	1.4%	0.7%
U/G Dist. Lines (MVA-kms)	2.8%	3.3%	2.6%	1.9%
Transformers (MVA)	2.1%	3.6%	1.3%	2.0%
All Capital inputs	1.8%	2.8%	1.4%	1.3%
Partial productivity:				
Output / Real Opex	-2.6%	-4.3%	-1.8%	-1.9%
Output / OH Sub-tran. Lines	0.1%	1.5%	-0.5%	0.6%
Output / OH Distr. Lines	0.7%	2.1%	-0.1%	0.2%
Output / UG Sub-tran. Lines	-1.0%	-0.1%	-1.5%	-0.7%
Output / UG Distr. Lines	-2.2%	-1.2%	-2.7%	-1.9%
Output / Transformers	-1.5%	-1.5%	-1.5%	-2.0%
Output / Capital	-1.3%	-0.7%	-1.5%	-1.3%

Over 2006–2024, SAP's RMD increased at an average annual rate of 0.8 per cent per year (below the industry's rate of 1.1 per cent), circuit length increased by 0.4 per cent per year (similar to the industry's 0.3 per cent), and customer numbers increased by 1.1 per cent per year (similar to 1.3 per cent for the industry). These three outputs, which have the highest output weights, combined, account for 104.0 per cent of SAP's output cost share (see Appendix A, s.A3.3) and contributed 0.76 percentage points to SAP's TFP change over the period.[30]

[30] CMOS has a negative output cost share weight, and the sum of the weights across all outputs equals 100 per cent.

Energy delivered *decreased* at an average annual rate of 0.7 per cent (compared with a 0.1 per cent annual *decline* for the industry). It represented 12.6 per cent of SAP's output cost share and contributed –0.08 percentage points to SAP's TFP change over the 19-year period.

Turning to the input side, over the 2006 to 2024 period, opex increased at an average annual rate of 3.2 per cent (above the industry's average of 1.1 per cent). Opex is the largest input cost share (36.8 per cent, see Appendix A, s.A3.4) and contributed –1.14 percentage points to TFP change. By 2024, SAP's opex usage was 77.9 per cent higher than its 2006 level. Transformers increased 2.1 per cent per year (same as the industry's rate). It accounts for 34.1 per cent of input cost share and contributed –0.69 percentage points to SAP's TFP.

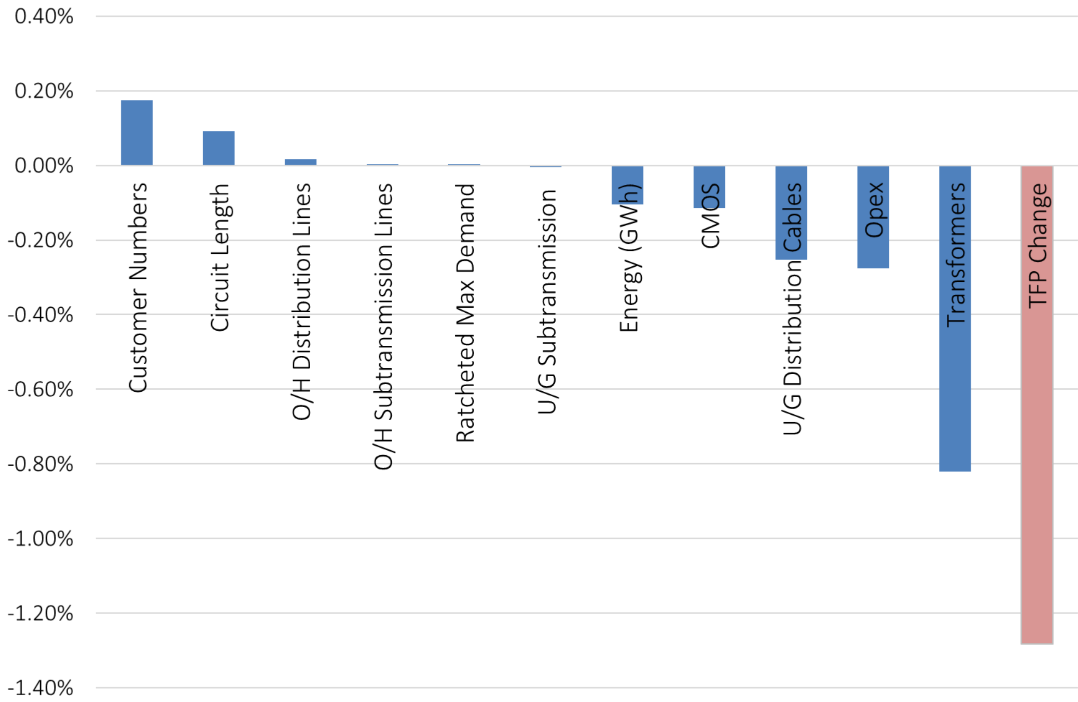
SAP's underground distribution and subtransmission cables increased 2.8 and 1.6 per cent per year, respectively, comparable to corresponding growth rates of 3.2 and 1.8 per cent for the industry. Overhead distribution lines *decreased* by 0.1 per cent per year (compared to an increase of 0.1 per cent for the industry), while overhead subtransmission lines increased by 0.4 per cent (same as the industry's). These four inputs accounted for 29.1 per cent of SAP's input cost share and contributed –0.50 percentage points to TFP change over the period.

Table 5.10.2 SAP output and input percentage point contributions to average annual TFP change: various periods

Year	*2006 to 2024*	*2006 to 2012*	*2012 to 2024*	*2024*
Energy (GWh)	-0.08%	0.01%	-0.13%	-0.10%
Ratcheted Max Demand	0.45%	1.36%	0.00%	0.00%
Customer Numbers	0.19%	0.25%	0.17%	0.18%
Circuit Length	0.11%	0.17%	0.08%	0.09%
CMOS	-0.09%	0.24%	-0.26%	-0.11%
Opex	-1.14%	-2.14%	-0.63%	-0.28%
O/H Subtransmission Lines	-0.01%	-0.01%	-0.01%	0.00%
O/H Distribution Lines	0.01%	0.01%	0.01%	0.02%
U/G Subtransmission Cables	0.00%	-0.01%	0.00%	0.00%
U/G Distribution Cables	-0.49%	-0.69%	-0.39%	-0.25%
Transformers	-0.69%	-1.14%	-0.46%	-0.82%
TFP Change	-1.74%	-1.95%	-1.63%	-1.28%

As shown in Figure 5.10.2, the largest positive impact on SAP's TFP in 2024 was the customer numbers output, which increased by 1.0 per cent in that year and contributed 0.18 percentage points to TFP growth. In contrast, transformers had the largest negative impact, contributing –0.82 percentage points due to a 2.0 per cent increase in the same year.

Figure 5.10.2 SAP output and input percentage point contributions to TFP change, 2024



5.11 AusNet Services Distribution (AND)

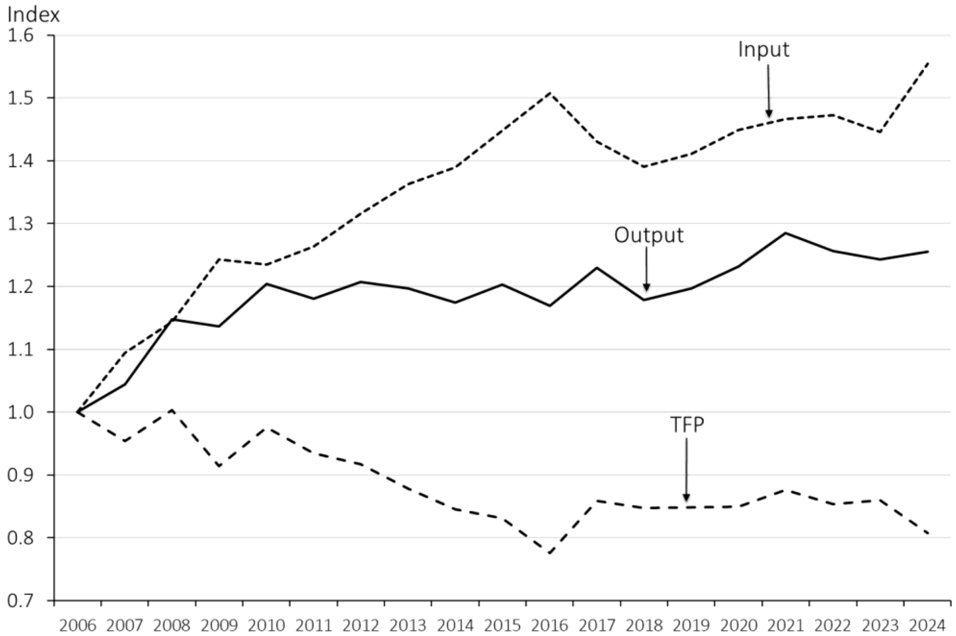
In 2024, AND delivered 7,599 GWh to 823,455 customers over 46,489 circuit kilometres of lines and cables. AND distributes electricity to eastern Victoria (including Melbourne's outer northern and eastern suburbs) across an area of 80,000 square kilometres.

5.11.1 AND's productivity performance

AND's total output, total input and TFP indexes are presented in Figure 5.11.1 and Table 5.11.1. Opex and capital PFP indexes are also presented in Table 5.11.1.

Over the 19-year period 2006 to 2023, 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 19-year period.

Figure 5.11.1 AND's output, input and TFP indexes, 2006–2024



AND's total output increased over the 19-year period at an average annual rate of 1.3 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 3.1 per year) than in the period from 2012 to 2024 (averaging 0.3 per cent per year).

AND's average annual rate of increase in input use of 2.5 per cent from 2006 to 2024 was higher than the rate of increase in total input use for the industry (1.4 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 1.4 per cent per year). By 2024, the input index was 55.4 per cent higher than in 2006.

After an increase in the period from 2006 to 2012 (at an average rate of 0.5 per cent per year), capital PFP decreased in the period after 2012 (averaging an annual rate of change of –1.0 per cent). On average over the full 19-year period, the average rate of change in capital PFP was –0.5 per cent per annum. Opex PFP declined over the 19-year period, the average rate of change being –2.2 per cent per annum. This contrasts with the industry overall, for which opex PFP *decreased* at an average rate of 0.1 per cent per year over the same period.

Table 5.11.1 AND's output, input, TFP and PFP indexes, 2006–2024

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	1.044	1.094	0.955	0.889	1.004
2008	1.148	1.143	1.004	0.897	1.089
2009	1.137	1.244	0.914	0.786	1.021
2010	1.204	1.234	0.975	0.854	1.075
2011	1.181	1.263	0.935	0.822	1.027
2012	1.208	1.316	0.917	0.782	1.031
2013	1.197	1.363	0.878	0.733	1.004
2014	1.175	1.390	0.845	0.702	0.970
2015	1.203	1.447	0.831	0.670	0.977
2016	1.169	1.508	0.776	0.608	0.933
2017	1.230	1.431	0.859	0.731	0.968
2018	1.178	1.391	0.847	0.771	0.910
2019	1.197	1.411	0.848	0.760	0.920
2020	1.232	1.449	0.850	0.749	0.932
2021	1.285	1.466	0.877	0.768	0.965
2022	1.257	1.473	0.853	0.764	0.926
2023	1.243	1.446	0.860	0.787	0.919
2024	1.255	1.554	0.807	0.675	0.919
Growth Rate 2006–2024	1.3%	2.5%	-1.2%	-2.2%	-0.5%
Growth Rate 2006–2012	3.1%	4.6%	-1.4%	-4.1%	0.5%
Growth Rate 2012–2024	0.3%	1.4%	-1.1%	-1.3%	-1.0%
Growth Rate 2024	0.9%	7.2%	-6.3%	-15.4%	0.0%

5.11.2 AND's output and input quantity changes & contributions to TFP change

Table 5.11.2 presents the average growth rates of AND's individual output quantity indexes, while Table 5.11.3 shows those for inputs. Table 5.11.4 decomposes AND's average TFP growth into the contributions of each output and input over the full 19-year period, the sub-periods before and after 2012, and for 2024. Figure 5.11.2 illustrates these contributions for 2024.

Over 2006–2024, AND's RMD increased at an average annual rate of 1.5 per cent per year (above the industry's rate of 1.1 per cent), circuit length increased by 0.6 per cent per year (above to the industry's rate of 0.3 per cent), and customer numbers increased by 1.8 per cent per year (above to 1.3 per cent for the industry). These three outputs, which have the highest output weights, combined, account for 102.4 per cent of AND's output cost share (see Appendix A, s.A3.3) and contributed 1.37 percentage points to AND's TFP change over the period.[31]

[31] CMOS has a negative output cost share weight, and the sum of the weights across all outputs equals 100 per cent.

Energy delivered increase modestly at an average annual rate of 0.2 per cent (compared with a 0.1 per cent annual *decline* for the industry). It represented 12.3 per cent of AND's output cost share and contributed 0.02 percentage points to AND's TFP change over the 19-year period.

Table 5.11.2 AND individual output, input and PFP growth rates

	2006-2024	*2006-2012*	*2012-2024*	*2023-2024*
Outputs:				
Energy (GWh)	0.2%	0.4%	0.0%	-0.4%
Ratcheted Max Demand (MVA)	1.5%	3.0%	0.8%	0.0%
Customer Numbers	1.8%	1.7%	1.8%	1.6%
Circuit Length (km)	0.6%	0.9%	0.5%	0.4%
CMOS	0.8%	-5.2%	4.0%	-4.0%
Inputs:				
Real Opex ($'000 2006)	3.5%	7.2%	1.6%	16.4%
O/H Sub-tran. Lines (MVA-kms)	0.6%	1.2%	0.2%	-5.2%
O/H Distr. Lines (MVA-kms)	-0.1%	0.4%	-0.4%	0.1%
U/G Sub-tran. Lines (MVA-kms)	6.0%	2.3%	8.0%	-5.9%
U/G Dist. Lines (MVA-kms)	4.7%	5.3%	4.5%	3.1%
Transformers (MVA)	2.4%	3.7%	1.7%	1.5%
All Capital inputs	1.8%	2.6%	1.3%	0.9%
Partial productivity:				
Output / Real Opex	-2.2%	-4.1%	-1.3%	-15.4%
Output / OH Sub-tran. Lines	0.7%	1.9%	0.1%	6.1%
Output / OH Distr. Lines	1.4%	2.8%	0.7%	0.9%
Output / UG Sub-tran. Lines	-4.7%	0.9%	-7.7%	6.9%
Output / UG Distr. Lines	-3.4%	-2.1%	-4.1%	-2.2%
Output / Transformers	-1.1%	-0.6%	-1.3%	-0.6%
Output / Capital	-0.5%	0.5%	-1.0%	0.0%

Turning to the input side, over the 2006 to 2024 period, opex increased at an average annual rate of 3.5 per cent, above the industry's 1.1 per cent. Opex is the largest input cost share (42.4 per cent, see Appendix A, s.A3.4) and contributed –1.48 percentage points to AND's TFP change. By 2024, AND's opex usage was 86.0 per cent higher than its 2006 level. Transformers increased 2.4 per cent per year (above to the industry's rate of 2.1 per cent). It accounts for 20.5 per cent of input cost share and contributed –0.51 percentage points to AND's TFP.

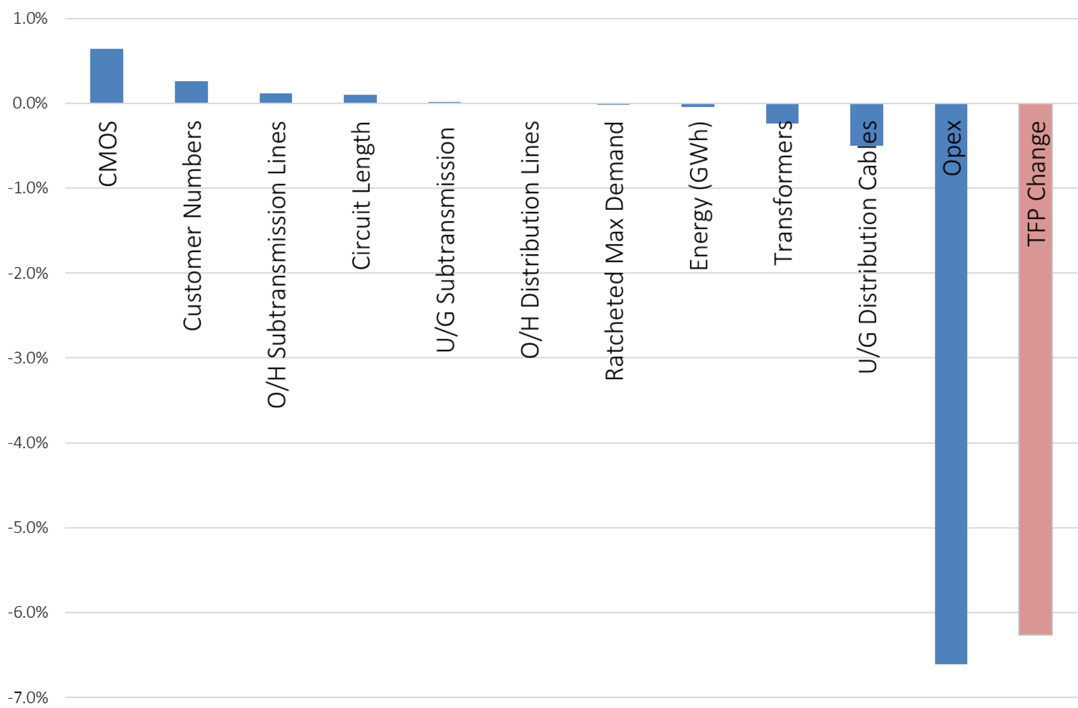
AND's underground distribution and subtransmission cables increased 4.7 and 6.0 per cent per year, respectively, above to industry's annual rates of 3.2 and 1.8 per cent. Overhead distribution lines *decreased* by 0.1 per cent per year (in contrast to industry that increased by 0.1 per cent), while overhead subtransmission lines increased by 0.6 per cent (similar to industry increase of 0.4 per cent annually). These four inputs accounted for 37.1 per cent of AND's input cost share and contributed –0.53 percentage points to TFP change over the period.

Table 5.11.3 AND's output and input percentage point contributions to average annual TFP change: various periods

Year	*2006 to 2024*	*2006 to 2012*	*2012 to 2024*	*2024*
Energy (GWh)	0.02%	0.06%	0.00%	-0.05%
Ratcheted Max Demand	0.86%	1.73%	0.41%	-0.01%
Customer Numbers	0.31%	0.31%	0.31%	0.26%
Circuit Length	0.20%	0.27%	0.16%	0.10%
CMOS	-0.10%	0.78%	-0.55%	0.64%
Opex	-1.48%	-3.06%	-0.65%	-6.61%
O/H Subtransmission Lines	-0.01%	-0.03%	-0.01%	0.12%
O/H Distribution Lines	0.03%	-0.08%	0.09%	0.00%
U/G Subtransmission Cables	-0.01%	-0.01%	-0.01%	0.02%
U/G Distribution Cables	-0.54%	-0.63%	-0.49%	-0.50%
Transformers	-0.51%	-0.77%	-0.37%	-0.24%
TFP Change	-1.22%	-1.44%	-1.11%	-6.26%

As shown in Figure 5.11.2, the components with a positive impact on AND's TFP in 2024 was CMOS, reflecting its 4.0 per cent *decrease* in that year and contributing 0.64 percentage points to TFP in 2024. In contrast, opex had the largest negative impact, contributing –6.61 percentage points due to a 16.4 per cent increase in the same year.

Figure 5.11.2 AND's output and input percentage point contributions to TFP change, 2024



5.12 TasNetworks Distribution (TND)

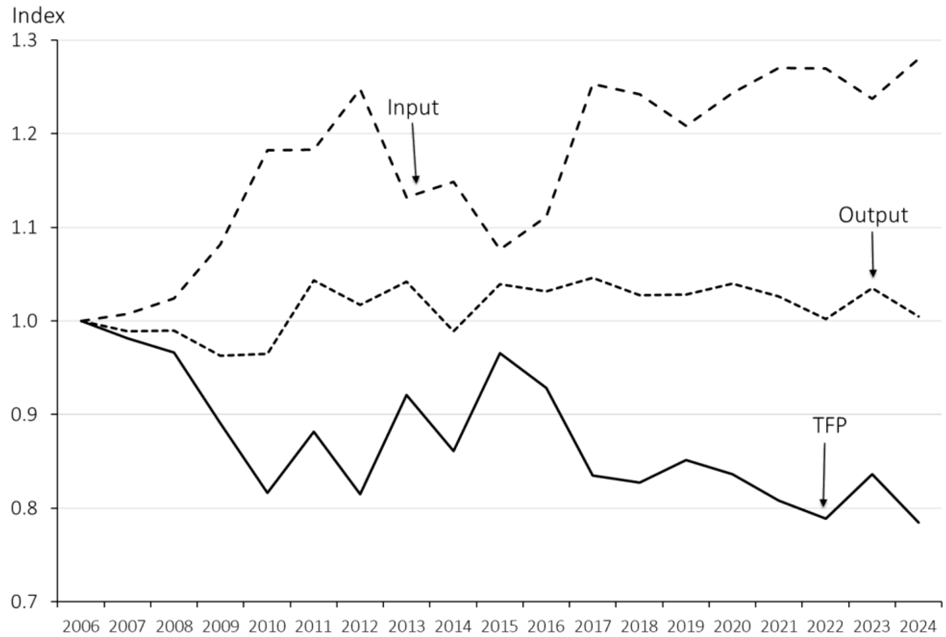
In 2024, TasNetworks Distribution (TND) it delivered 4,566 GWh to 307,118 customers over 22,943 circuit kilometres of lines and cables.[32] TND is the only energy distributor in the Tasmania (TAS).

5.12.1 TND's DNSP productivity performance

Tasmania's total output, total input and TFP indexes are presented in Table 5.12.1 and Figure 5.12.1. Opex and capital PFP indexes are also presented in Table 5.12.1.

Over the 19-year period 2006 to 2024, the Tasmanian DNSP's TFP *decreased* at an average annual rate of 1.3 per cent. Total output was unchanged between 2006 and 2024. Total input use, on the other hand, increased at an average annual rate of 1.4 per cent over the 19-year period.

Figure 5.12.1 TAS DNSP output, input and TFP indexes, 2006–2024



Input use increased at a faster rate of 3.7 per cent between 2006 and 2012 and at a rate of 0.2 per cent per year from 2012 to 2024. Output increased at an average annual rate of 0.3 per cent from 2006 to 2012, and *decreased* by 0.1 per cent per annum thereafter. The net effect of

[32] TasNetworks has a more 'downstream' boundary between transmission and distribution than is typical. Consequently, TasNetworks Distribution has far less subtransmission capacity than other Australian DNSPs. While this gives it an advantage in terms of a lower quantity of sub–transmission 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.

these trends was that TFP *decreased* at an average rate of 3.4 per cent up to 2012 and *decreased* at an average rate of 0.3 per cent from 2012 to 2024. In 2024, TND's TFP *decreased* significantly by 6.3 per cent, driven by an increase in 3.4 per cent in the input index and a *decrease* of 3.0 per cent in output.

Table 5.12.1 TND DNSP output, input, TFP and PFP indexes, 2006–2024

Year	*Output Index*	*Input Index*	*TFP Index*	*PFP Index*	
				Opex	*Capital*
2006	1.000	1.000	1.000	1.000	1.000
2007	0.989	1.007	0.981	0.991	0.976
2008	0.990	1.024	0.966	0.982	0.957
2009	0.963	1.082	0.890	0.857	0.913
2010	0.965	1.182	0.816	0.724	0.886
2011	1.043	1.183	0.882	0.810	0.930
2012	1.017	1.248	0.815	0.710	0.893
2013	1.042	1.132	0.921	0.940	0.910
2014	0.989	1.148	0.861	0.878	0.850
2015	1.039	1.077	0.966	1.125	0.886
2016	1.032	1.112	0.928	1.022	0.874
2017	1.046	1.253	0.835	0.783	0.875
2018	1.027	1.242	0.827	0.796	0.851
2019	1.028	1.208	0.851	0.869	0.839
2020	1.040	1.243	0.836	0.829	0.842
2021	1.026	1.270	0.808	0.785	0.826
2022	1.002	1.270	0.789	0.774	0.801
2023	1.035	1.237	0.836	0.863	0.816
2024	1.005	1.280	0.785	0.797	0.777
Growth Rate 2006–2024	0.0%	1.4%	-1.3%	-1.3%	-1.4%
Growth Rate 2006–2012	0.3%	3.7%	-3.4%	-5.7%	-1.9%
Growth Rate 2012–2024	-0.1%	0.2%	-0.3%	1.0%	-1.2%
Growth Rate 2024	-3.0%	3.4%	-6.3%	-8.0%	-5.0%

5.12.2 TND's DNSP output and input quantity changes & contributions to TFP change

Table 5.12.2 presents the average growth rates of TND's individual output and input quantity indexes, and of partial productivity indexes for individual inputs. Table 5.12.3 decomposes TND's average TFP growth into the contributions of each output and input over the full 19-year period, the sub-periods before and after 2012, and for 2024. Figure 5.10.2 illustrates these contributions for 2024.

Over 2006–2024, TND's RMD increased at an average annual rate of 0.5 per cent per year (below the industry's growth rate of 1.1 per cent), circuit length increased by 0.4 per cent per year (similar to the industry's rate of 0.3 per cent), and customer numbers increased by 1.1 per cent per year (similar to 1.3 per cent for the industry). These three outputs, which have the highest output weights, combined, account for 106.2 per cent of TND's output cost share (see

Appendix A, s.A3.3) and contributed 0.61 percentage points to TND's TFP change over the period.[33]

Energy delivered increase modestly at an average annual rate of 0.1 per cent (compared with a 0.1 per cent annual *decline* for the industry). It represented 12.9 per cent of TND's output cost share and contributed 0.02 percentage points to TND's TFP change over the 19-year period.

Table 5.12.2 TND individual output, input and PFP growth rates

	2006-2024	*2006-2012*	*2012-2024*	*2023-2024*
Outputs:				
Energy (GWh)	0.1%	-0.5%	0.5%	-1.4%
Ratcheted Max Demand (MVA)	0.5%	1.4%	0.0%	0.0%
Customer Numbers	1.1%	1.8%	0.8%	0.9%
Circuit Length (km)	0.4%	0.8%	0.3%	1.0%
CMOS	2.9%	5.0%	1.9%	14.8%
Inputs:				
Real Opex ($'000 2006)	1.3%	6.0%	-1.1%	5.0%
O/H Sub-tran. Lines (MVA-kms)	-0.1%	0.1%	-0.1%	1.6%
O/H Distr. Lines (MVA-kms)	0.6%	0.6%	0.7%	1.3%
U/G Sub-tran. Lines (MVA-kms)	3.4%	9.2%	0.5%	0.3%
U/G Dist. Lines (MVA-kms)	1.5%	1.6%	1.4%	4.2%
Transformers (MVA)	2.3%	4.0%	1.4%	2.1%
All Capital inputs	1.4%	2.2%	1.1%	2.0%
Partial productivity:				
Output / Real Opex	-1.3%	-5.7%	1.0%	-8.0%
Output / OH Sub-tran. Lines	0.1%	0.2%	0.0%	-4.6%
Output / OH Distr. Lines	-0.6%	-0.3%	-0.8%	-4.3%
Output / UG Sub-tran. Lines	-3.4%	-9.0%	-0.6%	-3.3%
Output / UG Distr. Lines	-1.5%	-1.3%	-1.5%	-7.1%
Output / Transformers	-2.3%	-3.7%	-1.6%	-5.0%
Output / Capital	-1.4%	-1.9%	-1.2%	-5.0%

Turning to the input side, over the 2006 to 2024 period, opex increased at an average annual rate of 1.3 per cent (similar to the industry's average of 1.1 per cent). Opex is the largest input cost share (40.3 per cent, see Appendix A, s.A3.4) and contributed –0.51 percentage points to TFP change. By 2024, TND's opex usage was 26.0 per cent higher than its 2006 level. Transformers increased 2.3 per cent per year (similar to the industry's rate of 2.1 per cent), accounted for 22.1 per cent of input cost share, and contributed –0.52 percentage points to TND's TFP.

[33] CMOS has a negative output cost share weight, and the sum of the weights across all outputs equals 100 per cent.

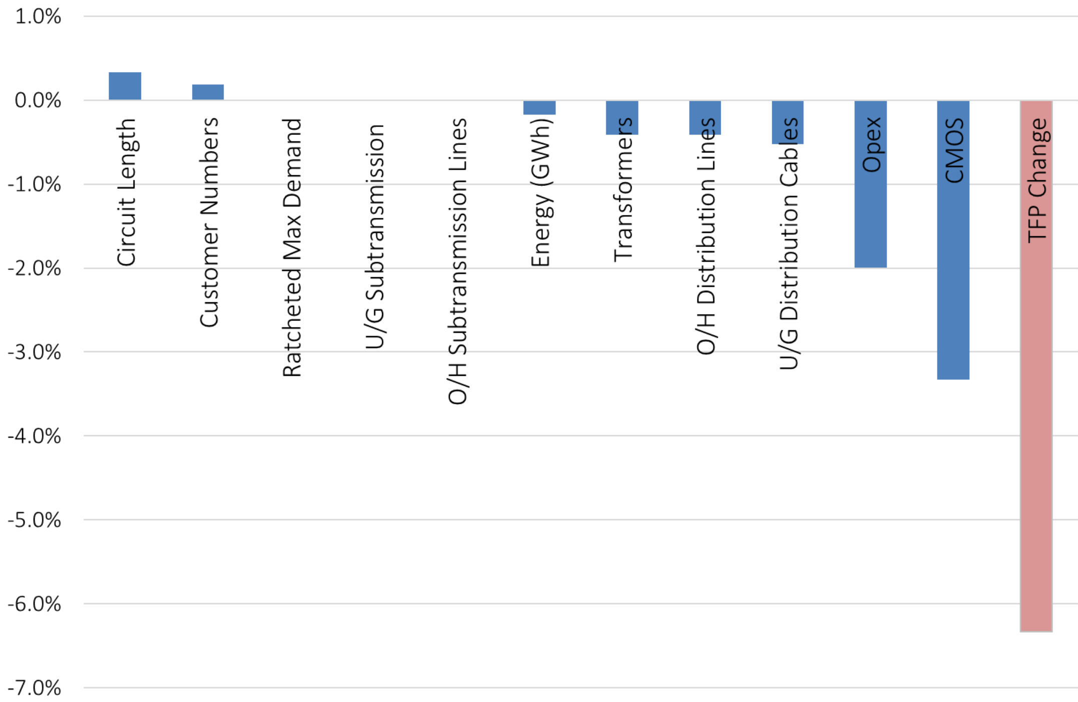
TND's underground distribution and subtransmission cables increased 1.5 and 3.4 per cent per year, respectively, compared to industry growth averages of 3.2 and 1.8 per cent. Overhead distribution lines increased by 0.6 per cent per year (above to industry that increased by 0.1 per cent), while overhead subtransmission lines *decreased* by 0.1 per cent (in contrast to industry increase of 0.4 per cent annually). These four inputs accounted for 37.6 per cent of TND's input cost share and contributed –0.34 percentage points to TFP change over the period.

Table 5.12.3 TND output and input percentage point contributions to average annual TFP change: various periods

Year	*2006 to 2024*	*2006 to 2012*	*2012 to 2024*	*2024*
Energy (GWh)	0.02%	-0.06%	0.06%	-0.18%
Ratcheted Max Demand	0.26%	0.79%	0.00%	0.00%
Customer Numbers	0.21%	0.32%	0.15%	0.19%
Circuit Length	0.14%	0.24%	0.08%	0.33%
CMOS	-0.60%	-1.00%	-0.40%	-3.33%
Opex	-0.51%	-2.36%	0.42%	-1.99%
O/H Subtransmission Lines	0.00%	0.00%	0.00%	-0.01%
O/H Distribution Lines	-0.17%	-0.14%	-0.18%	-0.42%
U/G Sub-transmission Cables	-0.01%	-0.03%	0.00%	0.00%
U/G Distribution Cables	-0.16%	-0.18%	-0.15%	-0.52%
Transformers	-0.52%	-0.98%	-0.29%	-0.41%
TFP Change	-1.34%	-3.40%	-0.32%	-6.33%

As shown in Figure 5.12.2, the outputs with a positive impact on AND's TFP in 2024 were circuit length and customer numbers, with increases of 1.0 and 0.9 per cent, respectively. Together, they contributed 0.52 percentage points to TFP in 2024. In contrast, CMOS had the largest negative impact, contributing –3.33 percentage points due to its 14.8 per cent increase. This was followed by opex, which increased by 5.0 per cent and contributed –1.99 percentage points to TFP growth.

Figure 5.12.2 TND output and input percentage point contributions to TFP change, 2024



5.13 United Energy (UED)

In 2023, UED delivered 7,507 GWh to 717,973 customers over 13,531 circuit kilometres of lines and cables. UED distributes electricity across east and south–east Melbourne and the Mornington Peninsula.

5.13.1 UED's productivity performance

UED's total output, total input and TFP indexes are presented in Figure 5.13.1 and Table 5.13.1. Opex and capital PFP indexes are also presented in Table 5.13.1.

Over the 19-year period 2006 to 2024, UED's TFP *decreased* at an average annual rate of 0.1 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 1.7 per cent per year, on average, from 2006 to 2012. It increased by an average of 0.7 per cent per year from 2012 to 2024.

UED's total output increased over the period from 2006 to 2024 at an average annual rate of 1.0 per cent, the same than the industry's rate. UED's average annual rate of increase in input use of 1.1 per cent was lower than the rate of increase in total input use for the industry (1.4 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 2024 (averaging 0.1 per cent per year).

Figure 5.13.1 UED's output, input and TFP indexes, 2006–2024

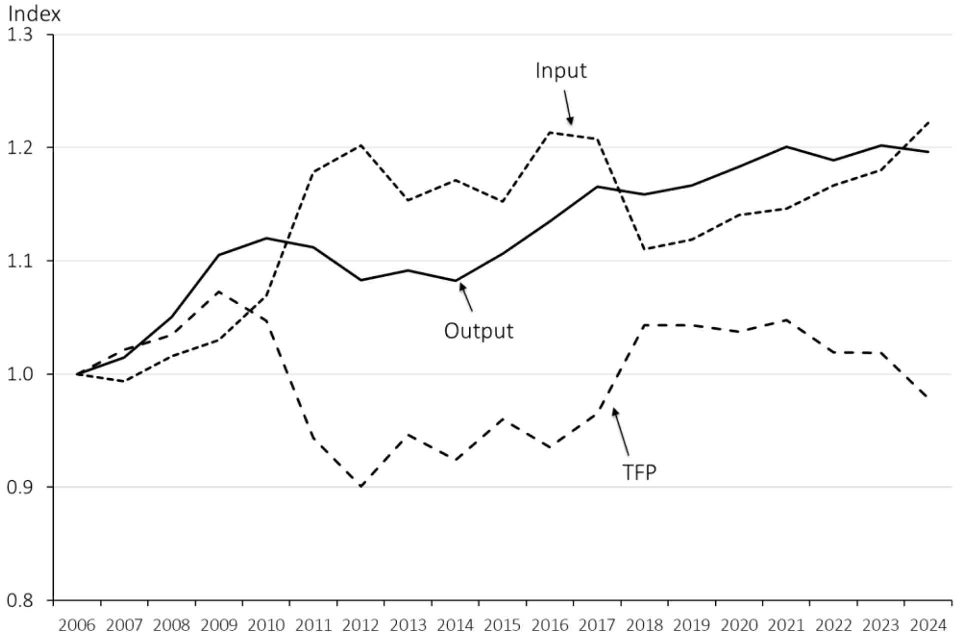


Table 5.13.1 UED's output, input, TFP and PFP indexes, 2006–2024

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	1.015	0.993	1.021	1.076	0.987
2008	1.050	1.016	1.034	1.110	0.988
2009	1.105	1.030	1.072	1.148	1.026
2010	1.120	1.069	1.047	1.114	1.006
2011	1.112	1.179	0.944	0.903	0.978
2012	1.083	1.202	0.901	0.874	0.922
2013	1.091	1.153	0.946	0.988	0.920
2014	1.082	1.171	0.924	0.958	0.903
2015	1.106	1.152	0.960	1.032	0.916
2016	1.135	1.213	0.935	0.916	0.950
2017	1.166	1.208	0.965	0.999	0.945
2018	1.158	1.110	1.043	1.252	0.933
2019	1.167	1.119	1.043	1.257	0.930
2020	1.183	1.140	1.037	1.216	0.937
2021	1.201	1.146	1.048	1.240	0.938
2022	1.189	1.166	1.019	1.191	0.919
2023	1.202	1.180	1.018	1.193	0.920
2024	1.196	1.222	0.979	1.103	0.909
Growth Rate 2006–2024	1.0%	1.1%	-0.1%	0.6%	-0.5%
Growth Rate 2006–2012	1.3%	3.1%	-1.7%	-2.3%	-1.3%
Growth Rate 2012–2024	0.9%	0.1%	0.7%	2.0%	-0.1%
Growth Rate 2024	-0.5%	3.5%	-3.9%	-7.9%	-1.3%

Capital PFP *declined* on average over the 19-year period by 0.5 per cent per annum. This decline was concentrated in the period from 2006 to 2012, with an average rate of –1.3 per cent per annum, whereas after 2012 its average rate of change was –0.1 per cent per annum. Opex PFP increased over the 19-year period, by 0.6 per cent per annum. In the period from 2006 to 2012, the average rate of change of opex PFP was –2.3 per cent per annum, and in the period after 2012, it was 2.0 per cent per annum.

5.13.2 UED's output and input quantity changes & contributions to TFP change

Table 5.13.2 presents the average growth rates of UED's individual output and input quantity indexes, and the partial productivity growth rates by individual input. Table 5.13.3 decomposes TND's average TFP growth into the contributions of each output and input over the full 19-year period, the sub-periods before and after 2012, and for 2024. Figure 5.13.2 illustrates these contributions for 2024.

Table 5.13.2 UED individual output, input and PFP growth rates

	2006-2024	*2006-2012*	*2012-2024*	*2023-2024*
Outputs:				
Energy (GWh)	-0.3%	0.4%	-0.7%	-1.3%
Ratcheted Max Demand (MVA)	1.2%	3.6%	0.0%	0.0%
Customer Numbers	0.9%	0.9%	0.9%	0.3%
Circuit Length (km)	0.5%	0.6%	0.5%	0.3%
CMOS	-2.0%	8.3%	-7.4%	8.2%
Inputs:				
Real Opex ($'000 2006)	0.5%	3.6%	-1.2%	7.4%
O/H Sub-tran. Lines (MVA-kms)	1.3%	2.8%	0.4%	0.6%
O/H Distr. Lines (MVA-kms)	0.3%	0.7%	0.1%	-0.2%
U/G Sub-tran. Lines (MVA-kms)	0.9%	7.7%	-2.7%	0.0%
U/G Dist. Lines (MVA-kms)	2.8%	3.4%	2.5%	2.3%
Transformers (MVA)	2.3%	3.4%	1.8%	1.2%
All Capital inputs	1.6%	2.7%	1.0%	0.8%
Partial productivity:				
Output / Real Opex	0.6%	-2.3%	2.0%	-7.9%
Output / OH Sub-tran. Lines	-0.2%	-1.5%	0.4%	-1.1%
Output / OH Distr. Lines	0.7%	0.6%	0.8%	-0.3%
Output / UG Sub-tran. Lines	0.1%	-6.4%	3.6%	-0.5%
Output / UG Distr. Lines	-1.8%	-2.1%	-1.6%	-2.8%
Output / Transformers	-1.3%	-2.1%	-0.9%	-1.7%
Output / Capital	-0.5%	-1.3%	-0.1%	-1.3%

Over 2006–2024, UED's RMD increased at an average annual rate of 1.2 per cent per year (similar to the industry rate of 1.1 per cent), circuit length increased 0.5 per cent per year (similar to the industry's 0.3 per cent), and customer numbers increased by 0.9 per cent per year (below to 1.3 per cent for the industry). These three outputs, which have the highest output weights, combined, account for 96.7 per cent of UED's output cost share (see Appendix A, s.A3.3) and contributed 0.93 percentage points to UED's TFP change over the period.

Energy delivered *decreased* modestly at an average annual rate of 0.3 per cent (compared with a 0.1 per cent annual decline for the industry). It represented 11.7 per cent of UED's output cost share and contributed –0.04 percentage points to UED's TFP change over the 19-year period. UED's CMOS *decreased* at an average annual rate of 2.0 per cent, compared to a 0.1 per cent *decrease* for the industry. Given its negative output weight (–8.42 per cent), this decrease had a positive effect on UED's TFP of 0.12 percentage points over the 19-years period.

Turning to the input side, over the 19-year period, opex increased at an average annual rate of 0.5 per cent (below the industry average of 1.1 per cent). Opex is the largest input cost share (at 39.0 per cent, see Appendix A, s.A3.4) and contributed –0.18 percentage points to UED's TFP change over the period. By 2024, UED's opex usage was 8.4 per cent higher than its 2006 level. Transformers increased 2.3 per cent per year (similar to the industry's rate of 2.1 per cent), accounted for 21.3 per cent of input cost share, and contributed –0.55 percentage points to UED's TFP.

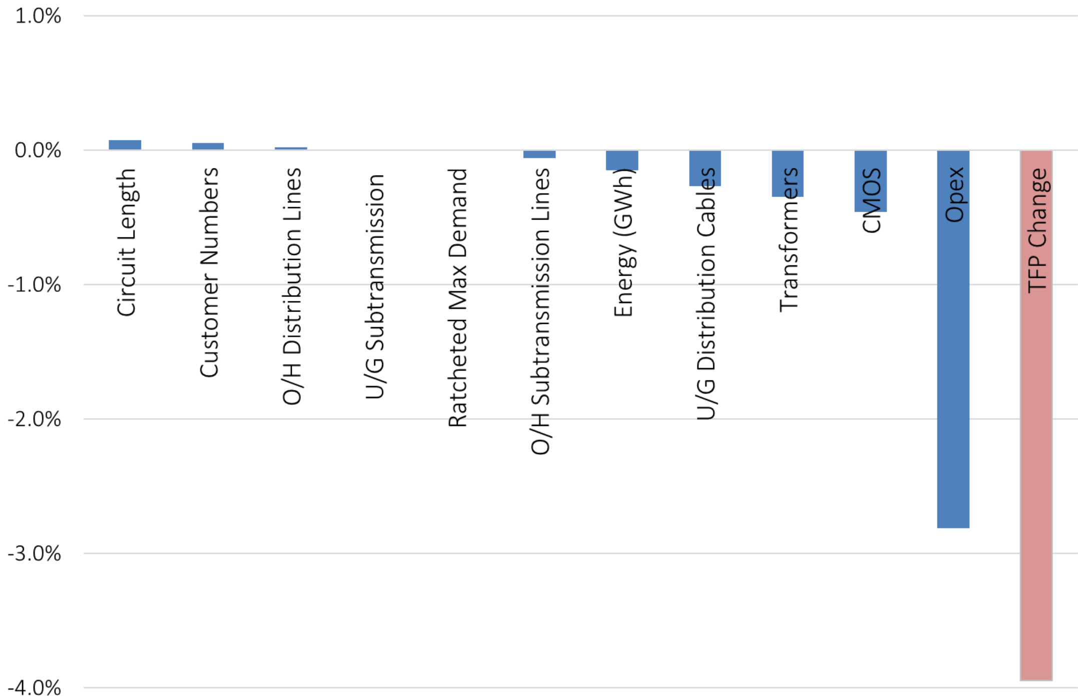
UED's underground distribution and subtransmission cables increased by 2.8 and 0.9 per cent per year respectively, below the industry averages of 3.2 and 1.8 per cent. Overhead distribution lines increased by 0.3 per cent per year (the industry increased by 0.1 per cent), while overhead subtransmission lines increased 1.3 per cent (above the industry increase of 0.4 per cent annually). Combined, these four inputs accounted for 39.7 per cent of UED's input cost share and contributed –0.42 percentage points to TFP change over the period.

Table 5.13.3 UED's output and input percentage point contributions to average annual TFP change: various points

Year	*2006 to 2024*	*2006 to 2012*	*2012 to 2024*	*2024*
Energy (GWh)	-0.04%	0.05%	-0.08%	-0.15%
Ratcheted Max Demand	0.64%	1.86%	0.01%	0.00%
Customer Numbers	0.15%	0.15%	0.15%	0.05%
Circuit Length	0.14%	0.16%	0.13%	0.08%
CMOS	0.12%	-0.90%	0.66%	-0.46%
Opex	-0.18%	-1.44%	0.48%	-2.81%
O/H Subtransmission Lines	-0.08%	-0.17%	-0.03%	-0.06%
O/H Distribution Lines	-0.07%	-0.15%	-0.02%	0.02%
U/G Subtransmission Cables	-0.01%	-0.14%	0.05%	0.00%
U/G Distribution Cables	-0.26%	-0.30%	-0.23%	-0.27%
Transformers	-0.55%	-0.86%	-0.39%	-0.35%
TFP Change	-0.12%	-1.74%	0.72%	-3.95%

As shown in Figure 5.13.2, circuit length and customer numbers output had a positive impact on UED's TFP in 2024, with both increasing by 0.3 per cent. Together, they contributed 0.13 percentage points to TFP in 2024. In contrast, opex had the largest negative impact, contributing –2.81 percentage points due to its 7.4 per cent increase.

Figure 5.13.2 UED's output and input percentage point contributions to TFP change, 2024



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 comparing between DNSPs, the data is pooled as panel data and the index is applied across the full sample of 234 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 108 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;[34] i denotes individual outputs; j denotes individual inputs; and

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

[34] 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;[35]
- 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.[36] 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:

[35] 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.

[36] 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.

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

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

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

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 input 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: $g_t^Y = \ln Y_t - \ln Y_{t-1}$.[37] 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 (2020 Appendix C) also included, as supplementary information, trend measures of annual growth

[37] 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.[38] This report also presents regression–based trend estimates for TFP indexes in Appendix C.

A2 Output and input contributions to TFP change

Analysis of contributions to TFP change of the individual outputs and inputs 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

[38] 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 (2020 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 (2020) and updated by Quantonomics (2025) 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 and Quantonomics 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 (ie, the cost imposed on consumers) as measured by the Values of Customer Reliability (VCR) published by the AER (2019; 2019). 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 recalibrated 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. The values of the shares of revenue, as shown in Table A.1, are exclusively utilized in Section 1.3 to explain the transition from shares of gross revenue—derived from the Leontief cost function discussed in section A3.1— to shares of revenue. Industry output weights mentioned in the remaining sections are derived from the last column of Table A.2.

Table A.1 Output cost–based weights (industry average 2006 to 2024*)

Output	*Shares of gross revenue (%)*	*Shares of revenue (%)*
Energy throughput	10.79[(a)]	12.27
Ratcheted max. demand	47.83[(a)]	54.36
Customer numbers	15.23[(a)]	17.31
Circuit length	26.15[(a)]	29.72
CMOS	–11.62	–13.67
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.

A3.3 Output Weights by DNSP and for the Aggregated Industry

The average output weights for each DNSP and for the aggregated industry are shown in Table A.2. The output cost share weights for the aggregated industry shown in the last column of Table A.2 are slightly different than the output cost share weights shown in Table A.1, derived by averaging across all observations. This is because the value (or customer cost) per minute of CMOS differs substantially between DNSPs and the industry average shares shown in Table A.2 are based on the weighted average value of CMOS, rather than the simple average implied in Table A.1.

Table A.2 Output cost share weights by DNSP (%, average 2006 to 2024)

Output	*EVO*	*AGD*	*CIT*	*END*	*ENX*	*ERG*	*ESS*
Energy throughput	11.25	11.91	11.24	12.28	11.98	13.75	13.15
Ratcheted max. demand	49.85	52.79	49.80	54.41	53.10	60.91	58.27
Customer numbers	15.87	16.81	15.86	17.32	16.91	19.40	18.55
Circuit length	27.26	28.86	27.23	29.75	29.04	33.31	31.86
CMOS	-4.23	-10.38	-4.12	-13.76	-11.03	-27.36	-21.83
Total	100	100	100	100	100	100	100

Output	*JEN*	*PCR*	*SAP*	*AND*	*TND*	*UED*	*Industry**
Energy throughput	11.62	12.78	12.58	12.39	12.85	11.70	12.43
Ratcheted max. demand	51.48	56.64	55.75	54.92	56.95	51.86	55.08
Customer numbers	16.39	18.04	17.75	17.49	18.14	16.51	17.55
Circuit length	28.15	30.97	30.48	30.03	31.14	28.35	30.12
CMOS	-7.64	-18.42	-16.56	-14.83	-19.08	-8.42	-15.18
Total	100	100	100	100	100	100	100

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

A3.4 Input weights & annual user cost of capital

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 – ie, 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; 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 2024)

Input	*EVO*	*AGD*	*CIT*	*END*	*ENX*	*ERG*	*ESS*
Real opex	45.09	36.51	37.75	43.53	43.33	45.29	47.92
O/H Sub–trans. lines	3.03	3.93	0.49	3.82	3.19	8.16	6.04
O/H Distribution lines	10.87	6.35	6.02	9.01	11.12	18.88	17.92
U/G Sub–trans. cables	0.05	6.04	5.99	1.72	4.22	0.39	0.17
U/G Distribution cables	16.44	14.61	30.45	15.14	10.70	2.86	3.23
Transformers	24.52	32.57	19.30	26.78	27.44	24.42	24.73
Total	100	100	100	100	100	100	100

Input	*JEN*	*PCR*	*SAP*	*AND*	*TND*	*UED*	*Industry**
Real opex	44.97	48.93	36.77	42.37	40.32	39.00	42.31
O/H Sub–trans. lines	4.78	3.35	1.82	2.56	0.40	7.27	4.31
O/H Distribution lines	27.40	19.58	10.13	23.55	26.13	21.02	14.22
U/G Sub–trans. cables	0.18	0.09	0.29	0.19	0.32	1.94	2.14
U/G Distribution cables	1.97	9.97	16.90	10.80	10.72	9.44	10.59
Transformers	20.69	18.08	34.09	20.54	22.10	21.33	26.43
Total	100	100	100	100	100	100	100

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

As stated in section 1.1, this report uses a revised definition of Opex which includes capitalised corporate overhead (CCO). This has implications for the calculation on input weights. The reallocation of CCO to Opex means that an equivalent amount needs to be removed from Capex for the purpose of calculating the AUC.

For a specific DNSP, the AUC is equal to the return on capital, depreciation and the benchmark tax liability. From 2006, the RAB is recalculated for the purpose of calculating AUC, by removing capitalised corporate overhead (CCO) from Capex. To this end, CCO is first allocated to each asset category on a pro–rata basis, and then deducted from the Capex of each asset category. Second, the straight-line depreciation of each asset category is then recalculated using the same ratio to the opening RAB as for the original RAB series. The AUC is then calculated using the weighted average cost of capital applied to this alternative RAB series, the restated depreciation and the benchmark tax liability.

A3.5 Output and Input weights by State and Territory

Tables A.4 and A.5 show the complete set of output and input weights by State which are referred to in chapter 4.

Table A.4 Output cost share weights by State (%, average 2006 to 2024)

Output	*ACT*	*NSW*	*VIC*	*QLD*	*SA*	*TAS*
Energy throughput	11.25	12.36	12.12	12.86	12.58	12.85
Ratcheted max. demand	49.85	54.75	53.72	56.99	55.75	56.95
Customer numbers	15.87	17.43	17.11	18.15	17.75	18.14
Circuit length	27.26	29.94	29.37	31.16	30.48	31.14
CMOS	-4.23	-14.48	-12.33	-19.17	-16.56	-19.08
Total	100.00	100.00	100.00	100.00	100.00	100.00

Table A.5 Input cost share weights by State (%, average 2006 to 2024)

Input	*ACT*	*NSW*	*VIC*	*QLD*	*SA*	*TAS*
Real opex	45.09	41.70	43.19	44.4	36.77	40.32
O/H Sub–trans. lines	3.03	4.56	3.71	5.79	1.82	0.40
O/H Distribution lines	10.87	10.57	20.37	15.17	10.13	26.13
U/G Sub–trans. cables	0.05	3.24	1.19	2.22	0.29	0.32
U/G Distribution cables	16.44	11.10	11.57	6.59	16.90	10.72
Transformers	24.52	28.84	19.97	25.83	34.09	22.10
Total	100.00	100.00	100.00	100.00	100.00	100.00

A3.6 Drivers of changes in the output weights

Given the materiality of the changes in output weights and the concerns raised by some stakeholders, we undertook a supplementary analysis on this matter. The full analysis is provided in the memo "*Non-reliability Output Index Weights ABR25 – Supplementary Analysis (11 November 2025)*" and summarised below.

Two major changes to the dataset were the additional five years, representing an approximate 40 per cent increase in the number of observations (5 years / 13 years = 38 per cent), and changes in data definitions, particularly in the treatment of capitalised corporate overheads (CCOs). Our analysis found that changes in the output weights were mostly driven by the inclusion of additional data, with revisions to data definitions also playing a significant role. In particular, the sharp increase in the cost share of RMD reflects the combined impact of data revisions and the inclusion of new data, both of which substantially raised its weight. The modest increase in the cost share of Energy Throughput resulted from largely offsetting effects between data revisions and new data. The marked decline in the cost share of Circuit Length was mainly due to the additional data, which reduced the estimated influence of this output on input demands.

The largest changes in output weights, especially for RMD and Circuit Length, occurred with the inclusion of the 2020 and 2021 data. With this new data, the relationship between Opex and Circuit Length weakened, and the importance of Circuit Length as a driver of OH Lines and UG Cables declined (possibly reflecting changes in line capacities). Costs were increasingly attributed to RMD across all inputs. At the same time, the sharp fall in capital input prices in 2020 and 2021 increased the share of Opex in total costs. Since RMD represents a relatively high share of Opex costs, while Circuit Length accounts for a relatively low share, these factors further accentuated the shift in cost shares away from Circuit Length and towards RMD.

We also considered Frontier Economics' proposal to use alternative starting values, obtained by adding an extra step to the estimation process. We acknowledge the merit of this approach and recommend it as a potential improvement. However, we also note its limitations, including convergence failures in two of the 52 models. In such cases, we suggest reverting to the standard starting value of 0.001. While the use of ML-derived starting values produces similar weights for Circuit Length and Customer Numbers and lower weights for Energy Throughput, it further amplifies the increase in the RMD weight. Hence, it would not substantially alter the changes in assessed productivity between rural and urban networks observed by SA Power Networks. Some submitters recommended using the updated data for the period 2006-2024. For the present we have retained Economic Insights' practice of using the previous years' benchmarking dataset, which facilitates updating output weights prior to carrying out benchmarking analysis. However, the suggestion of using the current dataset does have some merit, and should be considered in future updates of output weights.

In summary, our findings indicate that the material changes in weights are primarily driven by the inclusion of additional data and data revisions. These changes are not an artefact of estimation shortcomings, and potential refinements to model specifications do not alter the materiality of these results.

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 D. 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;

$K = (K_1, K_2, \dots, K_H)$ = a $H \times 1$ vector of capital quantities;[39]

$Z = (Z_1, Z_2, \dots, Z_R)$ = a $R \times 1$ vector of operating environment factors;[40] and

$W = (W_1, W_2, \dots, W_S)$ = 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:

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

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:

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

while the Translog cost frontier may be specified as:

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

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:

[39] 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.

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

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

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:

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

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).

A5 Measuring AUC in a changing inflation environment

As discussed in section A3, AUC is used for calculating input index weights. Using the established method of calculation, there has been a sharp fall in AUC values in 2023, with some AUC values being negative. This anomaly appears to be caused by the very large difference in 2023 between:

- the lagged December-on-December CPI inflation outturn used to calculation the Inflation Addition (IA) component of Regulatory Depreciation (7.8 per cent), and
- the market inflation expectations embedded in the Nominal WACC, as evidenced by the relationship between nominal and indexed Commonwealth 10-year bond yields (2.2 per cent).

This section addresses the method adopted in this report to remedy this problem and calculate valid AUC weights.

A5.1 Previously used method for calculating AUC

AUC is the annual economic cost of holding the assets, which is the relevant cost of capital services. The method of calculating AUC follows Jorgenson (1967). The formula for calculating AUC used previously is:

$$AUC_t = NWACC_t \cdot RAB_t^B + RegDep_t + Tax_t \tag{15}$$

where:

- RAB_t^B is the RAB at the beginning of period t
- $NWACC_t$ is the Nominal Vanilla WACC, and
- Tax_t is the benchmark tax liability, in period t
- *RegDep* is regulatory depreciation defined as:

$$RegDep_t = SLD_t - IA_t \tag{16}$$

where:

- SLD_t is straight–line depreciation and
- IA_t is the Inflation Addition in period t.

Both IA_t and $NWACC_t$ depend on the rate of inflation, denoted here as $\dot{P}$. The Inflation Addition is defined as:

$$IA_t = RAB_t^B \cdot \dot{P}_t \tag{17}$$

In the calculation of Inflation Addition, $\dot{P}_t$ is the December quarter on December quarter inflation rate for the previous year for those DNSPs/years with financial year reporting. For example, for t = 2023, $\dot{P}_t$ is the percentage change between the December 2021 CPI and the December 2020 CPI. For Victorian DNSPs in those years where calendar year reporting is used, $\dot{P}_t$ is the June quarter on June quarter inflation rate.

The Nominal Vanilla WACC can be expressed as:

$$NWACC_t = RWACC_t + \dot{P}_t^* \tag{18}$$

where $RWACC_t$ is the Real Vanilla WACC, and $\dot{P}_t^*$ is the inflation rate expectation embodied in the nominal WACC.

A5.2 The effect of inflation rates

Using equations (2) to (4) in (1) shows the effect of inflation on the AUC.

$$AUC_t = RWACC_t \cdot RAB_t^B + SLD_t + Tax_t + \left(\dot{P}_t^* - \dot{P}_t\right)RAB_t^B \tag{19}$$

The last term shows the effect of the discrepancy between the inflation rate used to calculate the Inflation Addition and the inflation rate expectation embedded in the Nominal WACC. If $\dot{P}_t^* = \dot{P}_t$, then the inflation rate does not directly affect AUC.

A5.3 Revised approach to calculating AUC

The revised approach is to impose $\dot{P}_t^* = \dot{P}_t$ in equation (19) for the purpose of calculating the AUC used in calculating input index weights for benchmarking. It is important to note that the RAB calculation does not change. The revised formula is:

$$AUC_t = RWACC_t \cdot RAB_t^B + SLD_t + Tax_t \tag{20}$$

Implementing this formula requires calculating the Real WACC. This is derived from the Nominal WACC using a series for inflation expectations based on a similar method as the AER uses in its regulatory determinations.

From 2006 to 2019, the Nominal WACC is calculated consistent with the AER (2013) *Rate of Return Guideline*, from 2020 to 2023, in line with the AER (2018) *Rate of Return Instrument* and from 2024, in line with AER (2023) *Rate of Return Instrument*. The Real WACC is calculated using the formula: $RWACC_t = \left((1 + NWACC_t)/\left(1 + \dot{P}_t^e\right)\right) - 1$, where $\dot{P}_t^e$ is the average rate of expected inflation calculated using AER's standard methods.

The expected rate of inflation is calculated based on the method used by the AER in its Final Position on the Regulatory Treatment of Inflation (2020). The expected rate of inflation is a 5 or 10-year average of the Reserve Bank of Australia's (RBA) headline rate forecasts. This average includes the forecast for 1 and 2 years ahead,[41] the mid–point of the RBA's target band —2.5 per cent— for year 5 or 10, with linear interpolation used from the RBA's forecasts of inflation for years 1 and 2 to the mid-point of the inflation target of 2.5 per cent in year 5 or 10. [42]

[41] The 2006-2008 period uses only a one-year headline rate forecast due to no available T+8 (quarter) forecasts in this period.

[42] From 2006-2019, the forward period over which inflation is averaged is over ten years to match the term of the rate of return. From 2020 onward, this forward period is five years to match the regulatory period.

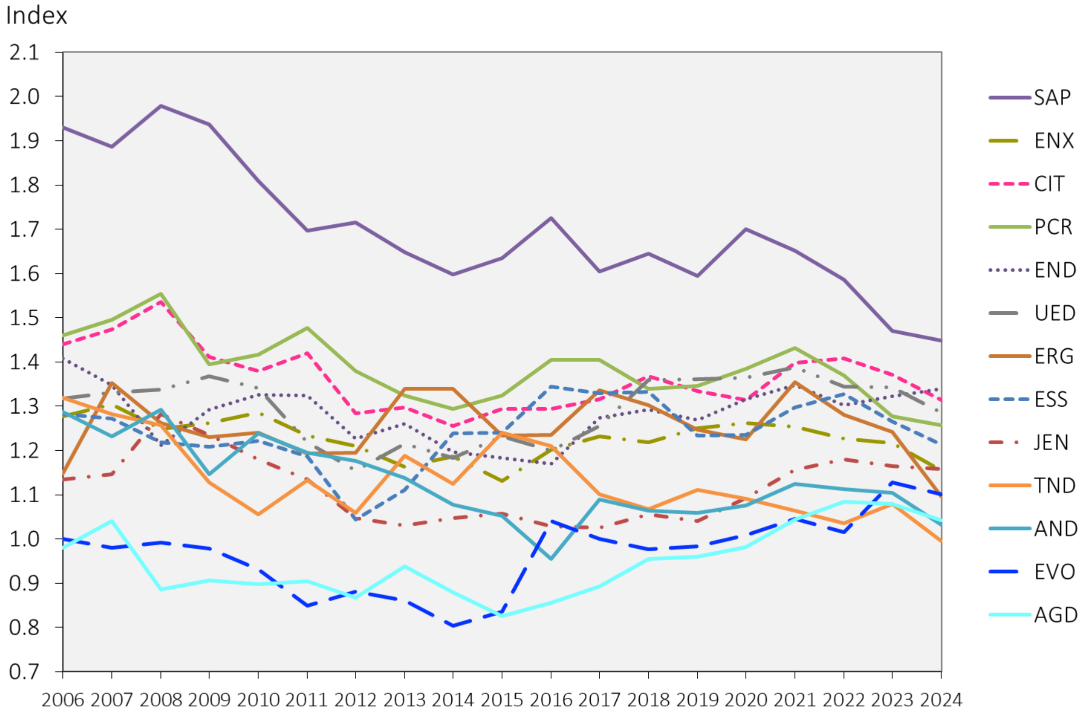
Appendix B: MTFP/MPFP results using previous weights

In this Appendix, we present the MTFP and MPFP index results calculated using the previous output cost share weights from Economic Insights (2020). These results are provided for readers who wish to compare them with the results in Section 3, which use the updated output cost share weights.[43]

B1 Pooled Multilateral TFP Indexes

Figure B.1 and Table B.1 present the MTFP indexes calculated using the previous output weights. These can be compared with Figure 3.1 and Table 3.1.

Figure B.1 DNSP MTFP indexes using previous output weights, 2006–2024



[43] Results using the previous set of output weights for individual DNSPs are provided in the supporting files.

Table B.1 DNSP MTFP indexes using previous output weights, 2006–2024

Year	EVO	AGD	CIT	END	ENX	ERG	ESS
2006	1.000	0.980	1.440	1.408	1.276	1.149	1.283
2007	0.980	1.041	1.473	1.349	1.305	1.352	1.272
2008	0.992	0.885	1.537	1.212	1.248	1.262	1.218
2009	0.979	0.907	1.412	1.293	1.263	1.231	1.208
2010	0.931	0.898	1.380	1.326	1.286	1.240	1.221
2011	0.849	0.905	1.419	1.325	1.233	1.193	1.187
2012	0.881	0.867	1.283	1.228	1.210	1.196	1.045
2013	0.860	0.937	1.297	1.261	1.163	1.339	1.110
2014	0.805	0.879	1.256	1.197	1.186	1.340	1.239
2015	0.835	0.826	1.294	1.184	1.131	1.233	1.240
2016	1.040	0.855	1.294	1.169	1.202	1.235	1.345
2017	1.001	0.893	1.316	1.274	1.233	1.336	1.330
2018	0.977	0.955	1.367	1.292	1.218	1.303	1.333
2019	0.983	0.961	1.335	1.268	1.250	1.248	1.234
2020	1.009	0.981	1.314	1.316	1.262	1.226	1.236
2021	1.046	1.045	1.399	1.347	1.255	1.354	1.298
2022	1.016	1.083	1.408	1.302	1.227	1.281	1.328
2023	1.127	1.079	1.372	1.323	1.217	1.243	1.265
2024	1.101	1.042	1.314	1.339	1.155	1.096	1.213

Table B.1 (cont.)

Year	JEN	PCR	SAP	AND	TND	UED	AVG
2006	1.134	1.461	1.930	1.287	1.319	1.317	1.306
2007	1.146	1.496	1.887	1.232	1.282	1.331	1.319
2008	1.283	1.555	1.979	1.292	1.257	1.337	1.312
2009	1.235	1.395	1.937	1.147	1.128	1.368	1.269
2010	1.179	1.417	1.809	1.239	1.055	1.341	1.256
2011	1.135	1.477	1.697	1.195	1.133	1.219	1.228
2012	1.046	1.379	1.716	1.176	1.059	1.156	1.172
2013	1.031	1.324	1.649	1.138	1.189	1.215	1.193
2014	1.047	1.294	1.599	1.078	1.124	1.184	1.171
2015	1.057	1.324	1.636	1.053	1.241	1.232	1.176
2016	1.028	1.405	1.725	0.955	1.210	1.200	1.205
2017	1.025	1.405	1.604	1.090	1.101	1.256	1.220
2018	1.056	1.339	1.645	1.063	1.067	1.359	1.229
2019	1.041	1.345	1.594	1.059	1.112	1.360	1.215
2020	1.092	1.385	1.700	1.076	1.091	1.364	1.235
2021	1.156	1.432	1.652	1.125	1.064	1.388	1.274
2022	1.180	1.370	1.586	1.113	1.035	1.344	1.252
2023	1.164	1.277	1.471	1.105	1.079	1.344	1.236
2024	1.158	1.257	1.448	1.032	0.994	1.285	1.187

Figure B.2 presents the percentage difference in MTFP between the results using the updated output weights (from Figure 3.1) and those using the previous output weights (from Figure

B.1). Broadly speaking, updating the output weights affected the MTFP of the DNSPs in a relatively consistent manner across the years, as indicated by the predominantly horizontal lines for each DNSP over the period. For six DNSPs (TND, AND, SAP, PCR, ERG, and ESS), the update led to a decrease in MTFP indexes of more than 10 per cent. Two DNSPs (END and ENX) experienced declines of less than 5 per cent. Three DNSPs (AGD, JEN, and UED) recorded modest increases of less than 2 per cent. CIT showed an increase of more than 10 per cent, while EVO, on average, exhibited no material change in its MTFP.

Figure B.2 Percentage change in MTFP indexes, 2006–2024

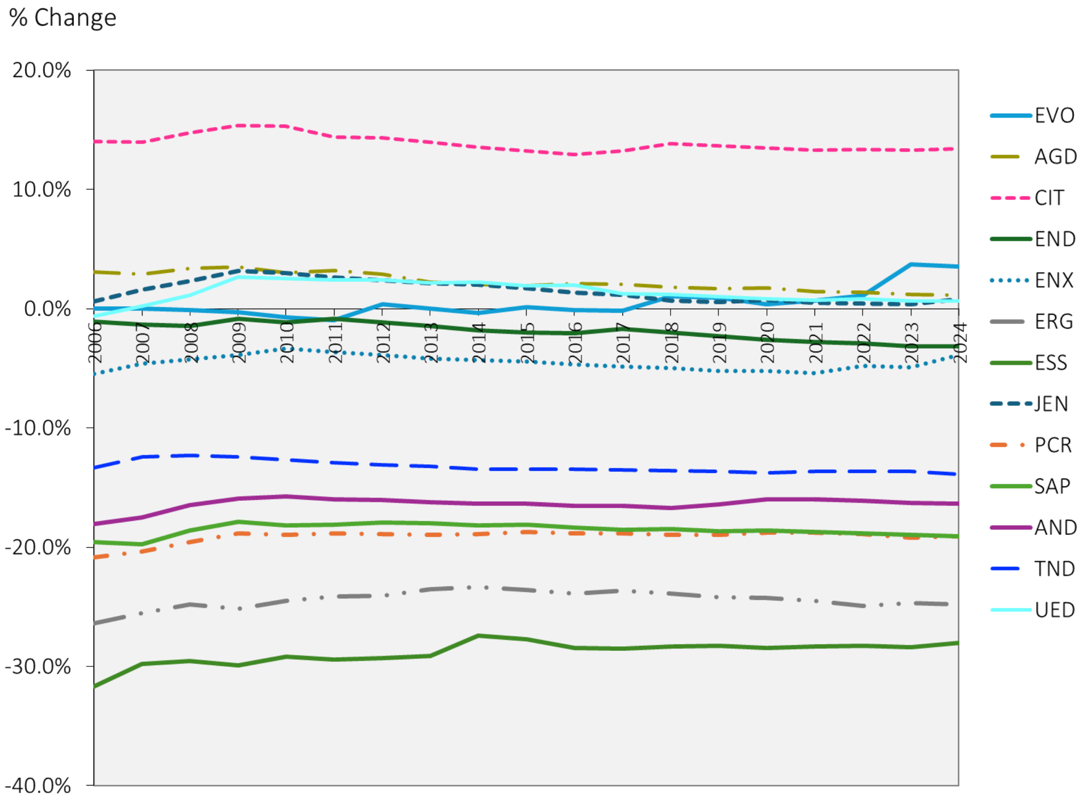


Figure B.3 presents a heat map showing the changes in MTFP ranking positions resulting from the updated output weights. Blue shading indicates DNSPs that improved their ranking positions, while red shading indicates those that moved down in the rankings.

Figure B.3 Change in DNSP MTFP rankings (# positions), 2006–2024

	EVO	AGD	CIT	END	ENX	ERG	ESS	JEN	PCR	SAP	AND	TND	UED
2006	1	3	2	1	4	-3	-4	3	-4	-1	-2	-2	2
2007	1	3	2	1	2	-7	-4	4	-4	-1	0	0	3
2008	2	1	2	4	3	-4	-3	2	-3	-1	-4	0	1
2009	3	2	1	1	0	-4	-4	2	-4	-1	0	3	1
2010	1	3	2	1	1	-2	-4	4	-5	-1	0	-1	1
2011	1	2	2	1	-1	-3	-4	3	-3	-1	-1	2	2
2012	0	2	2	1	0	-4	-2	3	-4	-1	-1	0	4
2013	1	2	3	2	3	-7	-3	4	-3	-1	-2	-1	2
2014	0	0	3	2	2	-6	-6	5	-4	-1	0	0	5
2015	-1	1	2	4	4	-3	-5	3	-4	-1	0	-4	4
2016	1	1	3	4	3	-6	-7	3	-4	-1	-1	-1	5
2017	3	1	4	2	3	-5	-7	4	-4	-1	-3	-1	4
2018	3	3	1	3	3	-2	-6	4	-2	-2	-3	-3	1
2019	4	4	3	1	1	-4	-4	4	-3	-2	-2	-1	0
2020	4	4	4	0	1	-3	-6	2	-4	-1	-1	0	0
2021	3	5	2	2	3	-5	-5	2	-4	-2	-1	-2	2
2022	4	3	1	2	2	-3	-6	4	-4	-2	-2	-1	2
2023	5	4	1	1	1	-3	-7	3	-4	-3	-1	1	1
2024	3	3	2	0	1	-3	-4	2	-4	-3	1	1	1

B2 Multilateral PFP Indexes

Figure B.4 and Table B.2 present the multilateral Opex PFP indexes calculated using the previous output weights. These can be compared with Figure 3.2 and Table 3.2.

Figure B.4 DNSP multilateral Opex PFP indexes using previous weights, 2006–2024

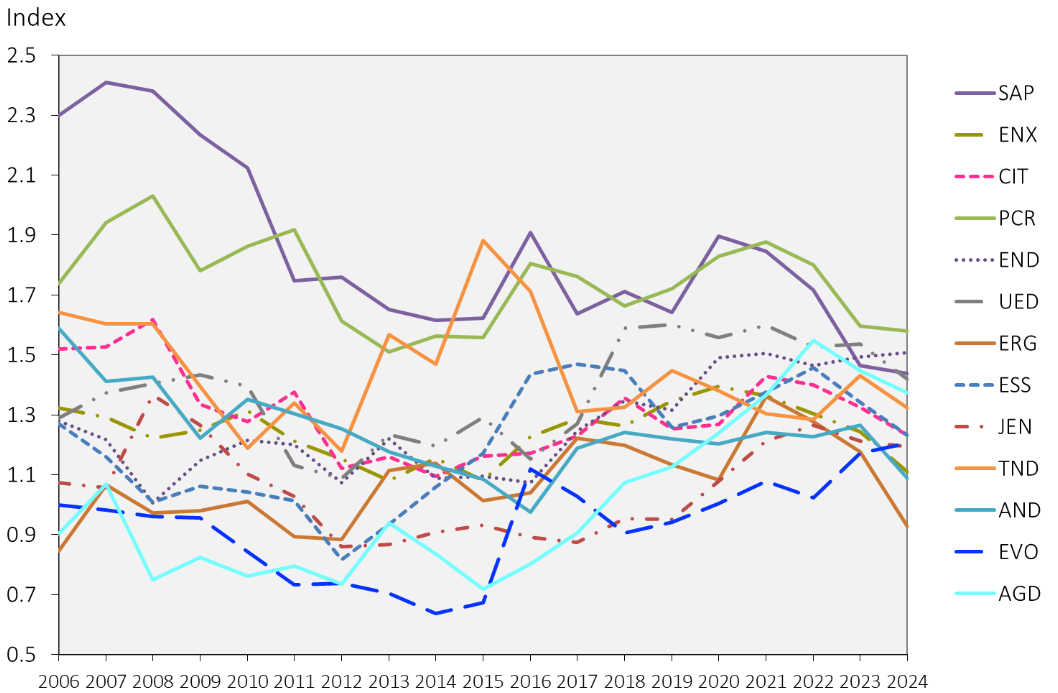


Table B.2 DNSP multilateral Opex PFP indexes using previous output weights, 2006–2024

Year	EVO	AGD	CIT	END	ENX	ERG	ESS
2006	1.000	0.903	1.519	1.280	1.324	0.847	1.271
2007	0.981	1.069	1.526	1.218	1.291	1.065	1.161
2008	0.961	0.750	1.618	1.005	1.223	0.972	1.009
2009	0.956	0.823	1.335	1.147	1.250	0.981	1.061
2010	0.844	0.762	1.279	1.214	1.314	1.012	1.041
2011	0.734	0.796	1.375	1.202	1.212	0.895	1.013
2012	0.738	0.735	1.121	1.073	1.153	0.885	0.818
2013	0.703	0.940	1.160	1.220	1.080	1.114	0.934
2014	0.638	0.837	1.095	1.088	1.156	1.138	1.060
2015	0.674	0.718	1.162	1.094	1.080	1.013	1.173
2016	1.118	0.804	1.172	1.073	1.227	1.041	1.437
2017	1.028	0.906	1.230	1.246	1.286	1.221	1.468
2018	0.906	1.073	1.356	1.347	1.264	1.198	1.448
2019	0.941	1.126	1.254	1.316	1.346	1.133	1.259
2020	1.003	1.240	1.268	1.491	1.395	1.084	1.297
2021	1.078	1.366	1.428	1.506	1.364	1.360	1.375
2022	1.022	1.548	1.400	1.463	1.303	1.278	1.457
2023	1.173	1.449	1.327	1.494	1.245	1.177	1.342
2024	1.206	1.374	1.231	1.507	1.110	0.928	1.231

Table B.2 (cont.)

Year	JEN	PCR	SAP	AND	TND	UED	AVG
2006	1.073	1.738	2.299	1.590	1.642	1.290	1.367
2007	1.056	1.942	2.410	1.413	1.604	1.374	1.393
2008	1.366	2.031	2.381	1.425	1.604	1.404	1.365
2009	1.265	1.781	2.235	1.222	1.396	1.433	1.299
2010	1.104	1.863	2.123	1.352	1.189	1.395	1.269
2011	1.029	1.919	1.748	1.304	1.341	1.130	1.208
2012	0.860	1.614	1.759	1.253	1.179	1.089	1.098
2013	0.867	1.509	1.650	1.178	1.567	1.235	1.166
2014	0.908	1.562	1.615	1.129	1.470	1.196	1.146
2015	0.931	1.559	1.623	1.086	1.882	1.293	1.176
2016	0.891	1.804	1.908	0.976	1.713	1.152	1.255
2017	0.874	1.763	1.638	1.188	1.312	1.270	1.264
2018	0.954	1.662	1.712	1.242	1.326	1.590	1.314
2019	0.952	1.722	1.643	1.220	1.448	1.600	1.305
2020	1.077	1.828	1.896	1.202	1.381	1.558	1.363
2021	1.212	1.877	1.846	1.241	1.304	1.599	1.427
2022	1.266	1.800	1.716	1.227	1.284	1.527	1.407
2023	1.213	1.596	1.465	1.265	1.431	1.537	1.363
2024	1.193	1.579	1.438	1.088	1.324	1.419	1.279

Figure B.5 shows the percentage difference in multilateral Opex PFP results between the updated output weights (Figure 3.2) and the previous output weights (Figure B.4). The results are consistent with those observed for the MTFP indexes. Figure B.6 presents a heat map illustrating the changes in multilateral Opex PFP ranking positions resulting from the updated output weights.

Figure B.5 Percentage change in Opex PFP indexes, 2006–2024

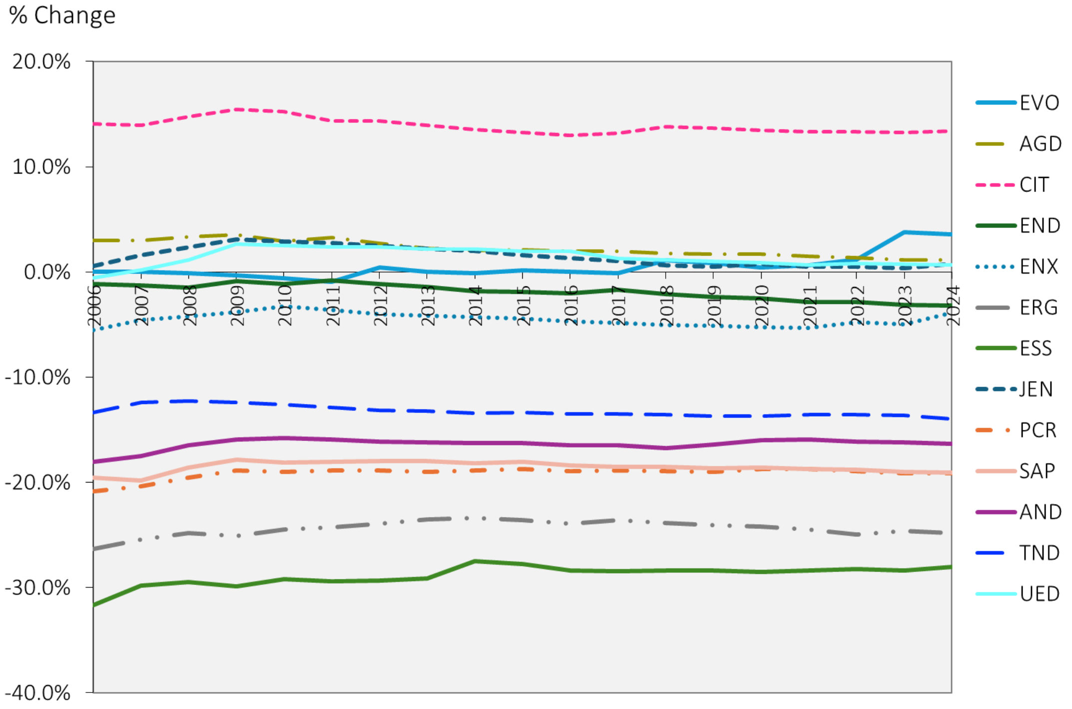


Figure B.6 Change in DNSP Opex PFP ranking positions, 2006–2024

	EVO	AGD	CIT	END	ENX	ERG	ESS	JEN	PCR	SAP	AND	TND	UED
2006	1	1	3	1	-2	0	-3	1	-2	0	-1	0	1
2007	2	1	2	1	1	-2	-3	2	-1	0	-3	-1	1
2008	2	2	1	1	0	-1	-4	1	-1	0	-2	-1	2
2009	2	2	3	1	0	-2	-2	1	-2	0	-1	-2	0
2010	2	2	3	1	0	-1	-3	1	0	0	-3	-1	-1
2011	2	2	2	3	1	-2	-2	0	-1	-1	-3	-1	1
2012	1	3	3	2	0	-3	-2	1	0	0	-4	-4	3
2013	1	1	4	-1	2	-3	-2	2	-2	-1	-2	1	0
2014	0	1	4	2	-1	-4	-2	2	-1	0	-1	1	-1
2015	0	0	2	1	2	-1	-5	3	-2	0	-1	0	1
2016	1	2	2	1	-1	-3	-5	2	-1	0	-1	1	2
2017	2	0	6	2	-1	-2	-5	0	0	-1	0	-3	2
2018	1	3	3	1	2	-3	-5	1	-2	-2	-1	0	2
2019	2	3	6	1	-1	-3	-5	2	-2	-2	0	-3	2
2020	2	2	3	0	-1	-2	-5	3	-1	-1	0	-2	2
2021	3	1	4	-1	1	-3	-7	4	-2	-2	0	1	1
2022	2	1	6	0	0	-3	-4	4	-3	-4	0	0	1
2023	6	2	6	-1	0	-1	-5	4	-4	-5	-2	0	1
2024	3	1	4	1	1	0	-5	3	-4	-5	1	-3	2

Figure B.7 and Table B.3 present the multilateral Capital PFP indexes calculated using the previous output weights. These can be compared with Figure 3.3 and Table 3.3.

Figure B.7 DNSP multilateral Capital PFP indexes using previous weights, 2006–2024

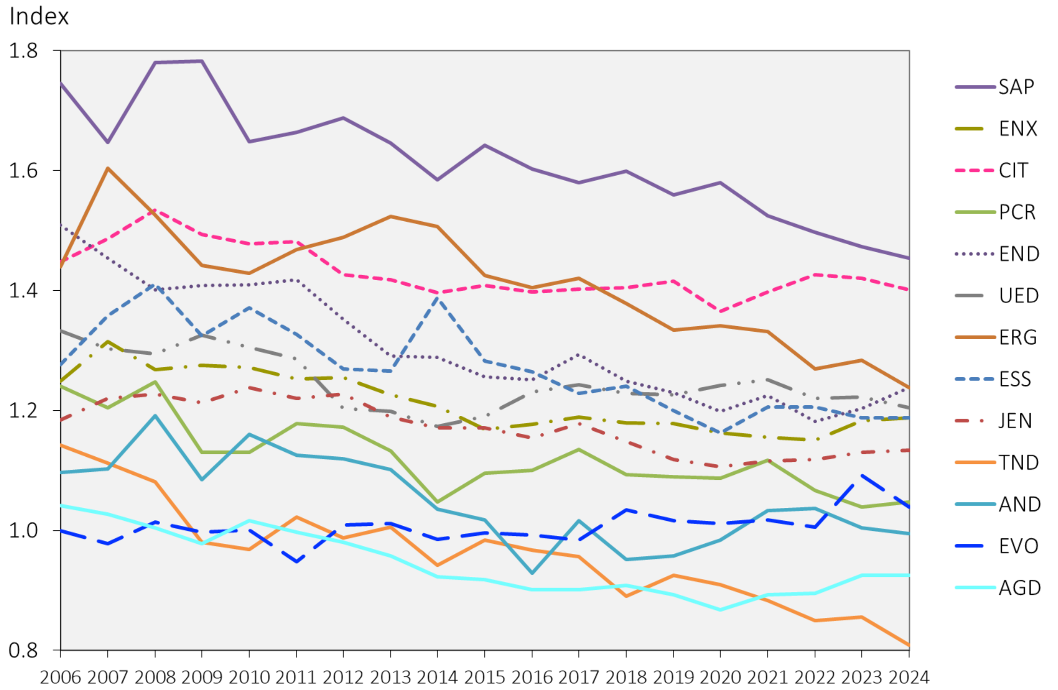


Table B.3 DNSP multilateral Capital PFP indexes using previous weights, 2006–2024

Year	EVO	AGD	CIT	END	ENX	ERG	ESS
2006	1.000	1.042	1.447	1.509	1.249	1.439	1.276
2007	0.978	1.027	1.487	1.453	1.315	1.604	1.358
2008	1.014	1.005	1.535	1.401	1.268	1.526	1.411
2009	0.997	0.978	1.494	1.409	1.275	1.442	1.325
2010	1.001	1.017	1.478	1.410	1.272	1.429	1.372
2011	0.948	0.997	1.482	1.417	1.253	1.468	1.327
2012	1.009	0.980	1.427	1.351	1.255	1.489	1.269
2013	1.012	0.958	1.417	1.291	1.227	1.524	1.265
2014	0.985	0.922	1.397	1.288	1.207	1.507	1.388
2015	0.996	0.918	1.408	1.256	1.169	1.425	1.282
2016	0.993	0.901	1.398	1.252	1.177	1.405	1.265
2017	0.984	0.901	1.402	1.294	1.189	1.420	1.228
2018	1.034	0.909	1.405	1.249	1.179	1.378	1.240
2019	1.016	0.893	1.416	1.230	1.177	1.334	1.199
2020	1.012	0.867	1.366	1.198	1.163	1.341	1.162
2021	1.018	0.892	1.398	1.225	1.156	1.332	1.206
2022	1.006	0.895	1.426	1.181	1.150	1.269	1.206
2023	1.092	0.925	1.421	1.203	1.183	1.284	1.187
2024	1.039	0.925	1.402	1.238	1.188	1.238	1.188

Table B.3 (cont.)

Year	JEN	PCR	SAP	AND	TND	UED	AVG
2006	1.184	1.241	1.745	1.097	1.142	1.333	1.285
2007	1.221	1.205	1.647	1.103	1.112	1.302	1.293
2008	1.228	1.247	1.780	1.191	1.080	1.295	1.306
2009	1.213	1.130	1.782	1.085	0.980	1.325	1.264
2010	1.238	1.130	1.649	1.160	0.968	1.306	1.264
2011	1.221	1.178	1.663	1.126	1.023	1.286	1.261
2012	1.227	1.172	1.687	1.119	0.988	1.203	1.244
2013	1.188	1.133	1.646	1.101	1.006	1.198	1.228
2014	1.171	1.047	1.585	1.035	0.942	1.173	1.204
2015	1.171	1.095	1.642	1.018	0.984	1.191	1.197
2016	1.154	1.100	1.603	0.929	0.967	1.231	1.183
2017	1.178	1.135	1.580	1.017	0.956	1.243	1.194
2018	1.148	1.093	1.599	0.952	0.890	1.228	1.177
2019	1.118	1.090	1.559	0.958	0.926	1.226	1.165
2020	1.106	1.088	1.580	0.984	0.909	1.242	1.155
2021	1.116	1.117	1.525	1.033	0.883	1.251	1.166
2022	1.118	1.067	1.497	1.037	0.849	1.220	1.148
2023	1.130	1.039	1.473	1.004	0.856	1.222	1.155
2024	1.134	1.047	1.454	0.995	0.808	1.205	1.143

Figure B.8 shows the percentage difference in multilateral Capital PFP results between the updated output weights (Figure 3.3) and the previous output weights (Figure B.7). The results are consistent with those observed for the MTFP and Opex PFP indexes.

Figure B.8 Percentage change in Capital PFP indexes,2006–2024

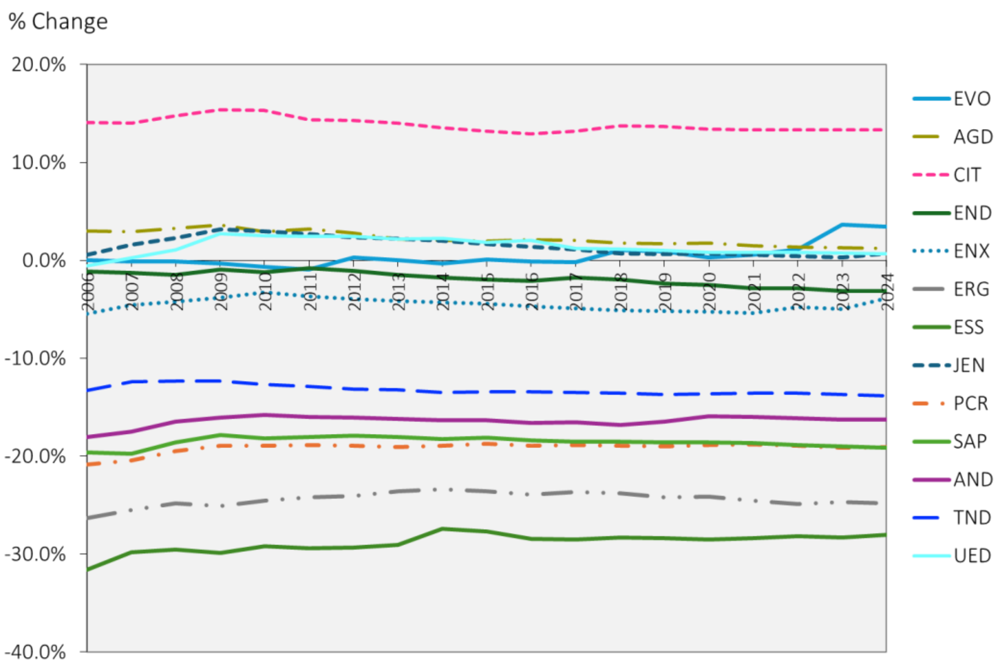


Figure B.9 presents a heat map illustrating the changes in multilateral Capital PFP ranking positions resulting from the updated output weights.

Figure B.9 Change in DNSP Capital PFP ranking positions, 2006–2024

	EVO	AGD	CIT	END	ENX	ERG	ESS	JEN	PCR	SAP	AND	TND	UED
2006	4	5	2	0	1	-4	-7	4	-3	-2	-1	0	1
2007	4	4	2	2	1	-5	-7	2	-2	-2	-2	0	3
2008	3	5	1	2	1	-4	-8	4	-2	-1	-1	-2	2
2009	2	5	1	1	1	-4	-5	3	-2	-1	-2	-1	1
2010	3	3	1	2	1	-4	-6	3	-2	-2	-1	0	2
2011	2	4	1	2	1	-4	-7	3	0	-2	0	-2	2
2012	3	4	2	1	0	-5	-7	3	-1	-1	-1	-1	3
2013	3	4	2	1	0	-5	-7	3	-2	-1	0	-1	3
2014	2	3	2	2	0	-4	-4	3	-3	-1	-1	-1	3
2015	3	4	2	2	2	-5	-6	2	-2	-1	-2	0	2
2016	2	4	2	1	1	-5	-6	3	-2	-1	-1	-1	3
2017	3	3	2	1	1	-5	-5	3	0	-1	-2	-1	1
2018	2	3	1	0	1	-4	-5	3	-2	-1	-1	0	3
2019	3	4	1	0	1	-5	-5	3	-1	-1	-1	-1	2
2020	2	3	1	1	0	-4	-4	3	0	-1	-1	-1	1
2021	4	2	1	1	1	-5	-6	4	-1	-2	-1	0	2
2022	4	3	1	2	1	-5	-6	3	-3	-2	0	0	2
2023	3	3	1	1	0	-5	-4	3	-2	-2	0	0	2
2024	3	4	1	0	1	-6	-4	3	-2	-3	-1	0	3

Appendix C: Regression–based trend growth rates

Table C.1 Output, input, TFP and PFP index trend annual growth rates, 2006–2024

DNSP	*Output*	*Input*	*TFP*	*PFP Index*	
Period	*Index*	*Index*	*Index*	*Opex*	*Capital*
Industry					
Growth Rate 2006–24	0.7%	0.9%	-0.2%	0.8%	-0.9%
Growth Rate 2006–12	1.9%	3.6%	-1.7%	-3.1%	-0.7%
Growth Rate 2012–24	0.4%	-0.1%	0.5%	2.2%	-0.7%
EVO/ACT					
Growth Rate 2006–24	1.9%	1.0%	0.9%	1.6%	0.4%
Growth Rate 2006–12	1.2%	4.1%	-2.9%	-5.7%	-0.6%
Growth Rate 2012–24	2.1%	-0.6%	2.7%	4.9%	0.7%
AGD					
Growth Rate 2006–24	0.4%	-0.3%	0.7%	3.2%	-0.8%
Growth Rate 2006–12	1.1%	3.5%	-2.4%	-4.3%	-1.5%
Growth Rate 2012–24	0.2%	-1.9%	2.0%	6.1%	-0.2%
CIT					
Growth Rate 2006–24	0.7%	1.3%	-0.6%	-0.7%	-0.6%
Growth Rate 2006–12	1.2%	3.8%	-2.6%	-4.7%	-1.4%
Growth Rate 2012–24	0.6%	-0.1%	0.7%	1.7%	0.1%
END					
Growth Rate 2006–24	1.1%	1.2%	-0.1%	1.5%	-1.4%
Growth Rate 2006–12	1.8%	3.2%	-1.4%	-1.2%	-1.7%
Growth Rate 2012–24	1.0%	0.2%	0.9%	3.1%	-0.8%
ENX					
Growth Rate 2006–24	1.2%	1.6%	-0.4%	0.1%	-0.8%
Growth Rate 2006–12	3.9%	4.5%	-0.6%	-1.4%	0.0%
Growth Rate 2012–24	0.6%	0.5%	0.1%	1.0%	-0.7%
ERG					
Growth Rate 2006–24	0.6%	0.6%	0.0%	1.3%	-1.0%
Growth Rate 2006–12	2.0%	2.6%	-0.5%	-0.8%	-0.4%
Growth Rate 2012–24	-0.2%	0.1%	-0.2%	1.2%	-1.4%
ESS					
Growth Rate 2006–24	1.0%	0.1%	0.9%	1.9%	-0.2%
Growth Rate 2006–12	0.9%	4.1%	-3.2%	-5.8%	-0.8%
Growth Rate 2012–24	0.8%	-0.8%	1.6%	3.4%	-0.1%
JEN					
Growth Rate 2006–24	1.1%	1.2%	-0.1%	0.0%	-0.2%
Growth Rate 2006–12	2.5%	3.3%	-0.8%	-3.1%	1.2%
Growth Rate 2012–24	0.9%	-0.4%	1.3%	3.4%	-0.4%

Table C.2 (cont.)

DNSP	*Output*	*Input*	*TFP*	*PFP Index*	
Period	*Index*	*Index*	*Index*	*Opex*	*Capital*
PCR					
Growth Rate 2006–24	1.0%	1.8%	-0.8%	-0.5%	-1.0%
Growth Rate 2006–12	2.0%	2.7%	-0.6%	-0.7%	-0.5%
Growth Rate 2012–24	1.0%	1.1%	-0.2%	0.7%	-1.1%
SAP					
Growth Rate 2006–24	0.5%	2.0%	-1.6%	-2.2%	-1.3%
Growth Rate 2006–12	2.1%	4.3%	-2.2%	-5.3%	-0.6%
Growth Rate 2012–24	0.0%	1.2%	-1.1%	-0.8%	-1.3%
AND					
Growth Rate 2006–24	0.9%	1.9%	-1.0%	-1.3%	-0.8%
Growth Rate 2006–12	3.1%	4.2%	-1.2%	-3.4%	0.4%
Growth Rate 2012–24	0.5%	0.9%	-0.3%	0.4%	-0.8%
TND/TAS					
Growth Rate 2006–24	0.2%	1.2%	-1.0%	-0.7%	-1.1%
Growth Rate 2006–12	0.5%	4.0%	-3.6%	-6.2%	-1.8%
Growth Rate 2012–24	-0.1%	0.9%	-1.0%	-0.9%	-1.1%
UED					
Growth Rate 2006–24	0.9%	0.9%	0.1%	1.0%	-0.5%
Growth Rate 2006–12	1.7%	3.4%	-1.6%	-2.7%	-0.9%
Growth Rate 2012–24	1.0%	0.0%	1.1%	2.7%	0.0%

Appendix D: Opex cost function regression results

This Appendix presents the detailed results of estimating the models using the revised definition of opex which includes capitalised corporate overheads (presented in section 4).

D1 Full sample results

D1.1 Regression outputs

The models in this section all have 1,159 observations over 61 DNSPs. The LSE models use panel–corrected standard errors. Table D.1 shows that LSE Cobb–Douglas cost frontier model.

Table D.1 LSE Cobb–Douglas cost function estimates using 2006–2024 data

Variable	*Coefficient*	*Standard error*	*t–ratio*
ln(Custnum)	0.518	0.077	6.690
ln(CircLen)	0.229	0.035	6.460
ln(RMDemand)	0.216	0.066	3.280
ln(ShareUGC)	-0.092	0.026	-3.540
Year	0.010	0.002	6.740
Country dummy variables:			
New Zealand	-0.364	0.133	-2.740
Ontario	-0.149	0.130	-1.140
DNSP dummy variables:			
AGD	-0.113	0.191	-0.590
CIT	-0.391	0.146	-2.670
END	-0.268	0.154	-1.740
ENX	-0.263	0.142	-1.860
ERG	-0.048	0.170	-0.280
ESS	-0.248	0.173	-1.430
JEN	-0.323	0.159	-2.030
PCR	-0.636	0.150	-4.250
SAP	-0.600	0.155	-3.870
AND	-0.453	0.150	-3.020
TND	-0.491	0.166	-2.960
UED	-0.556	0.157	-3.540
Constant	-9.990	3.030	-3.300
Rho	0.794		
R–Square			0.991

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 0.96, which suggests that a proportionate increase in all three outputs by 1 per cent would raise operating costs by almost 1 per cent.

Table D.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 Translog models at the sample means of outputs and at various sub–sample means of outputs in Tables D.5 and D.6.

Table D.2 LSE Translog cost function estimates using 2006–2024 data

Variable	*Coefficient*	*Standard error*	*t–ratio*
ln(Custnum)=x1	0.358	0.081	4.41
ln(CircLen)=x2	0.233	0.035	6.67
ln(RMDemand)=x3	0.364	0.068	5.34
x1*x1/2	-0.146	0.539	-0.27
x1*x2	0.250	0.129	1.94
x1*x3	-0.183	0.429	-0.43
x2*x2/2	-0.032	0.046	-0.68
x2*x3	-0.190	0.105	-1.81
x3*x3/2	0.446	0.342	1.31
ln(ShareUGC)	-0.103	0.029	-3.59
Year	0.012	0.002	7.74
Country dummy variables:			
New Zealand	-0.409	0.131	-3.13
Ontario	-0.252	0.129	-1.96
DNSP dummy variables:			
AGD	-0.114	0.197	-0.58
CIT	-0.388	0.146	-2.66
END	-0.327	0.154	-2.12
ENX	-0.289	0.148	-1.96
ERG	-0.164	0.188	-0.87
ESS	-0.398	0.192	-2.08
JEN	-0.207	0.166	-1.25
PCR	-0.716	0.153	-4.69
SAP	-0.686	0.159	-4.31
AND	-0.476	0.155	-3.07
TND	-0.536	0.163	-3.29
UED	-0.445	0.168	-2.66
Constant	-13.411	3.084	-4.35
Rho	0.784		
R–Square			0.991

The SFA models assume time–invariant inefficiencies with a truncated normal distribution. Table D.3 shows the Cobb–Douglas SFA cost model and Table D.4 shows the Translog SFA cost model. In the SFA Cobb–Douglas model the sum of output elasticities is 0.96, which is similar to the LSE Cobb–Douglas model. However, the SFACD model has much smaller elasticities for customer numbers and larger elasticity for RMD compared to the LSECD model.

Table D.3 SFA Cobb–Douglas cost frontier estimates using 2006–2024 data

Variable	*Coefficient*	*Standard error*	*t–ratio*
ln(Custnum)	0.242	0.072	3.35
ln(CircLen)	0.139	0.041	3.39
ln(RMDemand)	0.583	0.074	7.85
ln(ShareUGC)	-0.124	0.031	-4.01
Year	0.010	0.001	11.60
Country dummy variables:			
New Zealand	0.013	0.089	0.14
Ontario	0.079	0.069	1.13
Constant	-10.302	1.752	-5.88
Variance parameters:			
Mu	0.073	0.227	0.32
ln sigma squared	-2.264	0.549	-4.13
log gamma	1.635	0.657	2.49
Sigma squared	0.104	0.057	
gamma	0.837	0.090	
SigmaU squared	0.087	0.057	
SigmaV squared	0.017	0.001	
LLF			610.82

D1.2 Cost elasticities

Table D.4 shows the cost elasticities with respect to each of the outputs for the LSE Translog cost model, in total and for country sub-samples. Table D.5 shows the cost elasticities with respect to each of the outputs for the LSE Translog cost model, on average for individual Australian DNSPs.

Table D.4 Average DNSP output elasticities by country 2006–2024

	LSETLG model			
Sample	*Customer numbers*	*Circuit length*	*RMD*	*Total*
Australia	0.279	0.300	0.412	0.991
New Zealand	0.653	0.237	0.055	0.946
Ontario	0.200	0.200	0.544	0.944
Full sample	0.358	0.233	0.364	0.955

Table D.5 Average DNSP output elasticities by Aust. DNSP, 2006–2023

	LSETLG model			
Sample	*Customer numbers*	*Circuit length*	*RMD*	*Total*
EVO	0.219	0.264	0.473	0.956
AGD	0.016	0.338	0.643	0.997
CIT	-0.033	0.284	0.705	0.955
END	0.146	0.288	0.571	1.005
ENX	0.141	0.328	0.533	1.002
ERG	0.597	0.221	0.231	1.049
ESS	0.648	0.285	0.099	1.032
JEN	0.123	0.348	0.465	0.936
PCR	0.448	0.310	0.248	1.005
SAP	0.436	0.286	0.295	1.018
AND	0.380	0.349	0.251	0.980
TND	0.440	0.241	0.314	0.995
UED	0.070	0.360	0.525	0.955
Total (Aust.)	0.279	0.300	0.412	0.991

D1.3 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 2024 report. Tables D.6 and D.7 show the proportions of observations for which there are monotonicity violations in Translog model estimated using the full sample.

Table D.6 Frequency of monotonicity violations by country 2006–2024

	LSETLG model			
Sample	*Customer numbers*	*Circuit length*	*RMD*	*Total*
Australia	7.7%	0.0%	0.0%	7.7%
New Zealand	0.0%	0.0%	35.5%	35.5%
Ontario	10.3%	0.0%	0.0%	10.3%
Full sample	6.6%	0.0%	11.0%	17.6%

The LSETLG models have monotonicity violations in more than 50 per cent of the observations for one Australian DNSPs, related to the customer numbers output. For overseas DNSPs, there are also monotonicity violations related to RMD.

Table D.7 Frequency of monotonicity violations by DNSP (Aust.) 2006–2024

	LSETLG model			
Sample	*Customer numbers*	*Circuit length*	*RMD*	*Total*
EVO	0.0%	0.0%	0.0%	0.0%
AGD	0.0%	0.0%	0.0%	0.0%
CIT	100.0%	0.0%	0.0%	100.0%
END	0.0%	0.0%	0.0%	0.0%
ENX	0.0%	0.0%	0.0%	0.0%
ERG	0.0%	0.0%	0.0%	0.0%
ESS	0.0%	0.0%	0.0%	0.0%
JEN	0.0%	0.0%	0.0%	0.0%
PCR	0.0%	0.0%	0.0%	0.0%
SAP	0.0%	0.0%	0.0%	0.0%
AND	0.0%	0.0%	0.0%	0.0%
TND	0.0%	0.0%	0.0%	0.0%
UED	0.0%	0.0%	0.0%	0.0%
Total (Aust.)	7.7%	0.0%	0.0%	7.7%

D1.4 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 do not 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 D.2 which do not appear in Table D.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. This result implies that the independent variables added in the Translog models (ie, the higher order terms and interactions between log outputs) have a relationship with the dependent variable (log real opex). That is, at least some of the additional effects included in the Translog model are statistically significant explanatory variables. Hence, the Translog model does capture some element of nonlinearity in the relationship between log real opex and the log outputs.

D2 Sample from 2012 to 2023

D2.1 Regression results

This section presents the cost function econometric results using a shorter sample period from 2012 to 2024. The models in this section all have 793 observations over 61 DNSPs. Tables D.8 and D.9 present the results for the LSE Cobb–Douglas model and the LSE Translog model respectively.

Table D.8 LSE Cobb–Douglas cost function estimates using 2012–2023 data

Variable	*Coefficient*	*Standard error*	*t–ratio*
ln(Custnum)	0.515	0.079	6.56
ln(CircLen)	0.268	0.034	7.93
ln(RMDemand)	0.183	0.070	2.60
ln(ShareUGC)	-0.090	0.027	-3.38
Year	0.005	0.002	2.56
Country dummy variables:			
New Zealand	-0.387	0.147	-2.63
Ontario	-0.146	0.145	-1.00
DNSP dummy variables:			
AGD	-0.167	0.196	-0.86
CIT	-0.322	0.155	-2.07
END	-0.310	0.164	-1.89
ENX	-0.265	0.155	-1.71
ERG	-0.159	0.183	-0.87
ESS	-0.310	0.182	-1.70
JEN	-0.278	0.162	-1.71
PCR	-0.686	0.158	-4.34
SAP	-0.589	0.162	-3.63
AND	-0.442	0.160	-2.77
TND	-0.518	0.180	-2.87
UED	-0.568	0.169	-3.37
Constant	0.146	4.041	0.04
Rho	0.743		
R–Square			0.995

Table D.9 LSE Translog cost function estimates using 2012–2024 data

Variable	*Coefficient*	*Standard error*	*t–ratio*
ln(Custnum)=x1	0.300	0.084	3.570
ln(CircLen)=x2	0.279	0.032	8.620
ln(RMDemand)=x3	0.376	0.071	5.330
x1*x1/2	-0.255	0.580	-0.440
x1*x2	0.220	0.133	1.650
x1*x3	-0.133	0.449	-0.300
x2*x2/2	0.024	0.044	0.550
x2*x3	-0.214	0.108	-1.980
x3*x3/2	0.488	0.348	1.400
ln(ShareUGC)	-0.088	0.027	-3.280
Year	0.007	0.002	3.630
Country dummy variables:			
New Zealand	-0.441	0.141	-3.130
Ontario	-0.246	0.139	-1.770

Table D.9 (cont.)

Variable	*Coefficient*	*Standard error*	*t–ratio*
DNSP dummy variables:			
AGD	-0.080	0.195	-0.410
CIT	-0.341	0.151	-2.270
END	-0.325	0.158	-2.060
ENX	-0.206	0.156	-1.320
ERG	-0.316	0.194	-1.630
ESS	-0.452	0.198	-2.290
JEN	-0.106	0.167	-0.640
PCR	-0.685	0.160	-4.270
SAP	-0.631	0.163	-3.860
AND	-0.353	0.165	-2.140
TND	-0.547	0.172	-3.180
UED	-0.378	0.174	-2.170
Constant	-3.965	3.979	-1.000
Rho	0.716		
R–Square			0.995

Table D.10 presents the results for the SFA Cobb–Douglas model over this shorter period of 2012–2024.

Table D.10 SFA Cobb–Douglas cost frontier estimates using 2012–2024 data

Variable	*Coefficient*	*Standard error*	*t–ratio*
ln(Custnum)	0.200	0.123	1.63
ln(CircLen)	0.332	0.067	4.97
ln(RMDemand)	0.418	0.094	4.45
ln(ShareUGC)	0.015	0.052	0.29
Year	0.003	0.001	2.12
Country dummy variables:			
New Zealand	-0.111	0.094	-1.18
Ontario	0.136	0.093	1.47
Constant	4.203	2.759	1.52
Variance parameters:			
Mu	0.291	0.092	3.16
ln sigma squared	-3.000	0.249	-12.05
log gamma	1.004	0.343	2.93
Sigma squared	0.050	0.012	
gamma	0.732	0.067	
SigmaU squared	0.036	0.012	
SigmaV squared	0.013	0.001	
LLF			485.23

D2.3 Cost elasticities

Tables D.11 and D.12 provide information on the average elasticities of real opex with respect to the outputs in the LSE Translog model for the 2012–2024 period.

Table D.11 Average DNSP output elasticities by country 2012–2024

	LSETLG model			
Sample	*Customer numbers*	*Circuit length*	*RMD*	*Total*
Australia	0.048	0.366	0.540	0.954
New Zealand	0.611	0.327	0.006	0.944
Ontario	0.209	0.208	0.545	0.962
Full sample	0.300	0.279	0.376	0.955

Table D.12 Average DNSP output elasticities by Aust. DNSP, 2012–2024

	LSETLG model			
Sample	*Customer numbers*	*Circuit length*	*RMD*	*Total*
EVO	0.109	0.288	0.550	0.947
AGD	-0.272	0.366	0.852	0.947
CIT	-0.152	0.269	0.823	0.940
END	-0.103	0.337	0.738	0.972
ENX	-0.150	0.380	0.723	0.953
ERG	0.319	0.365	0.341	1.026
ESS	0.335	0.431	0.222	0.989
JEN	-0.032	0.365	0.560	0.893
PCR	0.165	0.417	0.373	0.956
SAP	0.158	0.393	0.427	0.978
AND	0.115	0.435	0.371	0.922
TND	0.277	0.331	0.371	0.978
UED	-0.143	0.375	0.674	0.906
Total (Aust.)	0.048	0.366	0.540	0.954

D2.4 Monotonicity performance

Tables D.13 and D.14 show the proportions of observations for which there are monotonicity violations in the Translog model. The monotonicity performance of the Translog model estimated over the shorter period is worse than that for the models estimated over the longer period, which is consistent with the 2024 study.

Table D.13 Frequency of monotonicity violations by country 2012–2024

	LSETLG model			
Sample	*Customer numbers*	*Circuit length*	*RMD*	*Total*
Australia	46.2%	0.0%	0.0%	46.2%
New Zealand	5.3%	0.0%	56.3%	61.5%
Ontario	12.7%	0.0%	0.0%	12.7%
Full sample	17.5%	0.0%	17.5%	35.1%

Table D.14 Frequency of monotonicity violations by DNSP (Aust.) 2012–2024

	LSETLG model			
Sample	*Customer numbers*	*Circuit length*	*RMD*	*Total*
EVO	0.0%	0.0%	0.0%	0.0%
AGD	100.0%	0.0%	0.0%	100.0%
CIT	100.0%	0.0%	0.0%	100.0%
END	100.0%	0.0%	0.0%	100.0%
ENX	100.0%	0.0%	0.0%	100.0%
ERG	0.0%	0.0%	0.0%	0.0%
ESS	0.0%	0.0%	0.0%	0.0%
JEN	100.0%	0.0%	0.0%	100.0%
PCR	0.0%	0.0%	0.0%	0.0%
SAP	0.0%	0.0%	0.0%	0.0%
AND	0.0%	0.0%	0.0%	0.0%
TND	0.0%	0.0%	0.0%	0.0%
UED	100.0%	0.0%	0.0%	100.0%
Total (Aust.)	46.2%	0.0%	0.0%	46.2%

D2.5 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 2024 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.

In the LSE models, the Wald test for the null hypothesis that coefficients on the higher-order terms in Table D.9, which do not appear in Table D.8, 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, indicating that the additional terms in the Translog model have a statistically significant relationship with the dependent variable. Hence, the Translog model does capture some element of nonlinearity in the relationship between log real opex and the log outputs.

D3 Non-convergence of the SFATLG models

The SFATLG truncated normal model did not converge in both long and short sample using Stata's *xtfrontier* command, assuming a truncated-normal distribution of inefficiencies, and using OLS parameter estimates as starting values for maximum likelihood estimation. Non-convergence implies that the estimation algorithm did not find a stable set of parameter values that satisfy the optimization criteria. This means the parameter estimates can be unreliable, leading to inaccurate or biased cost elasticities and inefficiency estimates, compromising the interpretation of the results, as mentioned in Section 4.1. For the purposes of this report the SFATLG models for both the long period and the short period have been omitted due to non-convergence under the truncated-normal assumption. In 2024, the short-sample SFATLG also did not converge and in 2023 the short-sample SFATLG presented difficulties, in that case relating to the reliability of some efficiency score estimates (although the model was excluded on monotonicity grounds).

We also tested the half-normal distribution of inefficiencies which involves restricting the 'mu' parameter to zero.[44] Under this assumption, the SATLG models converged in both the long and short periods. In the long-period model, the results produced the expected signs for the main output coefficients and undergrounding but showed excessive monotonicity violations. In the short-period model, the main output coefficients were also as expected. However, the coefficient on the undergrounding variable was positive, which suggests potential misspecification. This model also exhibited excessive monotonicity violations. These results suggest that use of the half-normal distribution for inefficiencies, as an alternative to the truncated-normal assumption, can be of assistance in avoiding convergence and other computational issues, but it is not a solution for monotonicity violations and unreliability of efficiency estimation.

Regarding these and other issues, the opex cost function methodology is currently under review. The second phase of the consultation is scheduled for mid-2025, when the AER will seek stakeholder views.[45]

[44] Refer to the folder "Supplementary Econometric Analysis" in the supporting files.

[45] See AER's webpage for details: https://www.aer.gov.au/industry/registers/resources/reviews/annual-benchmarking-reports-2024/consultation

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