

Quantonomics

QUANTITATIVE ECONOMICS

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

Report prepared for Australian Energy Regulator

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Acronyms & Abbreviations

TNSP names

<i>Abbreviation</i>	<i>TNSP name</i>	<i>State</i>
ANT	AusNet Services Transmission	Victoria
ENT	ElectraNet	South Australia
PLK	Powerlink	Queensland
TNT	TasNetworks Transmission	Tasmania
TRG	TransGrid	New South Wales

Other Abbreviations

<i>Abbreviation</i>	<i>Description</i>
AEMO	Australian Energy Market Operator
AUC	Annual user cost of capital
CAM	Cost allocation methodology
EBRIN	Economic Benchmarking Regulatory Information Notice
ENS	Energy Not Supplied
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
TFP	Total factor productivity
TNSP	Transmission network service provider
VCR	Value of customer reliability

1 Introduction

Quantonomics has been asked by the Australian Energy Regulator (AER) to update the electricity transmission network service provider (TNSP) multilateral total factor productivity (MTFP) and multilateral partial factor productivity (MPFP) results presented in the AER's 2024 TNSP Benchmarking Report (AER 2024). This annual update closely follows the methods used previously by Quantonomics (2024; 2023; 2022) and Economic Insights (2021). It includes data for the 2023-24 financial years ending June or March (as relevant) reported by the TNSPs 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 TNSP productivity change by quantifying the contribution of each individual output and input to total factor productivity (TFP) change.

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 exception. 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 (2020a, 124–25) 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 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.

1.2 Updates to data for the 2025 report

Regarding input variables the revisions are:

- This year's analysis includes the correction of a previous 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.
- Amended values for ANT's opex for 2022 and 2023, reflecting ANT's restatement of its RY22 and RY23 Economic Benchmarking RIN submissions.

- Amended values for TNT's overhead lines in 2023, correcting a previously reported error where 110 kV lines were incorrectly recorded as 115.5 MVA instead of 110 MVA.

In regard to output variables the key revisions are to TRG's ENS variable for 2015 to 2023 to correct an inconsistency in the reporting period.

1.3 Supporting Information

This report summarises the key results and insights from the benchmarking analysis of TNSPs. 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.

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

1.4 Specifications Used for Productivity Measurement

This report measures TFP using the multilateral Törnqvist TFP (MTFP) index method developed by Caves, Christensen and Diewert (1982), as explained in Appendix A. This method is used for the industry TFP indexes presented in chapter 2, the multilateral comparisons of productivity in chapter 3, and the individual TNSP indexes in chapter 4.

When the MTFP method is applied to data for a single TNSP, it provides information on the *changes over time* in productivity for the TNSP. The industry-level analysis in chapter 2 and the analysis of individual TNSPs in chapter 4, examine patterns of output, input and productivity over time. An analysis of *comparative productivity levels* of TNSPs is presented in chapter 3.

1.4.1 Defining Outputs

The output index for TNSPs is defined to include five outputs:¹

- Energy throughput in GWh (with 9.6 per cent share of gross revenue²),
- Ratcheted maximum demand (RMD) in Megawatts (MW) (with 29.0 per cent share of gross revenue),
- End-user numbers (with 9.4 per cent share of gross revenue),

¹ An exception arises in relation to Figure 2.1, and Figures 4.1.1, 4.2.1, 4.3.1, 4.4.1, and 4.5.1, which also show, for comparison, output and TFP indexes when output is defined to include only four outputs, not including Energy Not Supplied.

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 (TNSPs and years) shown in Table A.1 of Appendix A, section A3.2. Table A.1 assists in explaining the derivation of the output weights for the non-reliability outputs and the reliability output.

- (d) Circuit length in kms (with 53.1 per cent share of gross revenue), and
- (e) (minus) Energy not supplied (ENS) in MWh (with the weight based on current AER estimates of the Value of Customer Reliability (VCR) of –1.1 per cent, capped at a maximum absolute value of 2.5 per cent of total revenue).

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

In recognition of the variable nature of maximum demand, RMD is included as an output measure rather than maximum demand. Thereby, TNSPs get credit for providing the capacity to service maximum demands even when they decline in subsequent years. The RMD 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. Industry RMD is the sum of ratcheted maximum demands across the five TNSPs (rather than first summing the maximum demands and then calculating the ratcheted quantity).

Energy throughput is a measure of the size of the transport task. If an analogy to a road network is used, there is a distinction between the provision of the network (which has capacity, length and connectivity dimensions) and the amount of traffic, which influences maintenance requirements and the timing of asset renewal. Energy throughput is analogous to the latter. Important functions of a network include: the provision of capacity (i.e., the amount of flow that can be accommodated at particular points or over particular segments on the network); the spatial extension of the network which permits the energy to be transported over a given distance between specific places; and connectivity, which influences the complexity of the layout of a network. RMD is a measure of capacity. End-user numbers is an indicator of network connectivity or complexity. Circuit length is a measure of the spatial dimension of the supply activity.

The weights applied to non-reliability outputs are based on the estimated proportion of cost each output accounts for. These are derived from the coefficients of an econometrically-estimated Leontief cost function. This cost analysis was updated for this study as explained in section 1.1.

As discussed in more detail in Appendix A (section A3.2), the weight applying to the reliability output is based on the cost to end-users caused by lost supply; the quantity of ENS for each TNSP multiplied by the VCR in \$/MWh, which varies by State. The VCR was estimated by the AER for 2019 (AER 2019b, p. 71), and is adjusted by CPI in all other years of the data sample.

1.4.2 Defining Inputs

There are four TNSP inputs:³

- (a) Operating expenditure (opex) in '\$'000 (2006 prices) (total opex deflated by a composite labour, materials and services price index), making up 28.4 per cent of total cost on average,⁴
- (b) Overhead lines (quantity proxied by overhead MVAkms), making 27.5 per cent of total cost on average,
- (c) Underground cables (quantity proxied by underground MVAkms), making 1.6 per cent of total cost on average, and
- (d) Transformers and other capital (quantity proxied by transformer MVA), making 42.5 per cent of total cost on average.

These inputs are grouped into two broader categories. Input (a) is referred to as 'non-capital inputs', or 'opex input', whilst inputs (b) to (d) are together the 'capital inputs'. The capital inputs are aggregated for the purpose of calculating indexes of capital inputs and partial factor productivities (PFPs) for capital inputs.

As discussed in Economic Insights (2013), non-capital inputs are those consumed in a given year, whereas capital inputs are the productive services within the year from durable assets that last several years. Measuring the quantity of non-capital inputs is relatively straightforward, being the cost of labour, materials and services purchased in the year, deflated by an index of the prices of these inputs. Measurement of capital inputs raises more complicated conceptual issues. The method adopted by Economic Insights, which is well established in the productivity literature, is to assume that the flow of productive services from capital is proportionate to the quantity of capital measured in appropriate physical units.

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. As outlined in section 1.1, the return on capital is now 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 TNSPs. The calculation of the WACC for 2020 to 2023 reflects the AER's *Rate of Return Instrument 2018*

³ This is the average across years for the aggregated industry, as per the last column of Table A.3 of Appendix A.

⁴ This section reports average cost shares across all observations (TNSPs and years), as distinct from the averages for the aggregated industry shown in Table A.3.

(AER 2018). For 2024, the AER's *Rate of Return Instrument 2022* (AER 2023) applies.⁵ For earlier years (2006 to 2019), the AUC calculations broadly reflect the 2013 rate of return guideline (AER 2013). See Appendix A for further discussion of the input weights.

An opex price index is calculated from published ABS price indexes that approximate components of electricity TNSP costs, and it is used to deflate nominal opex to derive real opex. The opex price index differs depending on whether the TNSP reports data in financial April-to-March years for AusNet Services Transmission (AusNet) or July-to-June years (all other TNSPs).

1.5 Limitations

Economic Insights (2020b) suggested caution when using the TNSP economic benchmarking results to compare productivity levels across TNSPs given the difficulty of specifying the outputs. Nevertheless, it noted the ongoing development and refinement of TNSP economic benchmarking, including in the 2020 report.

This study uses EBRIN data, which is generally of high quality. The main limitation of the study is that the TNSPs included in the sample may not be fully comparable as they operate in different operating environments which can influence the ability of an efficient TNSP to transform inputs into outputs. The index analysis presented in this report does not explicitly take account of operating environment factors, although the multilateral index method does so to some extent, because the weights applied to inputs vary between TNSPs, reflecting both their own cost shares as well as industry average cost shares. Nevertheless, operating environment factors are not fully accounted for in this benchmarking analysis.

1.6 TNSP comments on draft report

Consistent with past practice, the AER released a draft version of this report to TNSPs for comment. Two submissions were received (Powerlink and Transgrid). Powerlink identified misalignment between the ENS reporting timeframes in the Quantonomics report and the AER's Annual Information Order (AIO) requirement to report for the calendar year preceding the reporting period. Powerlink recommended that the AER cross-check the AIO and Quantonomics data for consistency. In addition, Powerlink suggested a broader review of the transmission benchmarking specification to reflect the full range of TNSP services in the context of energy transformation. Powerlink encouraged the AER to advise when the next benchmarking specification review will be undertaken, preferably before the next Network

⁵ 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.

Information Requirements Review. Transgrid's comment concerned the use of benchmarking results in forecasting opex. These matters are addressed in the AER's TNSP report.

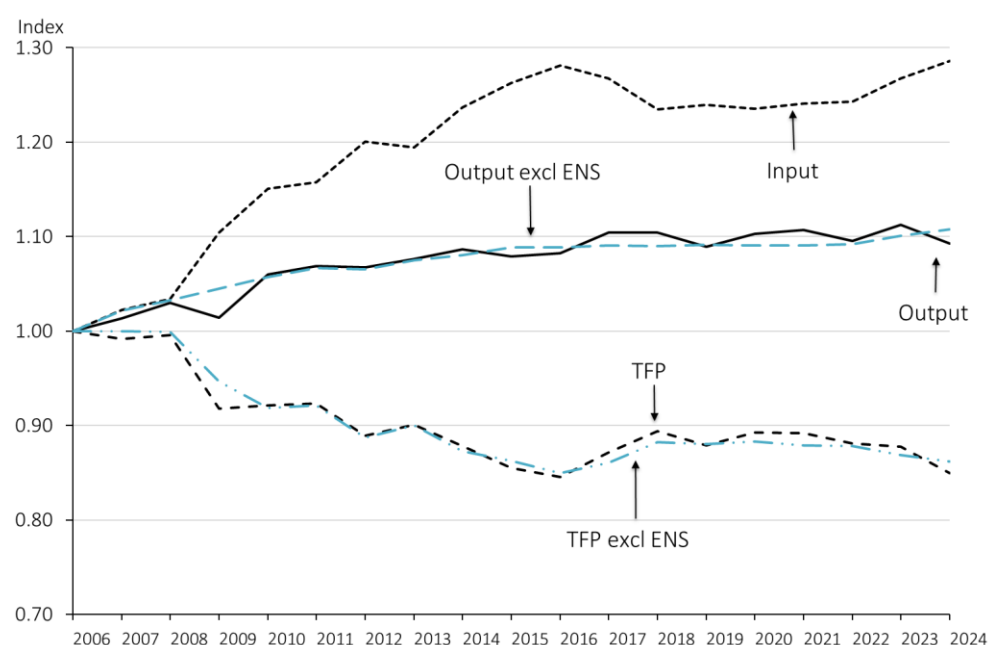
2 Industry-level Transmission Productivity Results

This chapter presents output, input and TFP indexes for the electricity transmission industry after aggregating across the five TNSPs; AusNet Services Transmission (ANT); ElectraNet (ENT); Powerlink (PLK); TasNetworks Transmission (TNT); and TransGrid (TRG).

2.1 Industry TFP

Transmission industry-level total output, total input and TFP indexes are presented in Figure 2.1 and Table 2.1.⁶ Opex and capital PFP indexes are also presented in Table 2.1. Figure 2.1 shows, for comparison, the industry output and TFP indexes if ENS was not included as an output. This highlights the effects of the ENS on movements in output and TFP.

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



Over the 19 years 2006 to 2024, industry-level TFP *declined* at an average annual rate of 0.9 per cent. Although total output increased on average by 0.5 per cent per year, total input use increased faster, at 1.4 per cent per year. Since the average rate of change in TFP is equal to the difference between the average rates of change in total output and total inputs, there was a negative average rate of productivity change over the same period.

⁶ Unlike the DNSP report, Figure 2.1 shows TFP results that exclude the reliability output (ENS). For TNSPs, which generally operate with very high reliability, even small variations in ENS can translate into large percentage changes, significantly affecting TFP outcomes. This sensitivity is less pronounced for DNSPs. Accordingly, the analysis excluding the reliability output is not presented in the DNSP report.

TFP change was positive in seven of the 19 years (2008, 2010, 2011, 2013, 2017, 2018 and 2020). Four of these were years where inputs decreased (2013, 2017, 2018 and 2020). The other three instances of TFP growth—where positive output growth exceeded positive input growth—were comparatively small increases. The industry output index *decreased* in seven of the 19 years (2009, 2012, 2015, 2018, 2019, 2022 and 2023). In all but one of these years, TFP decreased.

Table 2.1 TNSP 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	1.014	1.022	0.992	1.012	0.984
2008	1.030	1.034	0.996	1.034	0.980
2009	1.014	1.105	0.918	0.994	0.887
2010	1.060	1.151	0.921	0.991	0.892
2011	1.069	1.158	0.923	1.051	0.875
2012	1.067	1.201	0.889	1.020	0.840
2013	1.076	1.194	0.901	1.070	0.841
2014	1.086	1.237	0.878	0.998	0.833
2015	1.079	1.263	0.855	0.982	0.808
2016	1.083	1.281	0.845	0.968	0.799
2017	1.105	1.268	0.871	0.997	0.825
2018	1.104	1.235	0.894	1.131	0.814
2019	1.089	1.239	0.879	1.103	0.802
2020	1.103	1.235	0.893	1.122	0.813
2021	1.107	1.241	0.892	1.121	0.811
2022	1.095	1.243	0.881	1.088	0.806
2023	1.113	1.267	0.878	1.066	0.810
2024	1.093	1.286	0.850	0.995	0.797
Growth Rate 2006-2024	0.5%	1.4%	-0.9%	0.0%	-1.3%
Growth Rate 2006-2012	1.1%	3.0%	-2.0%	0.3%	-2.9%
Growth Rate 2012-2024	0.2%	0.6%	-0.4%	-0.2%	-0.4%
Growth Rate 2024	-1.8%	1.5%	-3.2%	-6.8%	-1.6%

In 2024, the input usage increased by 1.5 per cent, which is slightly above the average rate of increase for 2006 to 2024. Output *decreased* by 1.8 per cent in 2024, which is well below average growth of 0.5 per cent. The overall result was a strong *decline* in industry TFP, which *decreased* 3.2 per cent in 2024.

The decline in industry output was largely driven by a 248.6 per cent increase in ENS, which represents a negative output. This sharp rise in industry ENS was primarily due to a one-off outage event experienced by TRG in 2024, which resulted in a 438.4 per cent increase in its

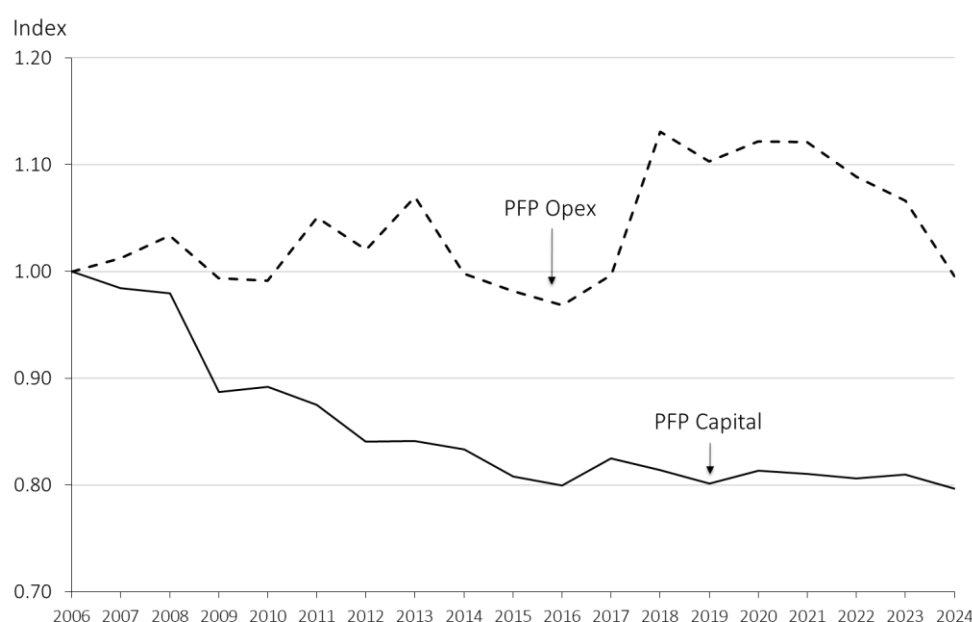
ENS. When ENS is excluded (as shown in Figure 2.1), output increased 0.7 per cent and TFP *decreased* by 0.8 per cent in 2024, similar to the long-term average rate of decline.

The average rate of growth of the industry output index from 2012 to 2024 is lower than the 2006-2024 period at 0.2 per cent per year. Similarly, the average rate of growth of the industry input index from 2012 to 2024 is lower than the 2006-2024 period at 0.6 per cent per year. Consequently, the average annual rate of TFP growth from 2012 to 2024 was –0.4 per cent. For the same period when ENS is excluded TFP decreased –0.2 per cent.

Table 2.1 also shows Partial Factor Productivity (PFP) indexes, which measure output relative to specific inputs, here the opex and aggregate capital inputs. Both PFP indexes were below 1.0 in 2024, indicating that the partial productivity of opex and capital input quantities was lower than the 2006 levels.

Figure 2.2 shows transmission industry PFP indexes trends for two broad categories of inputs, opex inputs and capital inputs. The average rate of change in opex PFP in the period from 2006 to 2024 was 0.0 per cent per annum. Opex productivity decreased relatively steadily from 2018, except for a small recovery in 2020. In 2024, opex PFP was 0.5 per cent *below* its 2006 level. Capital PFP *declined* on average at 1.3 per cent between 2006 and 2024. A substantial part of this decrease occurred in the period from 2006 to 2012. Capital PFP decreased fairly steadily up to 2016, partially recovered in 2017, then decreased again in five out of the next seven years. In 2024, capital PFP was 20.3 per cent *below* its 2006 level.

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



2.2 Industry output and input quantity changes & contributions to TFP change

To gain a more detailed understanding of what is driving these TFP changes, we examine the pattern of quantity change in the five transmission output components and the four transmission input components. We also consider the weight placed on each of these components in forming the total output and total input indexes. By decomposing TFP change into its constituent parts, contributions of individual output and inputs to that change can be ascertained.⁷ This section presents the growth rates of quantity indexes for individual outputs, shown in Table 2.2 and Figure 2.3, and inputs shown in Table 2.2 and Figure 2.4. Table 2.2 also shows growth rates of partial productivity indexes by individual input. We also present the contributions of each output and each input to TFP change, taking account of the quantity change in each component over time and its weight in forming the TFP index, as shown in Table 2.3 and Figures 2.5 and 2.6.⁸

Table 2.2 TNSP industry output, input and partial productivity growth rates

	2006-2024	2006-2012	2012-2024	2024
<i>Outputs:</i>				
Energy (GWh)	-0.3%	-0.1%	-0.4%	0.9%
Ratcheted Max Demand (MVA)	0.7%	1.8%	0.2%	1.2%
End-users	1.3%	1.3%	1.3%	1.0%
Circuit Length (km)	0.5%	0.8%	0.3%	0.3%
ENS (MWh)*	7.9%	-1.0%	12.3%	248.6%
<i>Inputs:</i>				
Real Opex (\$'000 2006)	0.5%	0.8%	0.4%	5.1%
O/H Lines (MVA-kms)	1.0%	2.7%	0.2%	-2.8%
U/G Lines (MVA-kms)	3.6%	4.3%	3.2%	-2.0%
Transformers (MVA)	2.2%	5.0%	0.8%	1.5%
NB: Capital inputs	1.8%	4.0%	0.6%	-0.2%
<i>Partial productivity:</i>				
Output / Real Opex	0.0%	0.3%	-0.2%	-6.8%
Output / OH Lines	-0.5%	-1.6%	0.0%	1.0%
Output / UG Lines	-3.1%	-3.2%	-3.1%	0.2%
Output / Transformers	-1.7%	-3.9%	-0.6%	-3.3%
NB: Output / Capital	-1.3%	-2.9%	-0.4%	-1.6%

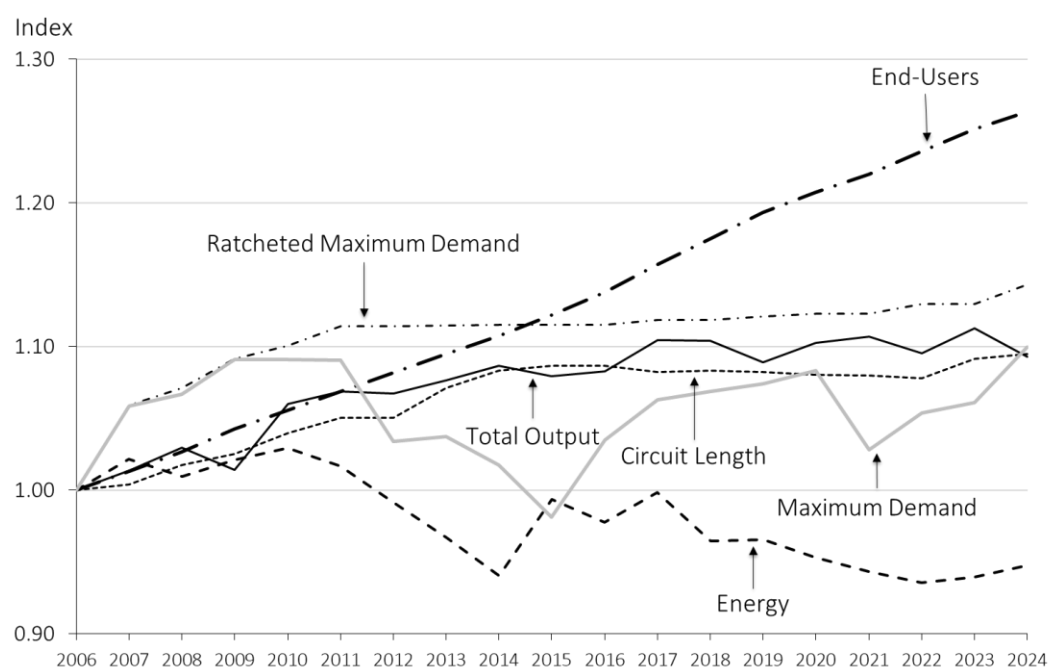
⁷ Consistent with Economic Insights (2020), growth rates in indexes are generally expressed in this report as logarithmic growth measures. That is, the growth rate of a variable Y between period $t-1$ and period t is calculated as: $g_t^Y = \ln Y_t - \ln Y_{t-1}$. It follows that some decreases in positively-valued 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 a mid-point between periods $t-1$ and t . The log-difference growth rate can be related to the more common growth rate measure based on the first period as follows: $(Y_t - Y_{t-1})/Y_{t-1} = \exp(g_t^Y) - 1$.

⁸ Appendix A presents the methodology that allows the change in productivity (i.e., the change in the MTFP index) to be decomposed into the contributions of changes in each output and each input.

As shown in Table 2.2, over the 2006–2024 period the industry output with the highest growth rate is ENS, energy not supplied due to network limitations, which is an inverse measure of reliability. This enters the total output index as a negative output since a reduction in ENS represents an improvement and a higher level of service for end-users. Conversely, an increase in ENS reduces total output as end-users are inconvenienced more by not having supply over a wider area and/or for a longer period.

ENS can fluctuate widely from year-to-year because transmission outage rates are usually very low so they can appear to be volatile in years where unusual events happen.⁹ For this reason this output is not presented in Figure 2.3. ENS had been on a downward trend in the 2006–2012 period, *decreasing* by 1.0 per cent per year. However, in 2024, it experienced a sharp spike, increasing by 248.6 per cent and reaching a level 314.9 per cent higher than in 2006. This affected the full period growth rate, which averaged 7.9 per cent per year, as well as the growth rate for the second half of the period, which averaged 12.3 per cent per year.¹⁰

Figure 2.3 TNSP industry output quantities, 2006–2024



⁹ The largest of these movements was the upwards spike in 2009 associated with a transformer failure at ANT's South Morang Terminal Station. The second largest was in 2024, associated with a severe storm that caused a major loss of supply event affecting TRG.

¹⁰ Although ENS has a comparatively small weight of –1.1 per cent of total revenue on average (see Table A.2 in Appendix A), the more extreme variation in ENS means that total output movements are significantly influenced by the pattern of movement in the ENS output (noting that an increase in ENS has a negative impact on total output). However, the impact of extreme ENS events on total output is limited by capping this output's weight (in absolute terms) for each TNSP at 2.5 per cent of total revenue of the TNSP.

As shown in Table 2.4, over the 2006 to 2024 period, the increase in ENS had only a minor impact on TFP, *reducing* it by just 0.08 percentage points. This reflects its small output cost weight of only –1.1 per cent (see Table A.2 in Appendix A). However, in 2024, the impact was more substantial, with ENS contributing a *reduction* of 2.5 percentage points to TFP.

End-user numbers experienced the second highest growth rate, increasing steadily over the 19-years period at an average of 1.3 per cent per year. This growth rate remained consistent in both halves of the period. Its relatively steady increase is approximately in line with population growth. In 2024, end-users was 26.3 per cent higher in 2024 than it was in 2006.¹¹ End-users has an output cost weight (see Table A.2 in Appendix A) of 9.4 per cent and contributed 0.12 percentage points to TFP change in 2006-2024 period and 0.09 percentage points in 2024.

Circuit length and RMD increased at relatively low rates over the 2006 to 2024 period, by 0.5 and 0.7 per cent per year respectively. Both outputs increased more strongly in the first half of the period and more slowly in the second half. In 2024, circuit length increased by 0.3 per cent, and was 9.5 per cent higher than in 2006 while RMD increased by 1.2 per cent and was 14.3 per cent above its 2006 level. Together, circuit length and RMD account for 82.2 per cent of the output cost share and contributed 0.49 percentage points to TFP change over both the 2006 to 2024 period and the year 2024. The relatively modest growth in the circuit length output compared to the growth in end-users reflects the fact that most of the increase in end-use customer numbers over the period has been able to be accommodated by ‘in fill’ off the existing TNSP networks without requiring large extensions of the transmission network length.

By contrast to other outputs, energy throughput for transmission *decreased* by 0.3 per cent per year over the 2006–2024 period. The majority of this decrease occurred in the 2012–2024 period, where it *declined* by 0.4 per cent per year. In 2024, transmission energy throughput was 5.2 per cent *less* than in 2006.¹² The difference between the increases in RMD and decreases in energy throughput indicates a deteriorating load factor for the NEM transmission industry.¹³ Energy throughput has an output cost weight of 9.6 per cent (see Table A.2 in Appendix A) and contributed –0.03 percentage points to TFP change over the 2006 to 2024 period, and 0.08 percentage points to TFP change in 2024.

Turning to the input side, the fastest growing input is underground cables whose quantity was 91.5 per cent higher in 2024 than it was in 2006 and increased 3.6 per cent per year over the

¹¹ The index value for each input and output in each year can be found in the supporting files, specifically in the "TNSP-MTP Tables-Charts" spreadsheet, sheet "Individ-O&I Tables".

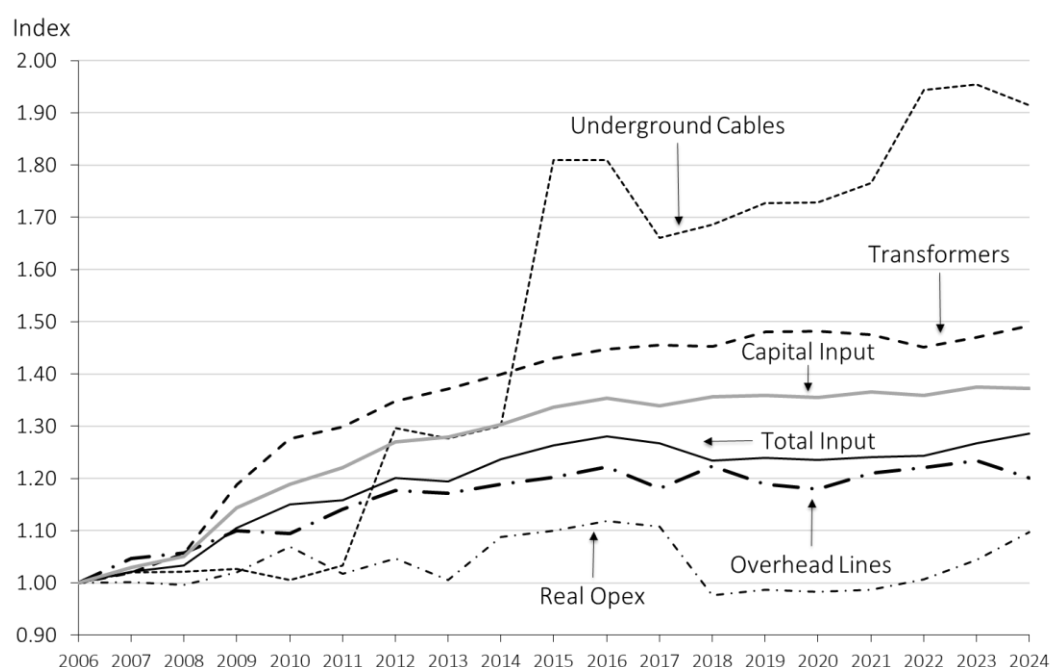
¹² The decline in energy throughput since around 2010 partly reflects economic conditions being more subdued since the global financial crisis but, more importantly, the increasing impact of energy conservation initiatives, more energy efficient buildings and appliances and greater penetration of local distributed generation (Economic Insights 2019, 4).

¹³ Load factor is here defined as the average hourly consumption on the network in a year divided by the maximum demand.

period. However, this growth starts from a quite small base and so a higher growth rate is to be expected. The increase in length and/or capacity of transmission underground cables in the 2006–2012 period was 4.3 per cent per year, and in the 2012–2024 it was 3.2 per cent per year. In 2024 it *decreased* 2.0 per cent.

The scope to put significant parts of the transmission network underground is considerably less than it is for distribution and the cost relatively greater. Underground cable inputs in transmission have an average share of total costs of only 1.6 per cent for the industry, (see Table A.3 in Appendix A) compared to a share in total costs of 12.7 per cent for distribution. Given its small weight, it contributed only to –0.06 percentage points to TFP change in 2006–2024 period and 0.01 percentage points in 2024.

Figure 2.4 TNSP industry output quantities, 2006–2024



Transformers account for the largest average share of total cost, at 42.5 per cent (see Table A.3 in Appendix A), and consequently is an important driver of the total input quantity index. The quantity of transformer input increased over the 2006–2024 period at 2.2 per cent per year. The majority of this increase occurred in the first half of the period, when transformer input increased by 5.0 per cent per year. In 2024, transformers increased 1.5 per cent and in that year was 49.2 per cent above its 2006 level. This input made a large negative contribution to TFP, *reducing* it by 0.88 percentage points over the 19-year period and by 0.72 percentage points in 2024.

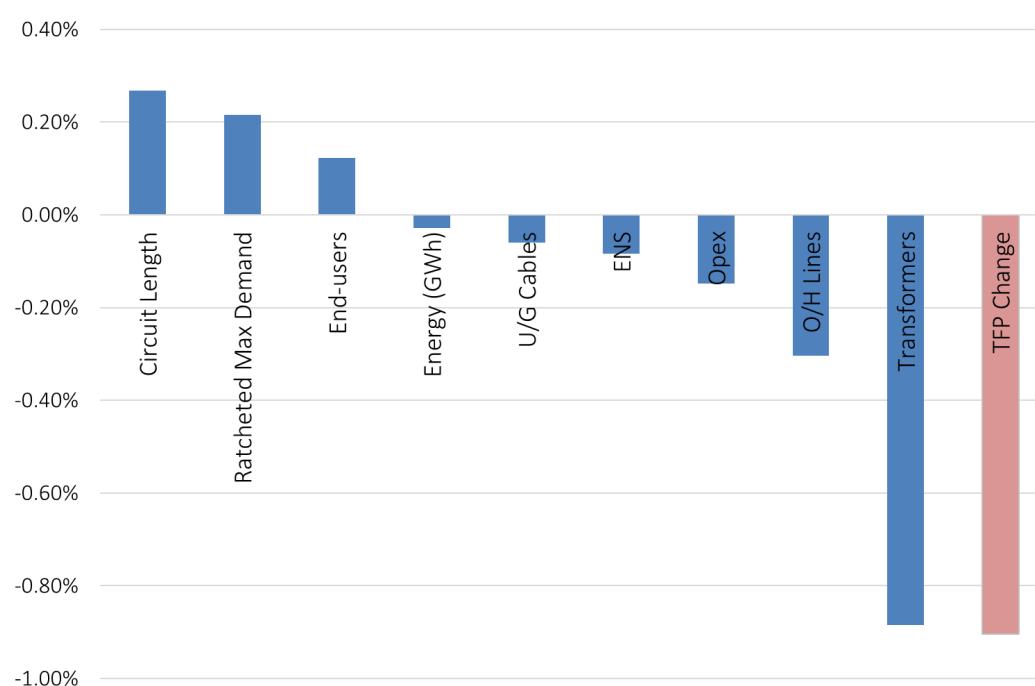
The overhead lines increased the second least over the entire period, at 1.0 per cent per year, being 20.1 per cent higher in 2024 than it was in 2006. In 2024, overhead lines *decreased* by 2.8 per cent. Overhead lines, which account for 27.5 per cent of total TNSP costs on average (see

Appendix A, Table A.3), contributed to -0.30 percentage points over the 19-year period and 0.67 percentage points in 2024. It should be noted that overhead line input quantities take account of both the length of lines and the overall ‘carrying capacity’ of the lines (in MVA). The fact that the overhead lines input quantity has increased substantially more than network length reflects the fact that the average capacity of overhead lines has increased over the period as new lines and replacement of old lines are both of higher carrying capacity than older lines.

Table 2.4 Transmission industry output and input percentage point contributions to average annual TFP change: various periods

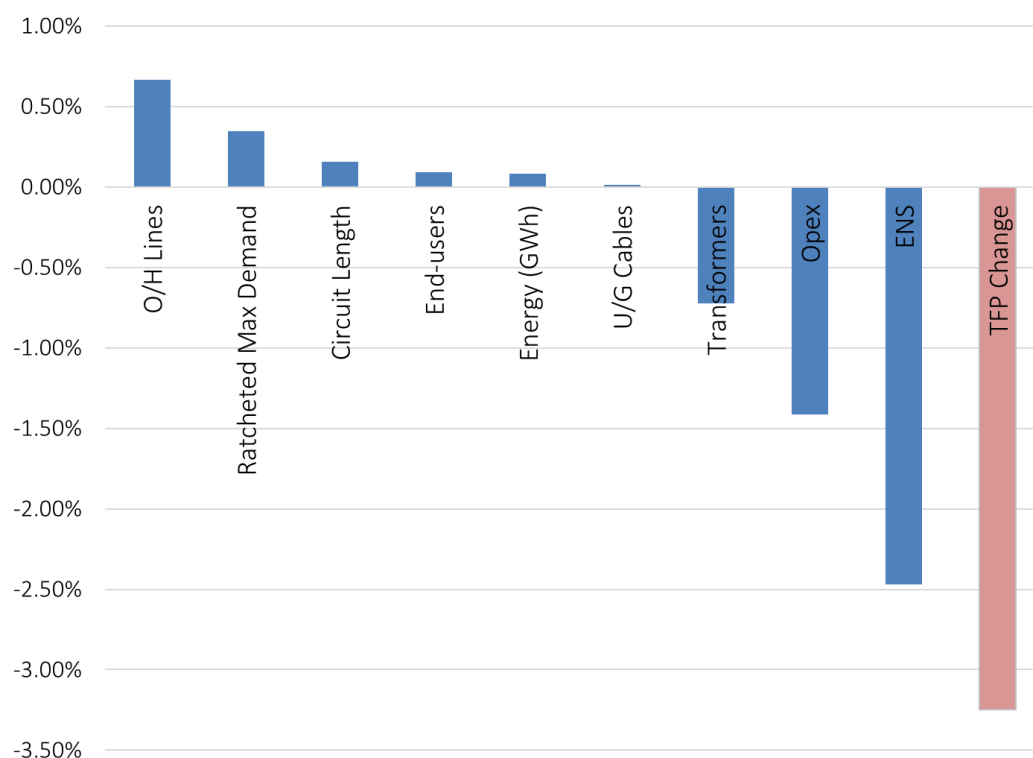
<i>Year</i>	<i>2006 to 2024</i>	<i>2006 to 2012</i>	<i>2012 to 2024</i>	<i>2024</i>
Energy (GWh)	-0.03%	-0.01%	-0.04%	0.08%
Ratcheted Max Demand	0.22%	0.52%	0.06%	0.35%
End-users	0.12%	0.12%	0.12%	0.09%
Circuit Length	0.27%	0.44%	0.18%	0.15%
ENS	-0.08%	0.01%	-0.13%	-2.47%
Opex	-0.15%	-0.21%	-0.12%	-1.41%
O/H Lines	-0.30%	-0.83%	-0.04%	0.67%
U/G Cables	-0.06%	-0.08%	-0.05%	0.01%
Transformers	-0.88%	-1.92%	-0.37%	-0.72%
TFP Change	-0.90%	-1.96%	-0.38%	-3.25%

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



The quantity of opex (i.e., opex in constant 2006 prices) is the input with lowest growth, increasing on average at 0.8 per cent per year over the period 2006–2012. From 2012 to 2024, the rate of increase slowed to 0.4 per cent per year. In 2024, opex increased by 5.1 per cent, making it the input with the highest growth in that year. By 2024, opex usage was 9.8 per cent higher than in 2006. Opex has the second largest average share in total costs at 28.4 per cent (see Table A.3 in Appendix A) and contributed –0.15 percentage points to TFP growth over the 19-year period and –1.41 percentage points in 2024.

Figure 2.6 Transformers industry output and input percentage point contributions to average annual TFP change, 2024



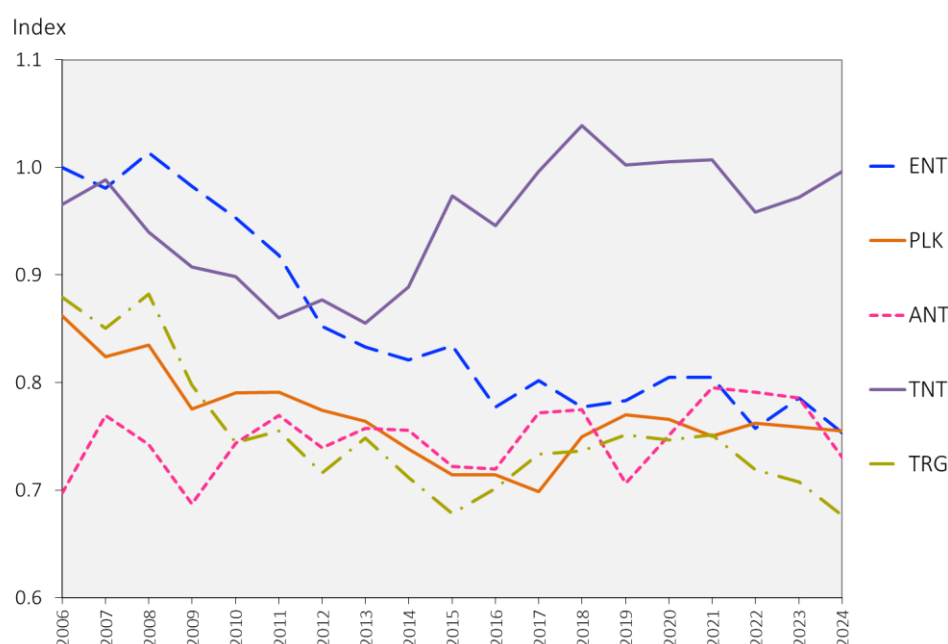
3 TNSP Comparative Productivity Results

In this chapter we present updated comparative results for TNSPs using MTFP and MPFP indexes. As outlined in chapter 1, MTFP and MPFP indexes calculated with pooled data allow comparisons of productivity levels as well as productivity growth to be made.¹⁴ These indexes are presented in Figure 3.1 and Table 3.1. These indexes are measured relative to ENT in 2006, which is equal to 1.00.

3.1 Multilateral TFP Indexes

Figure 3.1 plots the MTFP indexes of each TNSP. It shows that, except for TNT, differences between MTFP levels narrowed in the second half of the period.

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



The MTFP levels of three TNSPs—ENT, TRG and PLK—trended down to around 2016 before levelling out or increasing somewhat. In contrast, the MTFP level of TNT generally trended down to around 2013, then trended upward until 2018. There we subsequent declines up to 2022, and the increases in 2023 and 2024 were insufficient to reach the 2018 levels again. ANT’s MTFP, on the other hand, fluctuated over the 19-year period, at a relatively low level. It showed a small upward trend in 2020 and 2021, followed by marginal decreases in 2022 and 2023, and a sharp *decrease* of 7.3 per cent in 2024.

¹⁴ For convenience, index results are presented relative to ENT in 2006 having a value of one. The comparative results are invariant to which observation is used as the base.

Table 3.1 TNSP multilateral TFP indexes, 2006–2024

<i>Year</i>	<i>ENT</i>	<i>PLK</i>	<i>ANT</i>	<i>TNT</i>	<i>TRG</i>
2006	1.000	0.862	0.697	0.966	0.879
2007	0.981	0.824	0.769	0.988	0.850
2008	1.014	0.835	0.742	0.940	0.882
2009	0.982	0.775	0.687	0.907	0.797
2010	0.953	0.790	0.744	0.898	0.744
2011	0.918	0.791	0.770	0.860	0.755
2012	0.852	0.774	0.739	0.877	0.716
2013	0.833	0.764	0.757	0.855	0.749
2014	0.821	0.738	0.756	0.889	0.712
2015	0.834	0.714	0.722	0.974	0.678
2016	0.777	0.714	0.720	0.946	0.702
2017	0.802	0.699	0.772	0.996	0.733
2018	0.777	0.750	0.775	1.039	0.736
2019	0.783	0.770	0.707	1.002	0.751
2020	0.805	0.766	0.751	1.005	0.746
2021	0.805	0.750	0.7950	1.007	0.751
2022	0.757	0.762	0.7910	0.958	0.719
2023	0.785	0.759	0.786	0.972	0.707
2024	0.753	0.755	0.731	0.996	0.677
Avg. increase 2006-2024	-1.6%	-0.7%	0.3%	0.2%	-1.5%
Increase 2024	-4.2%	-0.5%	-7.3%	2.5%	-4.4%

The MTFP of the individual TNSPs can be summarised as follows:

- TNT's productivity level usually ranked second up until 2011 but increased noticeably in 2014 and 2015 with the introduction of restructuring and reform initiatives. TNT has remained the highest ranked TNSP in terms of productivity level from 2012 to 2024. Its TFP level in 2024 of 1.00 was 3.2 per cent higher than its productivity level in 2006.
- PLK had the second highest MTFP index in 2024 at 0.75, only marginally higher than that of ENT. In 2023, PLK held the second-lowest MTFP index. PLK experienced strong declines from 2006 to 2017, a partial recovery from 2018 to 2019, with a small declining trend thereafter. PLK's MTFP level in 2024 remained below that of 2006 (0.86), representing an average rate of MTFP change of –0.7 per cent per year. The increase in PLK's ranking in 2024 was larger decreases in MTFP of most of the other TNSPs.
- ENT's productivity level was usually ranked first up until 2011, and second up until 2021. However, in 2022, it dropped to fourth place with a decrease in MTFP of 6.1 per cent and partially recovered in 2023, with an MTFP increase of 3.7 per cent, which

elevated ENT to third place. In 2024, ENT remained in third position with a MTFP of 0.75, despite a 4.2 per cent *decrease* in MTFP in that year. Its TFP level in 2024 of 1.00 was 24.7 per cent *lower* than its productivity level in 2006.

- ANT started the period in 2006 with the lowest MTFP level at 0.70. In some years there has been substantial improvement (eg, 2007, 2010, 2017, 2020 and 2021) while in other years TFP has fallen back (eg, 2008, 2009, 2019 and 2024) due to increases in ENS and increases in input usage. Over the period from 2006 to 2024, the rate of change in MTFP averaged 0.3 per cent per year, which is slightly higher than TNT, the only other TNSP with a positive TFP trend over this period. In 2024, ANT had the second lowest ranking, with MTFP at 0.73.
- In 2006, TRG had the third highest MTFP level, at 0.88. TRG experienced a relatively steady decline up to 2016, and then a moderate recovery up to 2021. From 2022 to 2024, it had considerable decreases in MTFP. TRG had an average annual *decline* in MTFP between 2006 and 2024 of 1.5 per cent. Its MTFP level in 2024, at 0.68, was 23.0 per cent lower than in 2006. It ranked last place among TNSPs in 2024.

3.2 Multilateral PFP Indexes

MTFP levels are an amalgam of opex MPFP and capital MPFP levels. Opex MPFP indexes are presented in Figure 3.2 and Table 3.2 while capital MPFP indexes are presented in Figure 3.3 and Table 3.3.

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

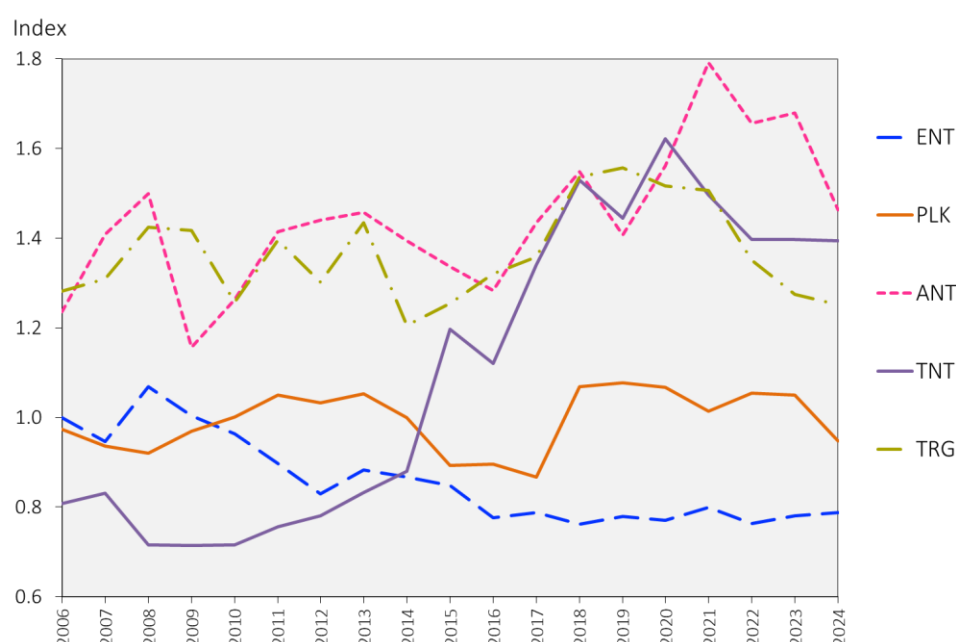


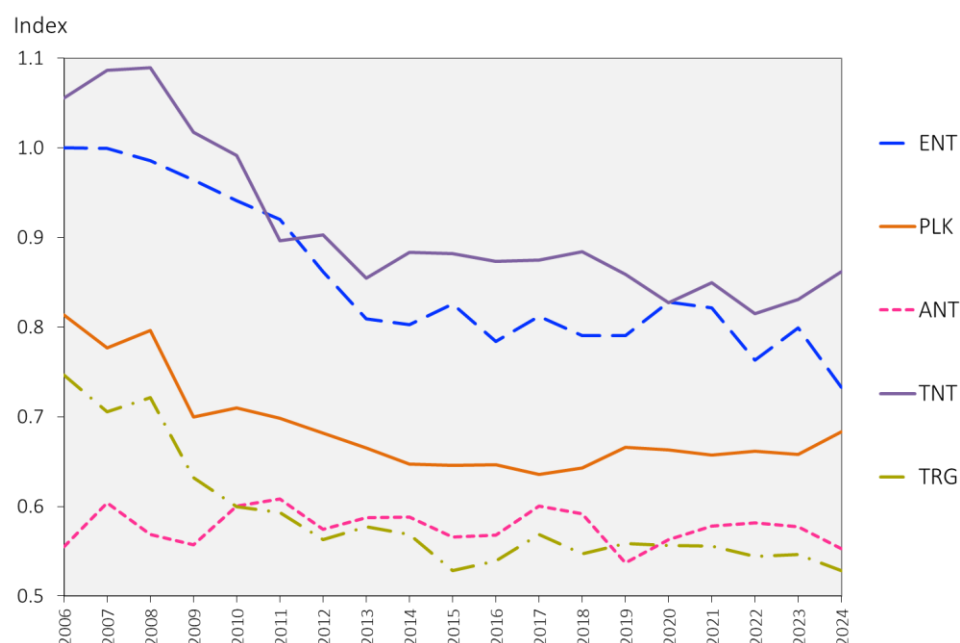
Table 3.2 TNSP multilateral opex partial factor productivity indexes, 2006–2024

<i>Year</i>	<i>ENT</i>	<i>PLK</i>	<i>ANT</i>	<i>TNT</i>	<i>TRG</i>
2006	1.000	0.973	1.235	0.808	1.282
2007	0.945	0.936	1.409	0.830	1.310
2008	1.069	0.920	1.499	0.715	1.424
2009	1.003	0.969	1.157	0.714	1.417
2010	0.964	1.001	1.262	0.716	1.257
2011	0.897	1.049	1.414	0.756	1.396
2012	0.829	1.033	1.440	0.781	1.302
2013	0.883	1.052	1.457	0.832	1.434
2014	0.867	0.999	1.394	0.879	1.206
2015	0.848	0.892	1.337	1.197	1.254
2016	0.776	0.896	1.282	1.121	1.321
2017	0.788	0.866	1.434	1.341	1.358
2018	0.762	1.069	1.548	1.530	1.537
2019	0.779	1.078	1.407	1.444	1.556
2020	0.770	1.067	1.561	1.622	1.516
2021	0.799	1.013	1.792	1.496	1.507
2022	0.763	1.054	1.656	1.397	1.350
2023	0.780	1.050	1.679	1.397	1.274
2024	0.788	0.948	1.463	1.393	1.251
Avg. increase 2006-2024	-1.3%	-0.1%	0.9%	3.0%	-0.1%
Increase 2024	1.1%	-10.2%	-13.8%	-0.3%	-1.9%

From Figure 3.2 we see that ANT and TRG had the highest opex MPFP levels over the first half of the 19-year period but have been joined at the top by TNT since 2015. TNT had the lowest opex MPFP levels from 2006 to 2013 but marked increases in opex MPFP in 2015 and again in 2017, 2018 and 2020 have taken it to the second highest ranking in 2022 despite consecutive declines since 2021. It had an average annual opex MPFP growth rate for the full period (2006 to 2024) of 3.0 per cent.

ANT has the highest opex MPFP level in 2024, despite a sharp *decrease* in opex MPFP growth in 2024 of 13.8 per cent. Its increase in opex MPFP from 2006 to 2024 averaged 0.9 per cent per annum. TRG had the third highest opex MPFP in 2024, and over the period 2006 to 2024, this *decreased* at an average annual rate of 0.1 per cent. TRG has been experiencing a downward trend in opex MPFP since 2020, and in 2024 there was a *decline* of 1.9 per cent.

PLK ranked the second lowest in opex MPFP in 2024 with an average annual change of –0.1 per cent over the period 2006 to 2024 and a large *decrease* in 2024 of 10.2 per cent. The TNSP with the lowest opex MPFP in 2024, ENT, also had the lowest opex MPFP average annual change over the period 2006 to 2024, at –1.3 per cent. For the year 2024, its opex MPFP increased 1.1 per cent.

Figure 3.3 TNSP multilateral capital partial factor productivity indexes, 2006–2024**Table 3.3** TNSP multilateral capital partial factor productivity indexes, 2006–2024

<i>Year</i>	<i>ENT</i>	<i>PLK</i>	<i>ANT</i>	<i>TNT</i>	<i>TRG</i>
2006	1.000	0.813	0.555	1.055	0.746
2007	0.999	0.777	0.604	1.087	0.706
2008	0.986	0.796	0.569	1.089	0.721
2009	0.964	0.700	0.557	1.018	0.632
2010	0.941	0.710	0.601	0.991	0.600
2011	0.920	0.698	0.608	0.896	0.593
2012	0.862	0.682	0.574	0.903	0.563
2013	0.809	0.665	0.588	0.855	0.577
2014	0.802	0.647	0.588	0.884	0.569
2015	0.826	0.646	0.566	0.882	0.529
2016	0.784	0.646	0.568	0.873	0.539
2017	0.812	0.636	0.601	0.874	0.569
2018	0.790	0.643	0.592	0.884	0.547
2019	0.791	0.666	0.537	0.859	0.559
2020	0.828	0.663	0.563	0.827	0.556
2021	0.821	0.658	0.578	0.849	0.556
2022	0.763	0.661	0.581	0.815	0.544
2023	0.799	0.658	0.578	0.831	0.547
2024	0.733	0.684	0.553	0.862	0.528
Avg. increase 2006-2024	-1.7%	-1.0%	0.0%	-1.1%	-1.9%
Increase 2024	-8.6%	3.8%	-4.3%	3.7%	-3.4%

From Figure 3.3 we can see that capital MPFP levels have generally declined over the 19-year period. The one exception is ANT, whose capital MPFP has fluctuated over time but had no underlying trend (an average annual rate of change of 0.0 per cent). In 2024, ANT's capital MPFP *decreased* by 4.3 per cent.

On average, the annual rates of change of capital MPFP for the other TNSPs over the 19-year period were as follows: PLK's was at -1.0 per cent; TNT's at -1.1 per cent; ENT's at -1.7 per cent and TRG's was at -1.9 per cent, the largest capital MPFP decline. In 2024, capital MPFP change was negative for ENT (-8.6 per cent), for ANT (-4.3 per cent), and for TRG (-3.4 per cent). PLK and TNT had positive capital MPFP changes in 2024 at 3.8 and 3.7 per cent respectively.

4 TNSP Outputs, Inputs and Productivity Change

In this chapter we review the outputs, inputs and productivity change results for the five NEM TNSPs. To provide context, individual TNSP results are generally compared with the corresponding transmission industry-level result presented earlier in section 2.

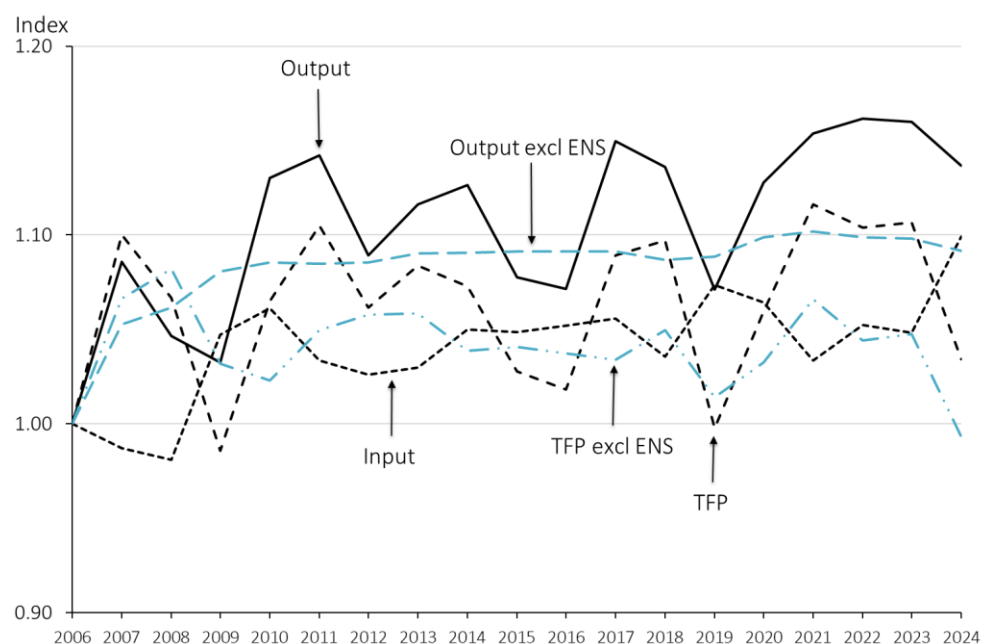
4.1 AusNet Services Transmission (ANT)

In 2024 ANT transported 42,933 GWh of electricity over 6,551 circuit kilometres of lines and cables. It forms a critical part of Victoria's energy supply chain, serving 3.2 million end-users. ANT is the third largest TNSP in the NEM in terms of both energy throughput and circuit length, but it serves the second largest number of end-users.

4.1.1 ANT's productivity performance

ANT's total output, total input, TFP indexes and capital PFP indexes are presented in Figure 4.1.1 and Table 4.1.1.

Figure 4.1.1 ANT output, input and TFP indexes, 2006–2024



Over the 19-year period from 2006 to 2024, ANT's TFP changed at an average annual rate of 0.2 per cent. Its total output increased by an average annual rate of 0.7 per cent, which is slightly large than its rate of increase in total input use of 0.5 per cent. This differs from the situation for the transmission industry as a whole where input use increased considerably more than output growth over this period. ANT's TFP growth in the first half of the period up to 2012 averaged 1.0 per cent per year. However, it decreased in the second half from 2012 to

2024, averaging –0.2 per cent per year. This decline is associated with a 9.5 per cent *decrease* in TFP in 2019 and a 6.8 per cent *decrease* in 2024.

Figure 4.1.1 also shows the output and TFP indexes when ENS is excluded. This highlights the effect of ENS, showing that the year-to-year volatility of output, which is apparent in Figure 4.1.1, is mostly driven by ENS. Poor reliability outcomes can sharply reduce the output index, and since total input is relatively steady with a small upward trend, the effect of ENS on output is to also produce fluctuations in TFP. When ENS is excluded, ANT's TFP *decreased* by 5.3 per cent in 2024. The 2.0 per cent *decrease* in output in 2024, shown in Table 4.1.1, is part due to reliability deterioration. When ENS is excluded, the output *decrease* is 0.6 per cent in 2024.

Table 4.1.1 ANT 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	1.086	0.987	1.100	1.141	1.087
2008	1.047	0.981	1.067	1.214	1.024
2009	1.032	1.047	0.986	0.938	1.002
2010	1.130	1.061	1.065	1.022	1.079
2011	1.142	1.033	1.105	1.144	1.092
2012	1.089	1.026	1.062	1.165	1.030
2013	1.116	1.030	1.084	1.180	1.054
2014	1.127	1.050	1.073	1.129	1.056
2015	1.078	1.048	1.028	1.082	1.011
2016	1.071	1.052	1.018	1.039	1.013
2017	1.150	1.056	1.089	1.160	1.068
2018	1.136	1.036	1.097	1.253	1.051
2019	1.071	1.073	0.998	1.140	0.955
2020	1.128	1.064	1.059	1.265	1.000
2021	1.154	1.034	1.116	1.450	1.025
2022	1.162	1.052	1.104	1.338	1.033
2023	1.160	1.048	1.107	1.358	1.033
2024	1.137	1.099	1.034	1.184	0.989
Growth Rate 2006-2024	0.7%	0.5%	0.2%	0.9%	-0.1%
Growth Rate 2006-2012	1.4%	0.4%	1.0%	2.5%	0.5%
Growth Rate 2012-2024	0.4%	0.6%	-0.2%	0.1%	-0.3%
Growth Rate 2024	-2.0%	4.7%	-6.8%	-13.6%	-4.4%

Table 4.1.1 also shows PFP indexes. The average rate of change in opex PFP in the period from 2006 to 2024 was 0.9 per cent per annum, with a rate of growth of 2.5 per cent in the first half of the period (2006-12) and 0.1 per cent in the second (2012-24). ANT's opex PFP *decreased* by 13.6 per cent in 2024.

Capital PFP had –0.1 per cent growth on average between 2006 and 2024. This is a net effect of an increase in the period 2006 to 2012, in which capital PFP grew on average by 0.5 per cent per annum, and *decrease* of 0.3 per cent in period 2012 to 2024. ANT’s capital PFP *decreased* by 4.4 per cent in 2024.

4.1.2 ANT's output and input quantity changes & contributions to TFP change

Average growth rates of quantity indexes for ANT’s individual outputs and inputs, and for partial productivity indexes for individual inputs, are presented in Table 4.1.2. Table 4.1.3 shows the decomposition of ANT’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 4.1.2 shows the contributions of outputs and inputs to ANT’s average rate of TFP change in 2024.

Table 4.1.2 ANT output, input and partial productivity growth rates

	2006-2024	2006-2012	2012-2024	2024
<u>Outputs:</u>				
Energy (GWh)	-0.3%	0.8%	-0.8%	-0.9%
Ratcheted Max Demand (MVA)	1.4%	4.0%	0.0%	0.0%
End-users	1.5%	1.4%	1.5%	1.2%
Circuit Length (km)	0.0%	0.0%	0.0%	-1.2%
ENS (MWh)*	-15.4%	-1.8%	-22.1%	263.7%
<u>Inputs:</u>				
Real Opex (\$'000 2006)	-0.2%	-1.1%	0.2%	11.6%
O/H Lines (MVA-kms)	0.0%	0.0%	0.0%	-0.8%
U/G Lines (MVA-kms)	-1.6%	0.0%	-2.3%	0.0%
Transformers (MVA)	1.3%	1.7%	1.1%	4.1%
NB: Capital inputs	0.8%	0.9%	0.7%	2.3%
<u>Partial productivity:</u>				
Output / Real Opex	0.9%	2.5%	0.1%	-13.6%
Output / OH Lines	0.7%	1.4%	0.3%	-1.2%
Output / UG Lines	2.3%	1.4%	2.7%	-2.0%
Output / Transformers	-0.6%	-0.2%	-0.8%	-6.2%
NB: Output / Capital	-0.1%	0.5%	-0.3%	-4.4%

Over the 2006–2024 period, ANT’s outputs with the highest growth rates were end-user numbers, which increased by 1.5 per cent per year (similar to the industry average of 1.3 per cent), and RMD, which increased by 1.4 per cent per year (faster than the industry average of 0.7 per cent). RMD accounted for 29.0 per cent of ANT’s output cost share and contributed 0.39 percentage points to TFP over the period, while end-users accounted for 9.4 per cent of costs and contributed 0.14 percentage points.

ANT's output with the lowest growth rate over the 19-year period was ENS, which *decreased* by 15.4 per cent per year, in contrast to the industry average increase of 7.9 per cent per year. The decline in ENS for ANT represents an improvement in output. ENS accounts for –1.2 per cent of ANT's total output cost share and contributed 0.21 percentage points to ANT's TFP over the period.

Turning to the input side, transformers are ANT's largest input component by cost, accounting for 46.2 per cent of total input costs. The quantity of transformers increased by 1.3 per cent per year over the 19-year period, which is below the industry growth rate of 2.2 per cent and contributed –0.59 percentage points to ANT's TFP.

Opex and overhead lines also have considerable weight in ANT's cost structure, together accounting for 52.8 per cent. Over the 2006–2024 period, their growth rates were low: –0.2 per cent for opex and 0.0 per cent for overhead lines, both below the industry averages of 0.5 and 1.0 per cent, respectively. As a result, their combined contribution to ANT's TFP was just 0.05 percentage points.

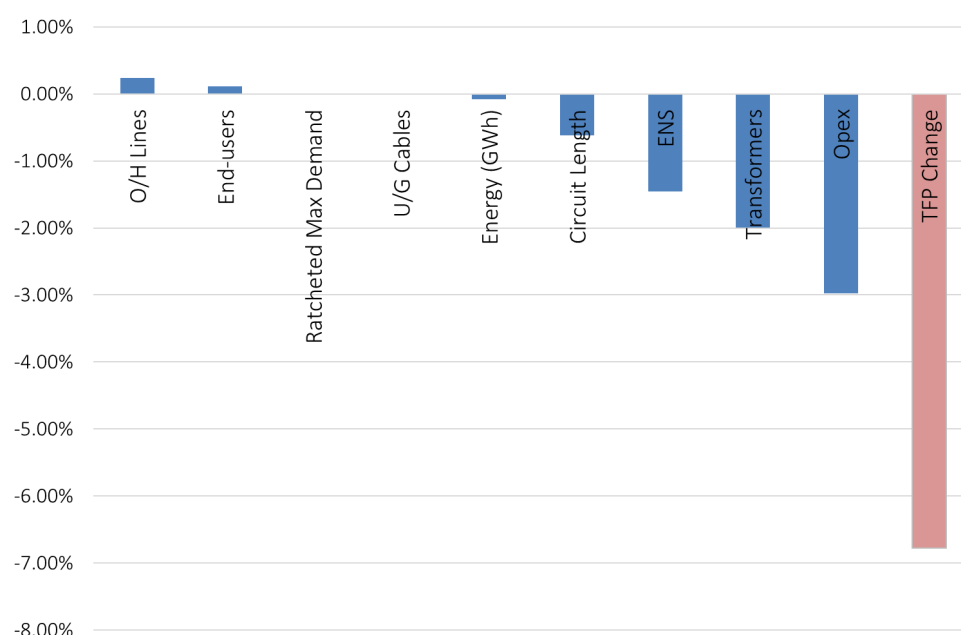
Underground cable quantity *decreased* by 1.6 per cent per year over the same period, in contrast to industry growth of 3.6 per cent. However, given its small cost share of 1.0 per cent, its impact on ANT's TFP was minimal, contributing only 0.02 percentage points.

Table 4.1.3 ANT output and input percentage point contributions to average annual TFP change: various periods

<i>Year</i>	<i>2006 to 2024</i>	<i>2006 to 2012</i>	<i>2012 to 2024</i>	<i>2024</i>
Energy	-0.03%	0.08%	-0.08%	-0.08%
Ratcheted Max Demand	0.39%	1.17%	0.01%	0.00%
End-users	0.14%	0.14%	0.14%	0.11%
Circuit Length	-0.01%	0.00%	-0.01%	-0.62%
ENS	0.21%	0.03%	0.31%	-1.45%
Opex	0.06%	0.27%	-0.05%	-2.98%
O/H Lines	-0.01%	0.00%	-0.01%	0.24%
U/G Cables	0.02%	0.00%	0.02%	0.00%
Transformers	-0.59%	-0.70%	-0.53%	-2.00%
TFP Change	0.19%	1.00%	-0.22%	-6.78%

In 2024, as shown in Figure 4.1.2, the components that had the greatest impact on ANT's TFP were opex and transformers. Together, these inputs *reduced* ANT's TFP by 4.98 percentage points, due to increases of 11.6 per cent in opex and 4.1 per cent in transformers, both of which were higher than the industry growth rates (5.0 per cent for opex and 1.5 per cent for transformers). ENS also had a notable impact, contributing –1.45 percentage points to TFP following a 263.7 per cent increase in 2024.

Figure 4.1.2 ANT's output and input percentage point contributions to TFP change, 2024



4.2 ElectraNet (ENT)

In 2024 ENT transported 12,611 GWh of electricity over 6,239 circuit kilometres of lines and cables. It forms a critical part of South Australia's energy supply chain serving 945,709 end-users. ENT is the smaller of the five TNSPs in the NEM in terms of energy throughput and the fourth in terms of circuit length and the number of end-users.

4.2.1 ENT's productivity performance

ENT's total output, total input and TFP indexes are presented in Table 4.2.1 and Figure 4.2.1. Opex and capital PFP indexes are also presented in Table 4.2.1. Figure 4.2.1 also shows the output and TFP indexes when ENS is excluded, which highlights the effect of ENS.

Over the 19-year period 2006 to 2024, ENT's TFP decreased, averaging an annual rate of change of -1.6 per cent. This can be compared to the industry's average annual TFP change of -0.9 per cent over the same period. ENT's total output over the same period averaged annual rate of 0.5 per cent, the same rate as for the industry. ENT's average annual rate of increase in input use of 2.1 per cent was higher than the rate of increase in total input use for the industry (averaging 1.4 per cent per year).

While in most years ENT's TFP has decreased, there have been some years when there was a small increase in TFP, including the period 2019 to 2021 and 2023. In 2024, ENT's TFP *decreased* by 5.7 per, mostly driven by input growth of 7.0 per cent in the same year.

Table 4.2.1 ENT's output, input, TFP and PFP indexes, 2006–2024

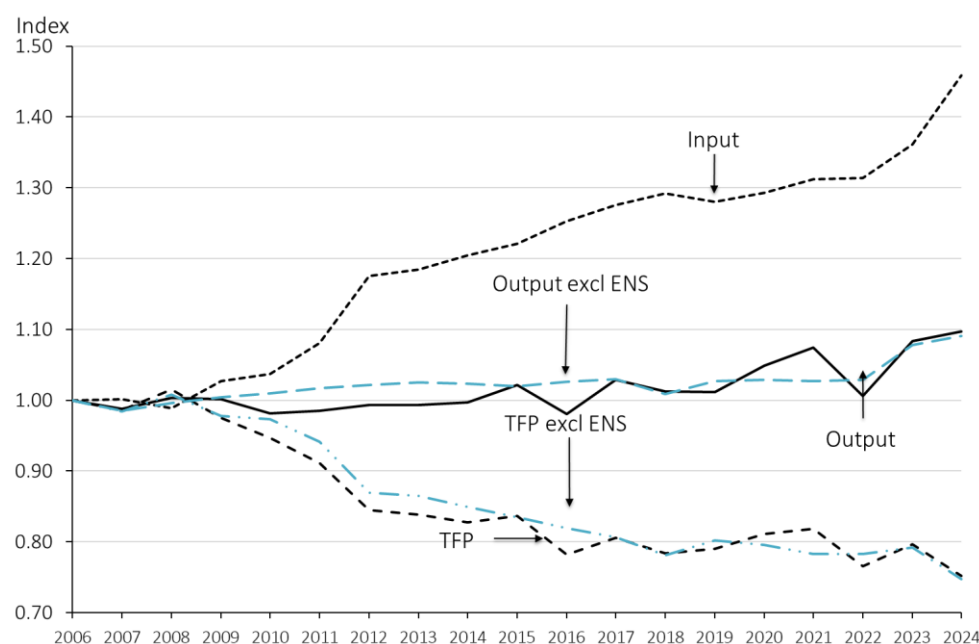
<i>Year</i>	<i>Output</i>	<i>Input</i>	<i>TFP</i>	<i>PFP Index</i>	
	<i>Index</i>	<i>Index</i>	<i>Index</i>	<i>Opex</i>	<i>Capital</i>
2006	1.000	1.000	1.000	1.000	1.000
2007	0.988	1.001	0.986	0.945	1.007
2008	1.003	0.988	1.015	1.069	0.991
2009	1.002	1.027	0.975	1.003	0.964
2010	0.982	1.037	0.947	0.963	0.940
2011	0.985	1.081	0.911	0.897	0.918
2012	0.993	1.175	0.845	0.829	0.853
2013	0.993	1.185	0.838	0.883	0.818
2014	0.997	1.204	0.828	0.867	0.809
2015	1.021	1.221	0.836	0.848	0.831
2016	0.980	1.253	0.782	0.775	0.786
2017	1.028	1.276	0.806	0.787	0.815
2018	1.012	1.292	0.784	0.762	0.795
2019	1.011	1.280	0.790	0.779	0.795
2020	1.049	1.293	0.811	0.771	0.832
2021	1.074	1.312	0.819	0.802	0.827
2022	1.006	1.314	0.766	0.763	0.766
2023	1.084	1.361	0.796	0.780	0.805
2024	1.098	1.459	0.752	0.788	0.736
Growth Rate 2006-2024	0.5%	2.1%	-1.6%	-1.3%	-1.7%
Growth Rate 2006-2012	-0.1%	2.7%	-2.8%	-3.1%	-2.7%
Growth Rate 2012-2024	0.8%	1.8%	-1.0%	-0.4%	-1.2%
Growth Rate 2024	1.3%	7.0%	-5.7%	1.1%	-8.9%

Growth of input usage was higher in the period 2006 to 2012 (averaging 2.7 per cent per year) than in the period 2012 to 2024 (averaging 1.8 per cent per year). Output growth up to 2012 averaged -0.1 per cent, and from 2012 to 2024 averaged 0.8 per cent per year. Accordingly, the average rate of change in TFP between 2006 and 2012 was -2.8 per cent per year, while after 2012 the rate of decline was not as strong, averaging -1.0 per cent per annum.

When ENS is excluded, output growth in the period from 2012 to 2024 averaged 0.5 per cent per year. The rate of TFP change over the same period when ENS is excluded is -1.3 per cent, which is lower than when ENS is included (-1.0 per cent).

The PFP indexes in Table 4.2.1 show that the moderation in negative average annual rates of change of TFP after 2012 was mirrored in reduced rates of decrease in both opex PFP and capital PFP.

Figure 4.2.1 ENT's output, input and TFP indexes, 2006–2024



4.2.2 ENT's output and input quantity changes & contributions to TFP change

Average growth rates of quantity indexes for ENT's individual outputs and inputs, and for partial productivity indexes for individual inputs, are presented in Table 4.2.2. Table 4.2.3 shows the decomposition of ENT'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 4.2.2 shows the contributions of outputs and inputs to ENT's average rate of TFP change in 2024.

Over the 2006–2024 period, ENT's output with the highest growth rate is end-user numbers, which increased by 1.1 per cent per year, slightly below the industry average of 1.3 per cent for the period. This was followed by circuit length and RMD, both increasing at 0.6 per cent per year, broadly in line with industry average growth rates over the same period (0.5 per cent for circuit length and 0.7 per cent for RMD). These three outputs together account for 91.9 per cent of ENT's output cost share and contributed 0.58 percentage points to ENT's TFP change of –1.6 per cent over the period.

ENT's output with the largest negative growth rate was ENS, which *declined* by 2.9 per cent per year, in contrast to a 7.9 per cent annual increase for the industry. ENS represents –1.5 per cent of ENT's total cost share and contributed just 0.03 percentage points to its TFP change. Energy throughput *decreased* by 1.0 per cent per year, a sharper decline than the industry average of 0.3 per cent per year. It accounts for 9.6 per cent of ENT's output cost share and *reduced* ENT's TFP by 0.10 percentage points over the 2006–2024 period.

Turning to the input side, underground lines increased at the highest rate, 8.5 per cent per year (well above the industry average of 3.6 per cent). However, underground cables represent only 2.1 per cent of ENT's input cost share and therefore contributed just 0.15 percentage points to ENT's TFP change. Transformers, opex, and overhead lines together account for 97.9 per cent of ENT's input cost share. These inputs increased by 2.3 per cent, 1.8 per cent, and 1.6 per cent per year, respectively—each above the industry average growth rates. Combined, they reduced ENT's TFP by 1.95 percentage points over the 2006–2024 period.

Table 4.2.2 ENT output, input and partial productivity growth rates

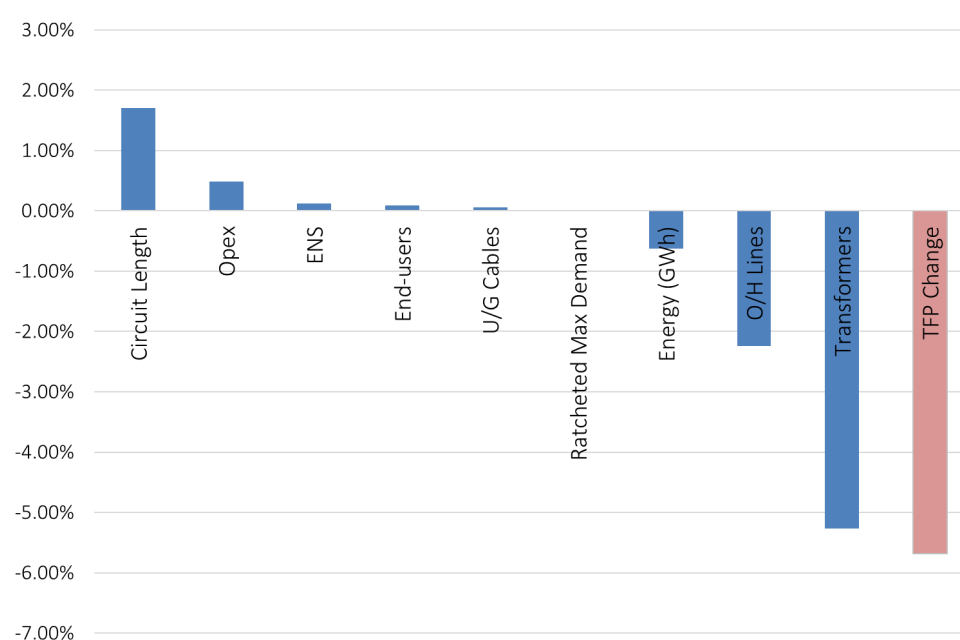
	2006-2024	2006-2012	2012-2024	2024
<u>Outputs:</u>				
Energy (GWh)	-1.0%	-1.2%	-0.9%	-6.6%
Ratcheted Max Demand (MVA)	0.6%	1.6%	0.1%	0.0%
End-users	1.1%	1.3%	0.9%	1.0%
Circuit Length (km)	0.6%	-0.2%	1.0%	3.2%
ENS (MWh)*	-2.9%	23.8%	-16.3%	-15.1%
<u>Inputs:</u>				
Real Opex (\$'000 2006)	1.8%	3.0%	1.3%	0.2%
O/H Lines (MVA-kms)	1.6%	0.5%	2.2%	9.6%
U/G Lines (MVA-kms)	8.5%	24.8%	0.4%	-5.0%
Transformers (MVA)	2.3%	2.9%	2.0%	10.9%
NB: Capital inputs	2.2%	2.5%	2.1%	10.2%
<u>Partial productivity:</u>				
Output / Real Opex	-1.3%	-3.1%	-0.4%	1.1%
Output / OH Lines	-1.1%	-0.6%	-1.4%	-8.3%
Output / UG Lines	-8.0%	-24.9%	0.4%	6.3%
Output / Transformers	-1.8%	-3.0%	-1.2%	-9.6%
NB: Output / Capital	-1.7%	-2.7%	-1.2%	-8.9%

Table 4.2.3 ENT 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	-0.10%	-0.11%	-0.09%	-0.63%
Ratcheted Max Demand	0.16%	0.46%	0.01%	0.00%
End-users	0.10%	0.13%	0.09%	0.09%
Circuit Length	0.32%	-0.12%	0.54%	1.70%
ENS	0.03%	-0.47%	0.28%	0.12%
Opex	-0.59%	-0.98%	-0.39%	0.49%
O/H Lines	-0.33%	-0.12%	-0.43%	-2.24%
U/G Cables	-0.15%	-0.37%	-0.04%	0.05%
Transformers	-1.03%	-1.21%	-0.95%	-5.27%
TFP Change	-1.58%	-2.80%	-0.97%	-5.68%

The contributions for 2024 are shown in Figure 4.2.2. The inputs that had the greatest impact on ENT's TFP were transformers and overhead lines, which together contributed -7.51 percentage points to TFP change. This was due to substantial increases of 10.9 per cent for transformers and 9.6 per cent for overhead lines, both well above the industry rates of change of 1.5 per cent for transformers and -2.8 per cent for overhead lines in 2024. The output with most effect was circuit length which contributed 1.70 percentage points to TFP growth, driven by a 3.2 per cent increase in 2024 compared to a 0.3 per cent increase for the industry.

Figure 4.2.2 ENT's output and input percentage point contributions to TFP change, 2024



4.3 Powerlink (PLK)

In 2024, PLK transported 52,798 GWh of electricity over 14,551 circuit kilometres of lines and cables. It forms a critical part of Queensland's energy supply chain serving 2.4 million end-users. PLK is the second largest of the five TNSPs in the NEM in terms of energy throughput but is the largest in terms of circuit length. It serves the third largest number of end-users.

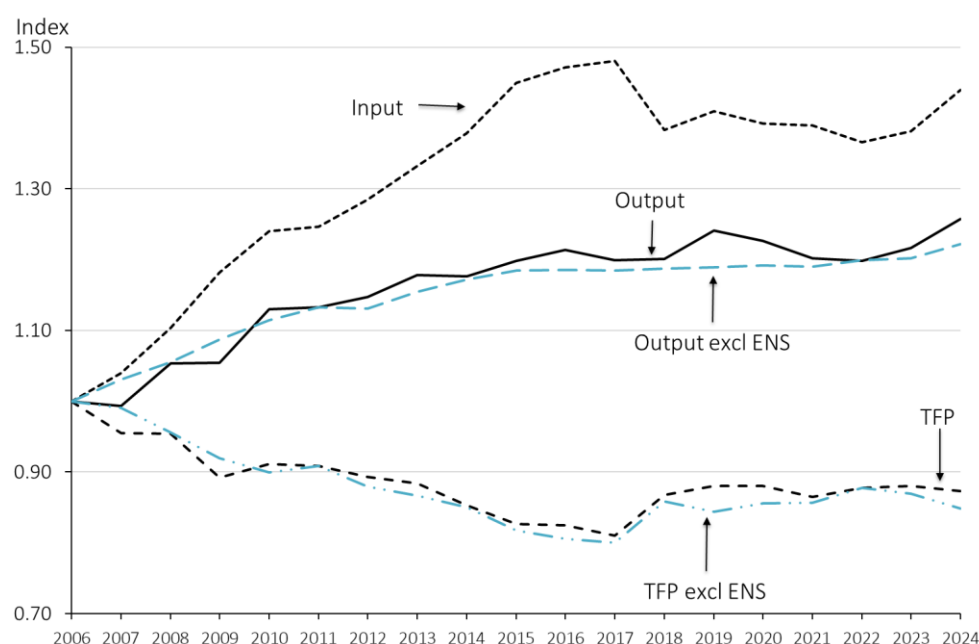
4.3.1 PLK's productivity performance

PLK's total output, total input and TFP indexes are presented in Figure 4.3.1 and Table 4.3.1. Opex and capital PFP indexes are also presented in Table 4.3.1. Figure 4.3.1 also shows the output and TFP indexes when ENS is excluded, which highlights the effect of ENS.

After a steady decline over the period up to 2017, PLK's TFP increased strongly in 2018 and has largely levelled off since then. In 2024, PLK's TFP *decreased* by 0.8 per cent, driven by increases of 4.1 per cent in the input index and 3.3 per cent in the output index. By 2017, the

input index was 48.1 per cent higher than its level in 2006, but there was a substantial decrease in the input index in 2018. In 2024, the input index was 43.9 per cent higher than in 2006. This remains a larger increase in inputs compared to the total industry, for which inputs increased by 28.6 per cent between 2006 and 2024. Figure 4.3.1 shows that TFP excluding ENS was also relatively flat between 2018 and 2023 but *decreased* by 2.4 per cent in 2024, indicating the positive impact of ENS.

Figure 4.3.1 PLK's output, input and TFP indexes, 2006–2024



Over the 19-year period from 2006 to 2024, PLK's TFP decreased at an average annual rate of change of -0.8 per cent. Its total output increased over the period with an average annual rate of change of 1.3 per cent. This was considerably higher than the industry average annual growth in output of 0.5 per cent. However, PLK's average annual rate of increase in input use of 2.0 per cent was above the rate of increase in total input use for the industry of 1.4 per cent. The net effect of these two differences is that PLK had a similar rate of decline in TFP to the industry average (-0.8 and -0.9 per cent, respectively). For the period from 2006 to 2012, PLK's rate of average annual growth in TFP was -1.9 per cent. Whereas in the period from 2012 to 2024, its average annual growth in TFP was -0.2 per cent.

The PFP indexes in Table 4.3.1 show that in the period from 2006 to 2012, the rate of capital PFP growth averaged -3.1 per cent per annum, while in the period from 2012 to 2024, it averaged 0.0 per cent per annum. This stabilisation of capital PFP strongly influenced the TFP trend but was partly offset by the Opex PFP trends. The average annual opex PFP rate of growth decreased from 1.0 per cent in the period up to 2012 to -0.8 per cent in the period after 2012.

Table 4.3.1 PLK's output, input, TFP and PFP indexes, 2006–2024

Year	Output	Input	TFP	PFP Index	
	Index	Index	Index	Opex	Capital
2006	1.000	1.000	1.000	1.000	1.000
2007	0.993	1.040	0.955	0.962	0.953
2008	1.053	1.104	0.954	0.945	0.958
2009	1.054	1.182	0.892	0.995	0.852
2010	1.130	1.240	0.912	1.031	0.865
2011	1.133	1.247	0.909	1.079	0.848
2012	1.148	1.285	0.893	1.063	0.833
2013	1.178	1.332	0.884	1.082	0.815
2014	1.176	1.378	0.853	1.028	0.790
2015	1.199	1.449	0.827	0.919	0.791
2016	1.213	1.471	0.825	0.920	0.788
2017	1.199	1.481	0.810	0.892	0.779
2018	1.201	1.383	0.868	1.100	0.787
2019	1.241	1.409	0.880	1.097	0.803
2020	1.226	1.392	0.881	1.093	0.804
2021	1.202	1.390	0.865	1.043	0.798
2022	1.198	1.366	0.878	1.082	0.801
2023	1.216	1.381	0.880	1.080	0.806
2024	1.257	1.439	0.873	0.971	0.836
Growth Rate 2006-2024	1.3%	2.0%	-0.8%	-0.2%	-1.0%
Growth Rate 2006-2012	2.3%	4.2%	-1.9%	1.0%	-3.1%
Growth Rate 2012-2024	0.8%	0.9%	-0.2%	-0.8%	0.0%
Growth Rate 2024	3.3%	4.1%	-0.8%	-10.6%	3.7%

4.3.2 PLK's output and input quantity changes & contributions to TFP change

Average growth rates of quantity indexes for PLK's individual outputs and inputs, and for partial productivity indexes for individual inputs, are presented in Table 4.3.2. Table 4.3.3 shows the decomposition of PLK'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 4.3.2 shows the contributions of outputs and inputs to PLK's average rate of TFP change in 2024.

Table 4.3.2 PLK output, input and partial productivity growth rates

	2006-2024	2006-2012	2012-2024	2024
<u>Outputs:</u>				
Energy (GWh)	0.2%	-0.1%	0.3%	2.9%
Ratcheted Max Demand (MVA)	1.1%	1.7%	0.8%	4.5%
End-users	1.5%	1.8%	1.4%	0.9%
Circuit Length (km)	1.2%	2.6%	0.5%	0.0%
ENS (MWh)*	-21.9%	-18.4%	-23.6%	-323.8%
<u>Inputs:</u>				
Real Opex (\$'000 2006)	1.4%	1.3%	1.5%	13.9%
O/H Lines (MVA-kms)	1.4%	3.8%	0.2%	-0.3%
U/G Lines (MVA-kms)	1.3%	4.1%	-0.1%	0.0%
Transformers (MVA)	3.2%	7.2%	1.2%	-0.4%
NB: Capital inputs	2.3%	5.3%	0.7%	-0.4%
<u>Partial productivity:</u>				
Output / Real Opex	-0.2%	1.0%	-0.8%	-10.6%
Output / OH Lines	-0.2%	-1.5%	0.5%	3.6%
Output / UG Lines	0.0%	-1.8%	0.9%	3.3%
Output / Transformers	-1.9%	-4.9%	-0.4%	3.7%
NB: Output / Capital	-1.0%	-3.1%	0.0%	3.7%

Over the 2006–2024 period, PLK’s output with the highest growth rate was end-user numbers, which increased by 1.5 per cent per year, slightly above the industry average of 1.3 per cent. This was followed by circuit length and RMD, which increased by 1.2 per cent and 1.1 per cent per year, respectively, both above the industry average growth rates of 0.5 per cent for circuit length and 0.7 per cent for RMD. These three outputs together accounted for 91.4 per cent of PLK’s output cost share and contributed 1.11 percentage points to PLK’s TFP change of –0.8 per cent over the period.

PLK’s output with the largest negative growth rate was ENS, which *declined* by 21.9 per cent per year, in contrast to a 7.9 per cent annual increase for the industry. ENS represents –0.9 per cent of PLK’s output cost share and contributed just 0.1 percentage points to its TFP change.

Turning to the input side, transformers increased at the highest rate, at 3.2 per cent per year, which is above the industry average of 2.2 per cent. Transformers account for 36.6 per cent of PLK’s input cost share and contributed –1.05 percentage point to PLK’s TFP growth rate over the 2006–2024 period.

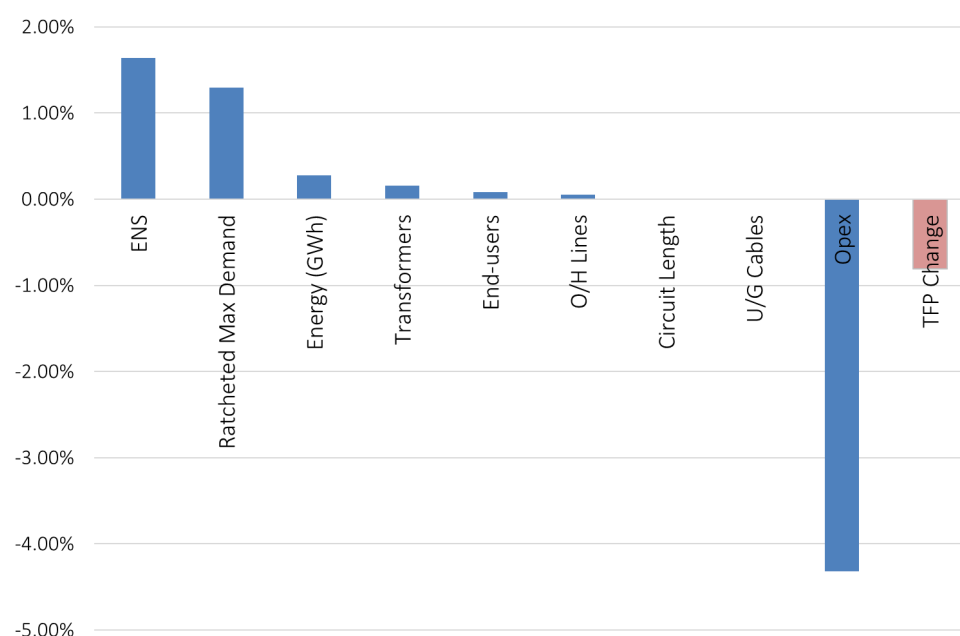
Opex, overhead lines, and underground cables increased at similar average rates of 1.3 to 1.4 per cent per year over the 19-year period and together represent 63.4 per cent of PLK’s input cost share. Combined, these inputs *reduced* PLK’s TFP growth rate by 0.97 percentage points over the same period.

Table 4.3.3 PLK output and input percentage point contributions to average annual TFP change: various periods

<i>Year</i>	<i>2006 to 2024</i>	<i>2006 to 2012</i>	<i>2012 to 2024</i>	<i>2024</i>
Energy	0.02%	-0.01%	0.03%	0.28%
Ratcheted Max Demand	0.32%	0.51%	0.23%	1.30%
End-users	0.14%	0.17%	0.13%	0.08%
Circuit Length	0.64%	1.40%	0.26%	0.01%
ENS	0.15%	0.22%	0.11%	1.64%
Opex	-0.43%	-0.41%	-0.45%	-4.32%
O/H Lines	-0.53%	-1.44%	-0.08%	0.06%
U/G Cables	-0.01%	-0.03%	0.00%	0.00%
Transformers	-1.05%	-2.30%	-0.42%	0.15%
TFP Change	-0.75%	-1.88%	-0.19%	-0.81%

For 2024, as shown in Figure 4.3.2, the component with greatest impact on PLK's TFP is opex, which contributed -4.32 percentage points to TFP change. This is due to a substantial increase in opex usage, which increased by 13.9 per cent, well above the industry increase of 5.1 per cent in 2024.

On the other hand, ENS and RMD contributed positively to PLK's TFP growth in 2024, together adding 2.94 percentage points. This reflects a 4.5 per cent increase in RMD (compared to a 1.2 per cent increase for the industry) and a 323.8 per cent *decrease* in ENS (in contrast to the industry's 248.6 per cent increase in ENS for the year).

Figure 4.3.2 PLK's output and input percentage point contributions to TFP change, 2024

4.4 TasNetworks Transmission (TNT)

In 2024, TNT transported 13,277 GWh of electricity over 3,337 circuit kilometres of lines and cables. It forms a critical part of Tasmania's energy supply chain serving 307,118 end-users. TNT is the second smallest TNSP in the NEM in terms of energy throughput and the smaller in terms of circuit length and the number of end-users.

4.4.1 TNT's productivity performance

TNT's total output, total input and TFP indexes are presented in Figure 4.4.1 and Table 4.4.1. Opex and capital PFP indexes are also presented in Table 4.4.1. Figure 4.4.1 also shows the output and TFP indexes when ENS is excluded, which highlights the effect of ENS.

Over the 19-year period 2006 to 2024, TNT's TFP rate of growth was 0.1 per cent. This outcome was the combined effect of its total output and total input both increasing at an average annual rate of 0.2 and 0.1 per cent over the same period respectively. This differs from the transmission industry as a whole where TFP growth was -0.9 per cent per year, and both input use and output increased faster (1.4 per cent and 0.5 per cent, per annum on average from 2006 to 2024, respectively).

Figure 4.4.1 TNT's output, input and TFP indexes, 2006–2024

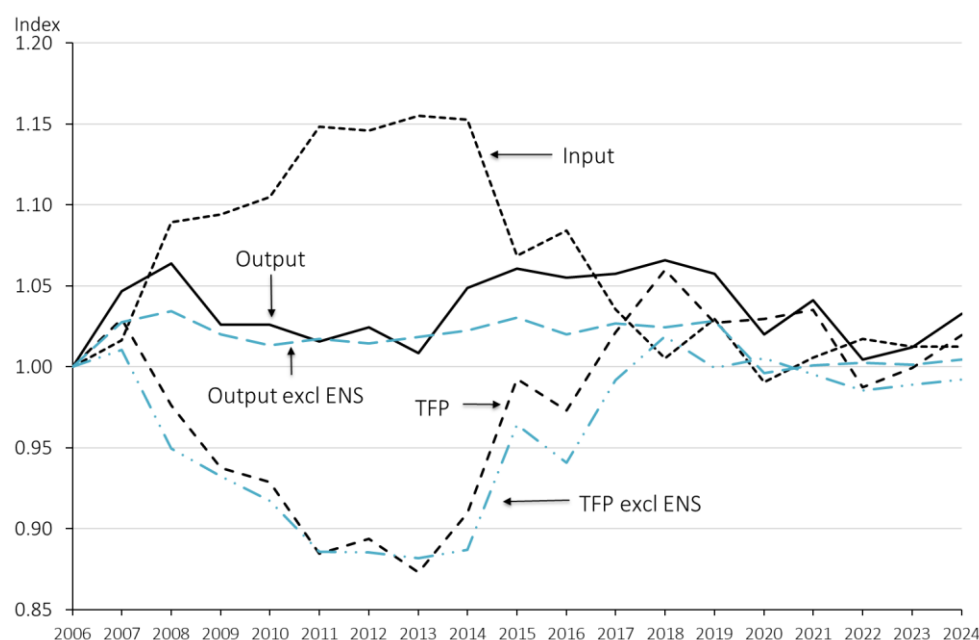


Table 4.4.1 TNT's output, input, TFP and PFP indexes, 2006–2024

Year	Output	Input	TFP	PFP Index	
	Index	Index	Index	Opex	Capital
2006	1.000	1.000	1.000	1.000	1.000
2007	1.047	1.017	1.030	1.030	1.034
2008	1.064	1.089	0.976	0.885	1.032
2009	1.026	1.094	0.938	0.884	0.962
2010	1.026	1.105	0.929	0.887	0.941
2011	1.016	1.148	0.884	0.936	0.851
2012	1.024	1.146	0.894	0.967	0.850
2013	1.008	1.155	0.873	1.028	0.804
2014	1.049	1.153	0.910	1.085	0.834
2015	1.061	1.069	0.993	1.477	0.838
2016	1.055	1.084	0.973	1.381	0.832
2017	1.058	1.036	1.021	1.657	0.836
2018	1.066	1.005	1.060	1.886	0.843
2019	1.057	1.029	1.027	1.787	0.820
2020	1.020	0.991	1.030	2.012	0.789
2021	1.041	1.006	1.035	1.846	0.808
2022	1.005	1.017	0.988	1.729	0.779
2023	1.012	1.013	0.999	1.731	0.788
2024	1.033	1.013	1.020	1.731	0.819
Growth Rate 2006-2024	0.2%	0.1%	0.1%	3.0%	-1.1%
Growth Rate 2006-2012	0.4%	2.3%	-1.9%	-0.6%	-2.7%
Growth Rate 2012-2024	0.1%	-1.0%	1.1%	4.8%	-0.3%
Growth Rate 2024	2.0%	0.0%	2.0%	0.0%	3.9%

TNT's average output growth over the period from 2006 to 2012 of 0.4 per cent per year compares to the average rate of change in the period from 2012 to 2024 of 0.1 per cent. Input usage and TFP had different trends in these two sub-periods. The input index increased in the period from 2006 to 2012 at an average annual rate of 2.3 per cent, whereas in the period from 2012 to 2024 it *decreased* at an average annual rate of 1.0 per cent. Conversely, the TFP index average annual rate *decreased* from 2006 to 2012 by 1.9 per cent and increased at an average annual rate of 1.1 per cent from 2012 to 2024. TFP increased in 2024 by 2.0 per cent, due to an increase in outputs of 2.0 per cent and no movement in inputs.

When ENS is excluded, the average rate of TFP growth from 2012 to 2024 is 0.9 per cent per annum, compared to 1.1 per cent when ENS is included. The 2024 output growth with ENS excluded is 0.3 per cent, and the 2024 rate of TFP change is 0.3 per cent.

The PFP indexes in Table 4.4.1 show a substantial improvement in opex PFP in the latter half of the period, from an average change of -0.6 per cent per annum before 2012 to 4.8 per cent per annum after 2012. There was also an improvement in capital PFP from a rate of change

of –2.7 per cent up to 2012, to a rate of –0.3 per cent after 2012. These were important reasons for the improvement in TFP performance in the period from 2012 to 2024. In 2024, opex PFP growth was 0.0 per cent, joined by an increase in capital PFP of 3.9 per cent.

4.4.2 TNT's output and input quantity changes & contributions to TFP change

Average growth rates of quantity indexes for TNT's individual outputs and inputs, and for partial productivity indexes for individual inputs, are presented in Table 4.4.2. Table 4.4.3 shows the decomposition of TNT'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 4.4.2 shows the contributions of outputs and inputs to TNT's average rate of TFP change in 2024.

Over the 2006–2024 period, TNT's outputs with the highest growth rates were energy throughput which increased by 1.3 per cent per year (compared to the industry average –0.3 per cent), and end-user numbers which increased by 1.1 per cent per year (similar to the industry average of 1.0 per cent). Together, these outputs account for 19.1 per cent of TNT's output cost share and contributed 0.23 percentage points to TNT's TFP change of 0.1 per cent over the same period.

Table 4.4.2 TNT output, input and partial productivity growth rates

	2006-2024	2006-2012	2012-2024	2024
<u>Outputs:</u>				
Energy (GWh)	1.3%	3.0%	0.4%	2.3%
Ratcheted Max Demand (MVA)	0.0%	0.0%	0.0%	0.0%
End-users	1.1%	1.8%	0.8%	0.9%
Circuit Length (km)	-0.4%	-0.4%	-0.4%	0.0%
ENS (MWh)*	-6.9%	-7.1%	-6.8%	-76.6%
<u>Inputs:</u>				
Real Opex (\$'000 2006)	-2.9%	1.0%	-4.8%	2.0%
O/H Lines (MVA-kms)	0.6%	1.3%	0.3%	-0.7%
U/G Lines (MVA-kms)	4.8%	0.0%	7.2%	0.0%
Transformers (MVA)	1.5%	4.1%	0.2%	-2.5%
NB: Capital inputs	1.3%	3.1%	0.4%	-1.9%
<u>Partial productivity:</u>				
Output / Real Opex	3.0%	-0.6%	4.8%	0.0%
Output / OH Lines	-0.4%	-0.9%	-0.2%	2.7%
Output / UG Lines	-4.6%	0.4%	-7.1%	2.0%
Output / Transformers	-1.3%	-3.7%	-0.2%	4.5%
NB: Output / Capital	-1.1%	-2.7%	-0.3%	3.9%

TNT's output with the largest negative growth rate was ENS, which *declined* by 6.9 per cent per year, compared to a 7.9 per cent annual increase for the industry. ENS accounts for –2.0

per cent of TNT's output cost share and contributed 0.15 percentage points to its TFP change. TNT's circuit length *decreased* by 0.4 per cent per year over the 19-year period, while the industry recorded an average increase of 0.5 per cent. Circuit length represents 53.6 per cent of TNT's output cost share and contributed –0.21 percentage points to TNT's TFP change during the period.

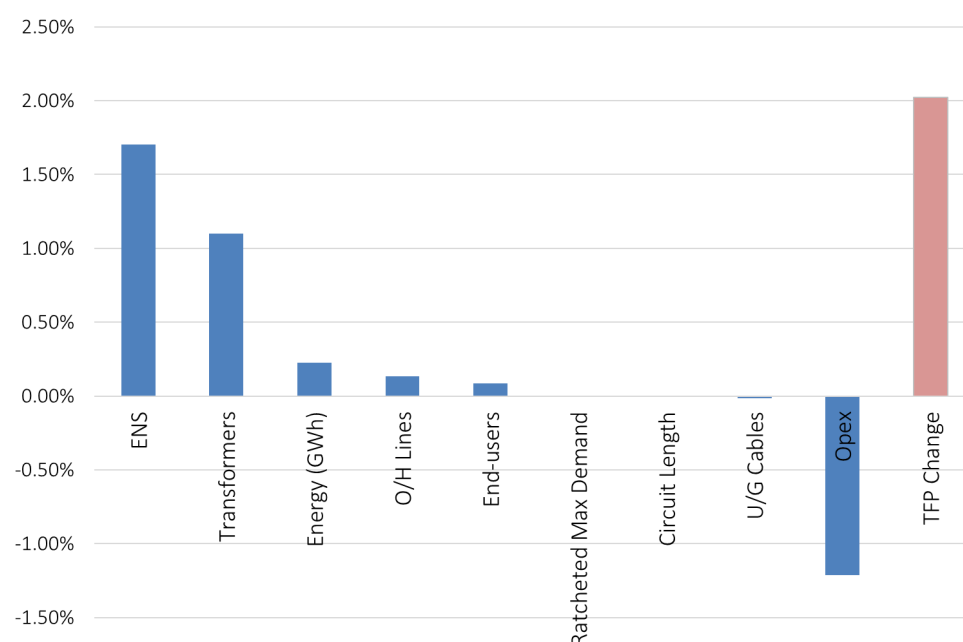
Turning to the input side, underground cables increased at the highest rate, at 4.8 per cent per year, which was above the industry average of 3.6 per cent. However, underground cables accounted for only 1.3 per cent of TNT's input cost share and contributed just –0.06 percentage points to TNT's TFP average change of 0.1 per cent over the 2006–2024 period.

Transformers and overhead lines increased by 1.5 per cent and 0.6 per cent per year, respectively. Both are below the industry averages of 2.2 per cent and 1.0 per cent respectively. These two inputs, together representing 70.2 per cent of TNT's input cost, contributed –0.84 percentage points to TNT's TFP change over the period. Opex, on the other hand, *decreased* by 2.9 per cent per year over the 2006–2024 period (compared to the industry increase of 0.5 per cent per year). Opex represents 28.5 per cent of TNT's input cost and contributed 0.83 percentage points to TNT's TFP over the period.

For 2024, as shown in Figure 4.4.2, the components with the greatest impact on TNT's TFP are ENS and transformers, which together contributed 2.80 percentage points to TNT's TFP change of 2.0 per cent for the year. This was driven by a substantial *decrease* in ENS of 76.6 per cent (in contrast to the industry where ENS increased by 248.6 per cent) and a 2.5 per cent *decrease* in TNT's transformers (compared to a 1.5 per cent increase for the industry). In contrast, opex contributed negatively to TNT's TFP in 2024, *reducing* it by 1.21 percentage points. This reflects a 2.0 per cent increase in opex (compared to a 5.1 per cent increase for the industry).

Table 4.4.3 TNT output and input percentage point contributions to average annual TFP change: various periods

<i>Year</i>	<i>2006 to 2024</i>	<i>2006 to 2012</i>	<i>2012 to 2024</i>	<i>2024</i>
Energy	0.12%	0.29%	0.04%	0.22%
Ratcheted Max Demand	0.00%	0.01%	0.00%	0.00%
End-users	0.11%	0.17%	0.08%	0.09%
Circuit Length	-0.21%	-0.22%	-0.20%	0.00%
ENS	0.15%	0.16%	0.15%	1.70%
Opex	0.83%	-0.13%	1.30%	-1.21%
O/H Lines	-0.13%	-0.28%	-0.06%	0.14%
U/G Cables	-0.06%	0.00%	-0.09%	-0.01%
Transformers	-0.70%	-1.86%	-0.12%	1.10%
TFP Change	0.11%	-1.87%	1.10%	2.02%

Figure 4.4.2 TNT's output and input percentage point contributions to TFP change, 2024


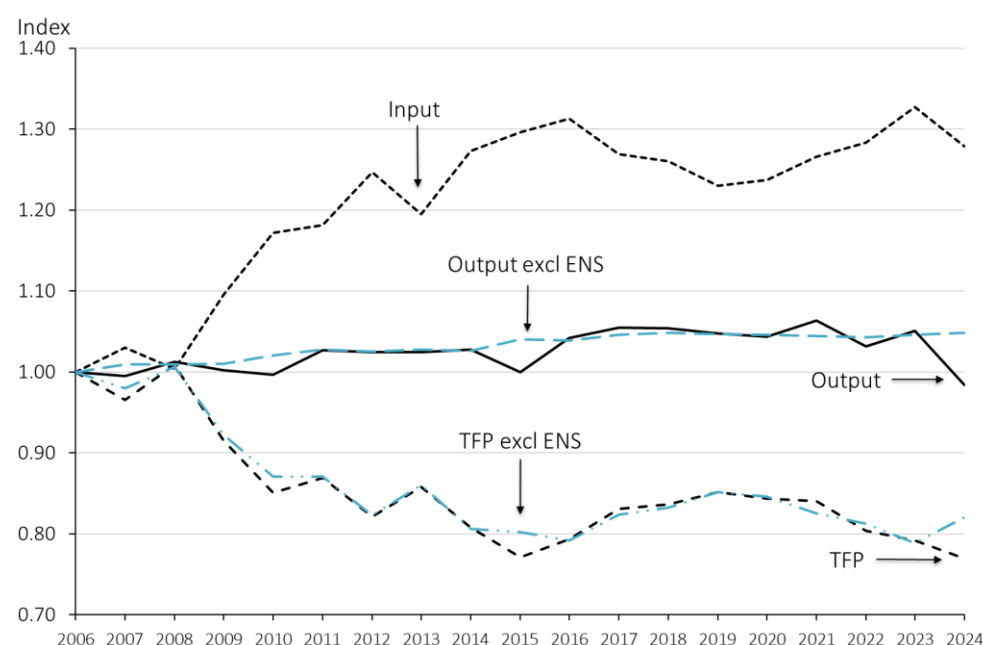
4.5 TransGrid (TRG)

In 2024 TRG transported 71,100 GWh of electricity over 13,078 circuit kilometres of lines and cables. It forms a critical part of New South Wales's energy supply chain serving around 4.1 million end-users. TRG is the largest of the five TNSPs in the NEM in terms of energy throughput and the number of end-users and the second largest in terms of circuit length.

4.5.1 TRG's productivity performance

TRG's total output, total input and TFP indexes are presented in Figure 4.5.1 and Table 4.5.1. Opex and capital PFP indexes are also presented in Table 4.5.1. Figure 4.5.1 also shows the output and TFP indexes when ENS is excluded, which highlights the effect of ENS.

Over the 19-year period from 2006 to 2024, TRG's total output *decreased* at an average annual rate of 0.1 per cent, in contrast with industry output growth of 0.5 per cent per annum on average. TRG's average annual rate of increase in input use of 1.4 per cent over the same period is similar to that of the industry's. The net effect of the output and input movements is TRG's annual rate of change in TFP of -1.5 per cent over the 19-years period, which was a more pronounced decline than the industry's average annual TFP change of -0.9 per cent over the 2006 to 2024 period.

Figure 4.5.1 TRG's output, input and total factor productivity indexes, 2006–2024


Over the period from 2006 to 2012, the average growth rate of TRG's output was 0.4 per cent per annum. Over the same period the average annual growth rate of inputs was 3.7 per cent. The net effect was a decline of TFP, averaging –3.3 per cent per year in this sub-period. For the period after 2012, the rate of average annual growth in output was –0.3 per cent per year, while the average annual change in input was at 0.2 per cent per year. The net effect was an average of –0.5 per cent TFP growth per annum from 2012 to 2024. During this sub-period, TFP fell significantly from 2013 to 2015. This was accentuated by unusually high levels of outages in 2015. From 2016 to 2019 TFP improved, followed by a decline up to 2024.

In 2024, TFP *decreased* by 2.9 per cent. This adverse outcome occurred due to a *decrease* of 6.6 per cent in output (associated with an increase of 438.4 per cent in ENS due primarily to a one-off outage event) and a *decrease* of 3.7 per cent in inputs. When ENS is excluded, output increased by 0.2 per cent in 2024, resulting in a TFP growth of 4.0 per cent.

The PFP indexes in Table 4.5.1 show that the slower rate of decline in average annual rates of change of TFP after 2012 was associated with an improvement in the trend of capital PFP index, more than offsetting a deterioration in opex PFP. The rate of change per annum in capital PFP between 2006 and 2012 was –4.7 per cent, but this improved to an average rate of –0.6 per cent from 2012 to 2024. The average rate of change in opex PFP between 2006 and 2012 was 0.3 per cent per annum, and between 2012 and 2024 was –0.3 per cent.

Table 4.5.1 TRG'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	0.995	1.030	0.966	1.021	0.944
2008	1.012	1.004	1.008	1.111	0.966
2009	1.002	1.095	0.915	1.105	0.846
2010	0.997	1.172	0.851	0.980	0.800
2011	1.027	1.181	0.869	1.089	0.793
2012	1.024	1.247	0.822	1.017	0.752
2013	1.025	1.195	0.858	1.119	0.771
2014	1.028	1.273	0.807	0.941	0.758
2015	1.000	1.296	0.771	0.979	0.700
2016	1.042	1.312	0.794	1.031	0.713
2017	1.055	1.269	0.831	1.059	0.753
2018	1.053	1.260	0.836	1.199	0.725
2019	1.047	1.230	0.851	1.215	0.739
2020	1.043	1.237	0.843	1.183	0.736
2021	1.064	1.266	0.840	1.172	0.732
2022	1.031	1.283	0.804	1.053	0.718
2023	1.051	1.327	0.792	0.994	0.721
2024	0.983	1.278	0.769	0.978	0.698
Growth Rate 2006-2024	-0.1%	1.4%	-1.5%	-0.1%	-2.0%
Growth Rate 2006-2012	0.4%	3.7%	-3.3%	0.3%	-4.7%
Growth Rate 2012-2024	-0.3%	0.2%	-0.5%	-0.3%	-0.6%
Growth Rate 2024	-6.6%	-3.7%	-2.9%	-1.6%	-3.3%

4.5.2 TRG's output and input quantity changes & contributions to TFP change

Average growth rates of quantity indexes for TRG's individual outputs and inputs, and for partial productivity indexes for individual inputs, are presented in Table 4.5.2. Table 4.5.3 shows the decomposition of TRG'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 4.5.2 shows the contributions of outputs and inputs to TRG's average rate of TFP change in 2024.

Over the 2006–2024 period, TRG's output with the highest growth rate is ENS, which increased by 20.7 per cent per year, well above the industry average of 7.9 per cent. However, ENS accounts for only –1.1 per cent of TRG's output cost share and contributed –0.36 percentage points to its TFP change of –1.5 per cent over the 19-year period.

End-user numbers increased by 1.1 per cent per year, similar to the industry average of 1.3 per cent. This output accounts for 9.4 per cent of TRG's output cost share and contributed 0.11 percentage points to TFP. RMD and circuit length increased marginally over the period, by

0.4 per cent and 0.2 per cent per year respectively (slightly below the industry growth rates of 0.7 per cent for RMD and 0.5 per cent for circuit length). Together, these outputs represent 82.1 per cent of TRG's output cost share and contributed 0.23 percentage points to its TFP over the 2006–2024 period.

Table 4.5.2 TRG output, input and partial productivity growth rates

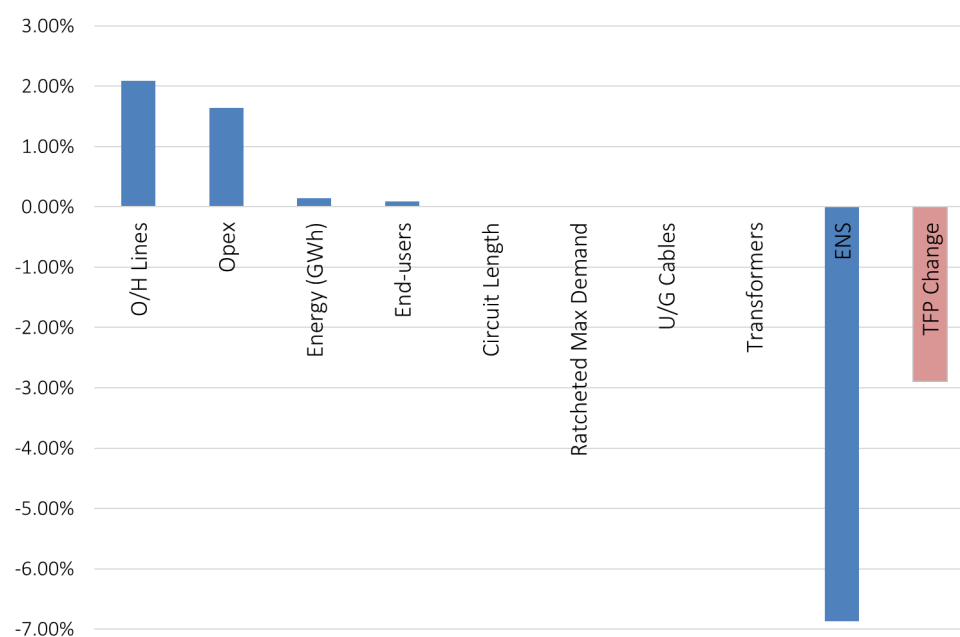
	2006-2024	2006-2012	2012-2024	2024
<u>Outputs:</u>				
Energy (GWh)	-0.8%	-1.0%	-0.6%	1.6%
Ratcheted Max Demand (MVA)	0.4%	1.1%	0.0%	0.0%
End-users	1.1%	0.9%	1.2%	0.8%
Circuit Length (km)	0.2%	0.2%	0.2%	0.0%
ENS (MWh)*	20.7%	2.4%	29.8%	438.4%
<u>Inputs:</u>				
Real Opex (\$'000 2006)	0.0%	0.1%	0.0%	-5.0%
O/H Lines (MVA-kms)	1.2%	4.3%	-0.3%	-9.2%
U/G Lines (MVA-kms)	3.6%	0.5%	5.1%	-1.7%
Transformers (MVA)	2.2%	6.1%	0.3%	-0.3%
NB: Capital inputs	1.9%	5.1%	0.3%	-3.3%
<u>Partial productivity:</u>				
Output / Real Opex	-0.1%	0.3%	-0.3%	-1.6%
Output / OH Lines	-1.3%	-3.9%	-0.1%	2.6%
Output / UG Lines	-3.7%	-0.1%	-5.4%	-4.9%
Output / Transformers	-2.3%	-5.7%	-0.6%	-6.3%
NB: Output / Capital	-2.0%	-4.7%	-0.6%	-3.3%

Turning to the input side, underground cables increased at the highest rate, at 3.6 per cent per year, matching the industry average. However, underground cables accounted for only 1.6 per cent of TRG's input cost share and contributed just –0.11 percentage points to TRG's TFP change of –1.5 per cent over the 2006–2024 period. Transformers and overhead lines increased by 2.2 per cent and 1.2 per cent per year respectively, in line with the industry averages of 2.2 per cent for transformers and 1.0 per cent for overhead lines. These two inputs together represent 69.3 per cent of TRG's input cost and contributed –1.25 percentage points to TRG's TFP change over the period.

For 2024, as shown in Figure 4.5.2, the component with the greatest impact on TRG's TFP was ENS, which contributed –6.87 percentage points to TRG's TFP change of –2.9 per cent for the year. The increase in ENS was 438.4 per cent, compared to a 248.6 per cent increase for the industry. In contrast, overhead lines and opex inputs contributed positively to TRG's TFP in 2024, adding 3.73 percentage points. This reflects a 5.0 per cent *decrease* in opex (in contrast to a 5.1 per cent increase for the industry as a whole) and a 9.2 per cent *decrease* in overhead lines (compared to a 2.8 per cent *decrease* for the industry overall).

Table 4.5.4 TRG output and input percentage point contributions to average annual TFP change: various periods

<i>Year</i>	<i>2006 to 2024</i>	<i>2006 to 2012</i>	<i>2012 to 2024</i>	<i>2024</i>
Energy	-0.07%	-0.10%	-0.06%	0.14%
Ratcheted Max Demand	0.10%	0.31%	0.00%	0.00%
End-users	0.11%	0.09%	0.12%	0.09%
Circuit Length	0.13%	0.13%	0.13%	0.01%
ENS	-0.36%	-0.02%	-0.53%	-6.87%
Opex	0.00%	-0.01%	0.00%	1.64%
O/H Lines	-0.34%	-1.18%	0.07%	2.09%
U/G Cables	-0.11%	-0.04%	-0.14%	0.00%
Transformers	-0.91%	-2.44%	-0.14%	0.00%
TFP Change	-1.46%	-3.28%	-0.55%	-2.89%

Figure 4.5.2 TRG'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 transmission 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 TNSPs is the same method as that used for calculating the comparative levels of TFP between TNSPs, namely the multilateral Törnqvist TFP index (MTFP) of Caves, Christensen and Diewert (1982) shown in equation (A.1). For the productivity growth and contributions analyses the multilateral Törnqvist index is applied to the annual time-series observations for each of the five TNSPs individually or to the aggregated time-series for the industry as a whole. For productivity comparative analysis, for comparing between TNSPs, the data is pooled as panel data and the index is applied across the full sample of 80 observations.

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

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

where m and n are two adjacent observations;¹⁵ i denotes individual outputs; j denotes individual inputs; and

- R_{im} is the revenue share of the i th output at observation m ;
- S_{jm} is the cost share of the j th input at observation m ;

¹⁵ 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 .

- R_i^* is the revenue share of the i th output averaged over the whole sample;¹⁶
- 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.¹⁷ 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 (A.1) can be separated into these two components. The rate of change in the output index is given by:

¹⁶ 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.

¹⁷ 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.

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

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

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

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 (A.2) or (A.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 PFP measure is obtained by dividing the index of all outputs over an index of one input, or over an index of a sub-group of inputs. Also note that for the construction of PFP indexes, we may need inputs indexes for individual inputs, or for sub-groups of inputs. For a sub-group of inputs, equation (A.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: $g_t^Y = \ln Y_t - \ln Y_{t-1}$.¹⁸ 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 2023, and these comparisons are not expressed in terms of log growth rates. Economic Insights (2020a Appendix C) also included, as supplementary information, trend measures of annual growth

¹⁸ 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.¹⁹ This report also presents regression-based trend estimates for TFP indexes in Appendix B.

A2 Output and input contributions to TFP change

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

The analysis of contributions to TFP change is carried out only for individual firm and industry TFP trends. In this case subscripts n and m in equation (A.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:

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

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:

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

where all variables in equations (A.4) and (A.5) have the same definition as those in equation (A.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 (A.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

¹⁹ For the linear regression model: $\ln Y_t = a + b \cdot t + \varepsilon_t$, the estimated coefficient $\hat{b}$ is a measure of the average growth rate of Y over the sample period.

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

A3.1 Leontief Cost Function Estimation

In the index analysis in this study, the output specification is based on functional outputs, and the weights for these outputs are based on the imputed or shadow values of these outputs. These imputed values were estimated by Economic Insights (2020a) 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 ENS

The fifth output is energy not supplied (ENS), the negative of which is a measure supply reliability. The formal way in which reliability is incorporated into the analysis is to treat ENS 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 energy not supplied (i.e. 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 TNSP reliability, economic benchmarking has relied on the VCR, which is a measure of how consumers value energy not supplied. The VCR, expressed on a per MWh basis, is multiplied by the quantity of ENS. That is, the cost of ENS is based on: $ENS \times VCR$. The VCR is estimated by the AER for 2019 (AER 2019b, p. 71), which is adjusted by CPI in all other years of the data sample.

In theory this measure could be expected to provide a proxy for TNSP costs of improving reliability since in equilibrium reliability would be improved to the point where the marginal cost of further improvement equals the marginal benefit of further improvement. However, unconstrained reliance on the VCR can produce some very large weights for the reliability output where unusual one-off outages occur. As a result, the 2017 review introduced a cap of 5.5 per cent of gross revenue (total revenue plus the value of the reliability output) on the reliability output weight. This cap was derived from statistical analysis of the energy not served (ENS) series. In 2020 this approach was reviewed and revised, to take account of incentives under the regulatory framework, which limits the 'value at risk' to a business under the Service

Target Performance Incentive Scheme (STPIS).²⁰ Having regard to this, the cap on the reliability output weight was reduced to 2.5 per cent of total revenue. This study uses the same cap.

A cap applies to the reliability output weight equal to 2.5 per cent of total revenue. The cap is needed because ENS can be highly volatile off a low base, and because TNSP's potential penalties for poor reliability and rewards for improved reliability are capped under the regulatory framework (Economic Insights 2021).

A3.2 Re-calibration of Output Weights

Weights are then re-calibrated as shares of gross revenue, which is defined as the sum of total revenue plus the value of energy not served. Since reliability carries a negative weight in the output index, this ensures that all of 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 ENS vary.

The ENS output has become very low, but also volatile, and is zero in some cases (specifically, for PLK in 2019). A minimum value of ENS equal to 0.2 MWh is imposed. This is a lower minimum threshold than that used in Economic Insights (2021) (which was 1 MWh). Also, sensitivity analysis on output and TFP indexes is carried out to show results when the reliability output, ENS, is excluded.²¹

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

<i>Output</i>	<i>Shares of gross revenue (%)</i>	<i>Shares of revenue (%)</i>
Energy throughput	9.45 ^(a)	9.57
Ratcheted max. demand	28.69 ^(a)	29.06
End-user numbers	9.33 ^(a)	9.45
Circuit length	52.54 ^(a)	53.23
Energy not supplied (minus)	-1.29	-1.31
Total		100.00

Note: Percentages shown may not sum to 100.00 due to rounding.

* Average across all observations (TNSPs and years);

(a) Derived from Economic Insights' Leontief cost function analysis.

²⁰ The STPIS for transmission has three key components: (i) a service component designed to incentivise TNSPs to reduce unplanned circuit outage events and outage duration; (ii) market-impact component to incentivise TNSPs to reduce the impact of planned and unplanned outages on wholesale market outcomes; and (iii) a network-capability component to encourage TNSPs to undertake operational and minor capital expenditure projects to improve reliability (AER 2015). The first component is capped at ± 1.25 per cent of annual maximum allowed revenue, and it is this component that is relevant to the capping of the cost of ENS for the purpose of benchmarking.

²¹ In this report, unless otherwise specifically stated, ENS is included in the measurement of total outputs and TFP and PFP indexes.

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

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

<i>Input</i>	<i>ENT</i>	<i>PLK</i>	<i>ANT</i>	<i>TNT</i>	<i>TRG</i>	<i>Industry*</i>
Energy throughput	9.59	9.53	9.55	9.63	9.54	9.55
Ratcheted max. demand	29.12	28.94	29.02	29.25	28.99	29.01
End-user numbers	9.47	9.41	9.44	9.51	9.43	9.43
Circuit length	53.33	53.01	53.15	53.57	53.09	53.14
Energy not supplied	-1.51	-0.89	-1.16	-1.95	-1.05	-1.14
Total	100.00	100.00	100.00	100.00	100.00	100.00

Note: Percentages shown may not sum to 100.00 due to rounding.

* Average across years for aggregated industry.

A3.4 Input weights and Asset Unit Costs

The input weights are the estimated cost shares of each input. The cost of the opex input is nominal opex. The cost of the capital inputs, in aggregate, is calculated by the AER from the other components of the building block calculation, namely: (a) the return on capital – i.e. the real 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. This aggregate cost of capital inputs is decomposed by the AER into the separate capital inputs using estimated shares of each capital asset type in the RAB for each TNSP in each year. The decomposed capital-related costs are referred to as the annual user cost (AUC) for each capital input. Table A.3 shows the average cost shares of each input for each TNSP.

Table A.3 Input cost share weights by TNSP (% , average 2006 to 2024)

<i>Input</i>	<i>ENT</i>	<i>PLK</i>	<i>ANT</i>	<i>TNT</i>	<i>TRG</i>	<i>Industry*</i>
Real opex	32.97	29.13	24.61	28.49	27.76	28.40
Overhead lines	19.85	33.63	28.19	22.25	24.97	27.50
Underground cables	2.07	0.61	0.97	1.33	2.95	1.61
Transformers	45.11	36.63	46.23	47.94	44.32	42.49
Total	100.00	100.00	100.00	100.00	100.00	100.00

Note: Percentages shown may not sum to 100.00 due to rounding.

* Average across years for the aggregated industry.

A4 Measuring AUC in a changing inflation environment

The 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 calculate 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.

A4.1 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:

$$AUC_t = NWACC_t \cdot RAB_t^B + RegDep_t + Tax_t \quad (1)$$

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:

$$RegDep_t = SLD_t - IA_t \quad (2)$$

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:

$$IA_t = RAB_t^B \cdot \dot{P}_t \quad (3)$$

In the calculation of Inflation Addition, $\dot{P}_t$ is the December quarter on December quarter inflation rate for the previous year. For example, for $t = 2022$, $\dot{P}_t$ is the percentage change between the December 2021 CPI and the December 2020 CPI.

The Nominal Vanilla WACC can be expressed as:

$$NWACC_t = RWACC_t + \dot{P}_t^* \quad (4)$$

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

A4.2 The effect of inflation rates

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

$$AUC_t = RWACC_t \cdot RAB_t^B + SLD_t + Tax_t + (\dot{P}_t^* - \dot{P}_t)RAB_t^B \quad (5)$$

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.

A4.3 Revised approach to calculating AUC

The revised approach is to impose $\dot{P}_t^* = \dot{P}_t$ in equation (5) 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:

$$AUC_t = RWACC_t \cdot RAB_t^B + SLD_t + Tax_t \quad (6)$$

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: $RWACC_t = ((1 + NWACC_t) / (1 + \dot{P}_t^e)) - 1$, 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 inflation rate forecasts. This average includes the forecasts for 1 and 2 years ahead,²² the mid-point of the RBA's target band—2.5 per cent—for year 5 or 10, with linear interpolation used from the forecasts for years 1 and 2 to the mid-point of the inflation target in year 5 or 10.²³

²² The 2006-2008 period uses only a one-year headline rate forecast due to no available T+8 (quarter) forecasts in this period.

²³ 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: Regression-based trend growth rates

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

<i>TNSP</i>	<i>Output</i>	<i>Input</i>	<i>TFP</i>	<i>PFP Index</i>	
<i>Period</i>	<i>Index</i>	<i>Index</i>	<i>Index</i>	<i>Opex</i>	<i>Capital</i>
<i>Industry</i>					
Growth Rate 2006–24	0.5%	1.2%	-0.7%	0.4%	-1.1%
Growth Rate 2006–12	1.2%	3.2%	-2.1%	0.3%	-3.0%
Growth Rate 2012–24	0.2%	0.3%	-0.1%	0.5%	-0.3%
<i>ANT</i>					
Growth Rate 2006–24	0.5%	0.3%	0.2%	1.3%	-0.2%
Growth Rate 2006–12	1.5%	0.9%	0.7%	1.0%	0.5%
Growth Rate 2012–24	0.4%	0.3%	0.2%	1.5%	-0.3%
<i>ENT</i>					
Growth Rate 2006–24	0.5%	2.0%	-1.6%	-1.7%	-1.5%
Growth Rate 2006–12	-0.2%	2.4%	-2.6%	-2.8%	-2.6%
Growth Rate 2012–24	0.7%	1.4%	-0.7%	-0.9%	-0.6%
<i>PLK</i>					
Growth Rate 2006–24	1.1%	1.7%	-0.6%	0.3%	-1.0%
Growth Rate 2006–12	2.7%	4.4%	-1.7%	1.8%	-3.2%
Growth Rate 2012–24	0.5%	0.3%	0.2%	0.3%	0.1%
<i>TNT</i>					
Growth Rate 2006–24	0.0%	-0.4%	0.5%	4.9%	-1.4%
Growth Rate 2006–12	-0.1%	2.4%	-2.5%	-1.0%	-3.5%
Growth Rate 2012–24	-0.1%	-1.2%	1.1%	5.2%	-0.5%
<i>TRG</i>					
Growth Rate 2006–24	0.2%	1.3%	-1.1%	0.2%	-1.6%
Growth Rate 2006–12	0.4%	3.9%	-3.5%	0.2%	-5.0%
Growth Rate 2012–24	0.0%	0.3%	-0.2%	0.3%	-0.5%

Appendix C: Sensitivity Analysis

In 2024, the average capacities for two TNSPs underwent significant changes. For ElectraNet, adjustments were introduced following line rating audits, while for TransGrid, capacities were revised due to the shift in peaking season from winter to summer. To assess the impact of these changes, the AER conducted a sensitivity analysis using the 2023 ratings for cables and lines (which we have replicated). Using the 2023 ratings:

- ENT's 2024 OH line MVAkms is 7.5 per cent higher and UG cable MVAkms 5.1 per cent higher than in the main report.
- TRG's 2024 OH line MVAkms is 9.7 per cent higher and UG cable MVAkms 0.8 per cent higher.
- For the industry overall, 2024 OH line MVAkms is 4.0 per cent higher and UG cable MVAkms 1.4 per cent higher than in the main report.

The sensitivity analysis produced alternative index results for the industry as well as for ENT and TRG individually. Table C.1 presents the industry results for the sensitivity analysis, which can be compared to Table 2.1.

Absent the change of ratings for cables and lines by ENT and TRG:

- TNSP industry input growth in 2024 would have been 2.5 per cent, rather than 1.5 per cent shown in Table 2.1; and
- TFP growth for the industry in 2024 would have been –4.3 per cent, rather than –3.2 per cent shown in Table 2.1.

Table C.1 TNSP industry output, input, TFP and PFP indexes, 2006–2024
(using ENT and TRG 2023 line ratings)

<i>Year</i>	<i>Output Index</i>	<i>Input Index</i>	<i>TFP Index</i>	<i>PFP Index</i>	
				<i>Opex</i>	<i>Capital</i>
2006	1.000	1.000	1.000	1.000	1.000
2007	1.014	1.022	0.992	1.012	0.984
2008	1.030	1.034	0.996	1.034	0.980
2009	1.014	1.105	0.918	0.994	0.887
2010	1.060	1.151	0.921	0.991	0.892
2011	1.069	1.158	0.923	1.051	0.875
2012	1.067	1.201	0.889	1.020	0.840
2013	1.076	1.195	0.901	1.070	0.841
2014	1.086	1.237	0.878	0.998	0.833
2015	1.079	1.263	0.855	0.982	0.808
2016	1.083	1.281	0.845	0.968	0.799
2017	1.105	1.268	0.871	0.997	0.825
2018	1.104	1.235	0.894	1.131	0.814

Table C.1 (cont.)

<i>Year</i>	<i>Output</i>	<i>Input</i>	<i>TFP</i>	<i>PFP Index</i>	
	<i>Index</i>	<i>Index</i>	<i>Index</i>	<i>Opex</i>	<i>Capital</i>
2019	1.089	1.240	0.879	1.103	0.801
2020	1.103	1.235	0.893	1.122	0.813
2021	1.107	1.241	0.892	1.121	0.810
2022	1.095	1.243	0.881	1.088	0.806
2023	1.113	1.268	0.878	1.066	0.809
2024	1.093	1.300	0.841	0.995	0.785
Growth Rate 2006-2024	0.5%	1.5%	-1.0%	0.0%	-1.3%
Growth Rate 2006-2012	1.1%	3.0%	-2.0%	0.3%	-2.9%
Growth Rate 2012-2024	0.2%	0.7%	-0.5%	-0.2%	-0.6%
Growth Rate 2024	-1.8%	2.5%	-4.3%	-6.8%	-3.1%

Table C.2 presents the TFP index results for ENT, which can be compared to Table 4.2.1. Absent the change of ratings for cables and lines by ENT:

- ENT's input growth in 2024 would have been 8.4 per cent, rather than 7.0 per cent shown in Table 4.2.1; and
- its TFP growth in 2021 would have been -7.1 per cent, rather than -5.7 per cent shown in Table 4.2.1.

Table C.3 presents the TFP index results for TRG, which can be compared to Table 4.5.1. Absent the change of ratings for cables and lines by TRG:

- TRG's input growth in 2024 would have been -1.4 per cent, rather than -3.7 per cent shown in Table 4.5.1; and
- its TFP growth in 2021 would have been -5.2 per cent, rather than -2.9 per cent shown in Table 4.5.1.

Table C.2 ENT's output, input, TFP and PFP indexes, 2006–2024
(using ENT's 2023 line ratings)

<i>Year</i>	<i>Output</i>	<i>Input</i>	<i>TFP</i>	<i>PFP Index</i>	
	<i>Index</i>	<i>Index</i>	<i>Index</i>	<i>Opex</i>	<i>Capital</i>
2006	1.000	1.000	1.000	1.000	1.000
2007	0.988	1.001	0.986	0.945	1.007
2008	1.003	0.988	1.015	1.069	0.991
2009	1.002	1.027	0.975	1.003	0.964
2010	0.982	1.037	0.947	0.963	0.940
2011	0.985	1.081	0.911	0.897	0.918
2012	0.993	1.175	0.845	0.829	0.853
2013	0.993	1.185	0.838	0.883	0.818
2014	0.997	1.205	0.828	0.867	0.808

Table C.2 (cont.)

<i>Year</i>	<i>Output Index</i>	<i>Input Index</i>	<i>TFP Index</i>	<i>PFP Index</i>	
				<i>Opex</i>	<i>Capital</i>
2015	1.021	1.221	0.836	0.848	0.831
2016	0.980	1.253	0.782	0.775	0.786
2017	1.028	1.276	0.806	0.787	0.815
2018	1.012	1.292	0.783	0.762	0.794
2019	1.011	1.281	0.790	0.779	0.795
2020	1.049	1.293	0.811	0.771	0.832
2021	1.074	1.313	0.818	0.802	0.826
2022	1.006	1.314	0.765	0.763	0.766
2023	1.084	1.361	0.796	0.780	0.804
2024	1.098	1.481	0.741	0.788	0.720
Growth Rate 2006-2024	0.5%	2.2%	-1.7%	-1.3%	-1.8%
Growth Rate 2006-2012	-0.1%	2.7%	-2.8%	-3.1%	-2.7%
Growth Rate 2012-2024	0.8%	1.9%	-1.1%	-0.4%	-1.4%
Growth Rate 2024	1.3%	8.4%	-7.1%	1.1%	-11.0%

Table C.3 TRG's output, input, TFP and PFP indexes, 2006–2024
(using TRG's 2023 line ratings)

<i>Year</i>	<i>Output Index</i>	<i>Input Index</i>	<i>TFP Index</i>	<i>PFP Index</i>	
				<i>Opex</i>	<i>Capital</i>
2006	1.000	1.000	1.000	1.000	1.000
2007	0.995	1.030	0.966	1.021	0.944
2008	1.012	1.004	1.008	1.111	0.966
2009	1.002	1.095	0.915	1.105	0.846
2010	0.997	1.172	0.851	0.980	0.800
2011	1.027	1.181	0.869	1.089	0.793
2012	1.024	1.247	0.821	1.017	0.752
2013	1.025	1.195	0.858	1.119	0.770
2014	1.028	1.273	0.807	0.941	0.757
2015	1.000	1.297	0.771	0.979	0.700
2016	1.042	1.313	0.793	1.031	0.713
2017	1.055	1.270	0.831	1.059	0.752
2018	1.053	1.261	0.836	1.199	0.725
2019	1.047	1.230	0.851	1.215	0.739
2020	1.043	1.237	0.843	1.183	0.736
2021	1.064	1.266	0.840	1.172	0.732
2022	1.031	1.284	0.803	1.053	0.718
2023	1.051	1.327	0.792	0.994	0.721
2024	0.983	1.308	0.752	0.978	0.676
Growth Rate 2006-2024	-0.1%	1.5%	-1.6%	-0.1%	-2.2%
Growth Rate 2006-2012	0.4%	3.7%	-3.3%	0.3%	-4.7%
Growth Rate 2012-2024	-0.3%	0.4%	-0.7%	-0.3%	-0.9%
Growth Rate 2024	-6.6%	-1.4%	-5.2%	-1.6%	-6.4%

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