AER BENCHMARKING

A REPORT PREPARED FOR ENERGY QUEENSLAND

15 JANUARY 2019

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1 INTRODUCTION

Energex and Ergon Energy are currently in the process of preparing their Regulatory Proposals to the Australian Energy Regulator (AER) for the forthcoming regulatory control period from 1 July 2020 to 30 June 2025. To inform their annual revenue requirements for the 2020–25 regulatory period, Energy Queensland has commissioned Frontier Economics to provide two separate reports:

- **A benchmarking report** outlining our assessment of the comparative efficiency of Energex's and Ergon's proposed base year opex for the 2020–25 regulatory period; and
- **An operating environment factors (OEFs) report** outlining our recommended framework for accounting for OEFs for each network in the AER's benchmarking.

We set out our findings from the efficiency benchmarking assessment in this report. This report is to be read alongside our OEFs report titled 'AER operating environment factors (OEFs)', henceforth referred to as our **OEFs report**.

1.1 Our terms of reference

Frontier Economics has been commissioned to provide an assessment of the comparative efficiency of Energex's and Ergon's proposed base year opex for the 2020–25 regulatory period using:

- the latest econometric models adopted by the AER in it its most recent draft decisions for the NSW, ACT and TAS businesses; and
- reasonable additional econometric models that can feasibly be estimated using the RIN data published by the AER.

We have also been asked to provide our comments on:

- whether there are any deficiencies in the benchmarking exercise that has been undertaken by the AER, and the extent to which those deficiencies can be addressed by the AER in the longer-term; and
- how the results from benchmarking should be applied by the AER in the context of the intrinsic challenges that the electricity distributors in Australia face.

The following matters are outside our terms of reference.

- The scope of our work excludes the investigation of additional techniques other than econometrics (such as MTFP, DEA and bottom-up analysis). However, we have been requested to comment on the extent to which additional techniques may be used by the AER to complement the evidence from its econometric models.
- The scope of our work excludes the quantification of adjustments for OEFs, However, we have been commissioned to provide a separate report setting out our recommended framework for accounting for OEFs in the AER's benchmarking. This benchmarking report is to be read alongside our OEFs report.

In the remainder of this introduction, we briefly discuss:

- What is benchmarking and how it can be used in the context of economic regulation (Section 1.2)
- The intrinsic challenges of benchmarking (Section 1.3)
- The enhanced challenges of international benchmarking (Section 1.4)
- The AER's approach to benchmarking (Section 1.5)

The structure of the remainder of our report is set out in Section 1.6.

1.2 What is economic benchmarking and how can it be used

Benchmarking is the process of evaluating the performance of an entity by comparison to some externally determined standard, or by reference to the performance of a peer or a set of peers. This definition is broad and could encompass a wide range of different approaches, used for a similarly wide range of purposes. Typically, benchmarking involves identifying a set of 'inputs' used by the business (e.g., physical inputs such as labour and materials, or financial resources) and a set of 'outputs' (e.g., services delivered and the quality of those services). A business is regarded as performing more efficiently than the benchmark if it is able to deliver the same or more outputs while using less inputs. Differences in the operating environment that affect the level of performance across different operators will need to be taken into account when assessing relative efficiency.

In the context of economic regulation, a review of practice around the world tells us that benchmarking has had an important role in price review proceedings, particularly in jurisdictions where incentive regulation is the prevailing paradigm (like it is in the electricity distribution sector Australia). Benchmarking provides an approach through which the mismatch in information between regulator and regulated business can, at least in part, be overcome. It can form an important part of a wider set of incentive arrangements, putting businesses on notice that their performance will be assessed against that of other businesses, with the prospect of inefficiency being identified and excess costs being disallowed.

There is a broad spectrum of 'benchmarking' that could be used for regulatory purposes. Benchmarking could involve comparing a business' performance against its own historical performance and/or against the contemporaneous or historical performance of suitable peers. The simplest forms of benchmarking use very basic performance metrics such as single-input, single-output ratios. These so-called 'Partial Performance Indicators' (PPIs) do not account for multiple factors that may simultaneously influence a business' performance (hence the nomenclature 'partial') and may therefore fail to measure 'inefficiency' adequately, as they do not control for possible trade-offs between different inputs, or for differences between businesses in the mix of outputs. They may also fail to capture important differences in operating environment. Moreover, they do not allow for variations in measured performance that is due purely to random statistical noise.

While there is a broad spectrum of what could constitute 'benchmarking' for regulatory purposes, we note that in the context of setting efficiency targets and expenditure allowances for regulated businesses, benchmarking is generally used to set the following two main types of efficiency targets.

- Catch-up efficiency measures the extent to which the current performance of a business lags behind the efficiency levels of comparator businesses. It is typically referred to as 'catch up' efficiency as it seeks to measure the extent to which a company must make efficiency improvements to 'catch up' to the efficiency frontier or best practice. This is also knowns as 'base year efficiency' in the context of the AER's base-step-trend approach.[1]
- Frontier shift measures the rate at which a firm already on the frontier should be able to improve performance. It reflects the extent to which a company operating on that frontier may be able to achieve productivity improvements in the future (i.e. this is over and above any scope for 'catch-up' efficiency savings to get to that frontier, owing to technological and other improvements over time). This is also knowns as 'productivity' in the context of the AER's base-step-trend approach.

Regulators may use benchmarking to measure the scope for catch-up, frontier shift or both.

[1] An overview of the AER's 'base-step-trend' approach can be found in Appendix A.

The scope for ***catch-up efficiency savings*** (also known as ***"base year efficiency"*** savings in the context of the AER's base-step-trend approach in Australia) is generally informed by assessments against external comparators (in order to estimate the scope for individual businesses to catch-up to "best-practice"). However, it can also be assessed by comparing different parts of the same firm to see whether some parts of the same firm are less efficient than others.

In order to provide businesses with incentives to continually improve their processes and take advantage of technological improvements, regulators may set a general ***frontier shift*** efficiency target (known as a ***"productivity rate"*** in the context of the AER's base-step-trend approach in Australia, or an ***"ongoing efficiency target"*** in the context of Ofgem's approach in Great Britain) that the regulated entities are required to meet (in addition to any catch up in efficiency that may be required). However, as the scope for frontier shift tends to be difficult to measure accurately, in practice these targets are generally very modest (between 0% to 1% per annum).The most sophisticated benchmarking approaches are statistical techniques which, if applied properly, can account for multiple drivers of performance as well as statistical noise. Whilst these more sophisticated statistical techniques may seem attractive, these techniques can be limited by practical factors such as:

- the availability of reliable data (without which any measure of relative efficiency may be rendered meaningless);
- the ability to identify the most important factors that explain differences in performance (over time and/or between businesses) not due to managerial inefficiency (such as differences in operating environment);
- the ability to quantify and measure those factors in a systematic and consistent way; and
- the ability to capture genuinely 'good' performance, so as to encourage and reward appropriate conduct on the part of the business and not create perverse incentives.

In practice, these challenges are very real, and even the most sophisticated models will be unable to perfectly capture the factors described above. It is critical that the limitations imposed by data and measurement issues are recognised explicitly to avoid overstating the validity and precision of measured inefficiencies.

Given the wide range of benchmarking techniques available, in our view regulators should not restrict themselves to a narrow set of techniques, but should consider a wide range of cross checks and sense checks to develop a holistic view of relative efficiency. Furthermore, it would be important for regulators to recognise that even the most sophisticated benchmarking models will have some limitations, and it is therefore necessary to apply the results from benchmarking with due caution.

1.3 The intrinsic challenges of benchmarking

No two network businesses are exactly the same. Differences in the operating expenditures incurred by networks can arise from a number of potential sources, including (but not necessarily limited to) differences in:

- core cost drivers (e.g., network scale, demand);
- operating environment (e.g., density, climate, topography, soil properties, vegetation, and the urban/rural nature of certain areas);
- regulatory obligations;
- scope of activities (e.g., sharing of vegetation management roles with local councils);
- input prices (e.g., labour rates);

- cost allocation policies and reporting practices;
- past (legacy) network configuration decisions (e.g., ownership of subtransmission assets, historical choices in the way networks were constructed) and planning constraints that cannot be altered easily or efficiently within a short period of time; and
- current managerial and operating efficiency.

All of these factors can influence (increase or reduce) a network's actual or reported opex compared to other networks, and therefore its (raw) efficiency score if not controlled for properly.

However, for the purposes of determining efficiency adjustments in regulatory proceedings, it is only excess cost due to the last type of underlying difference in the above list – genuine **differences in current managerial and operating efficiency** – that should be measured. Differences in measured performance due to the other factors mentioned above should not be used to justify the imposition of efficiency adjustments.

There is, by international standards, an unusually large degree of heterogeneity of circumstance (i.e. differences) within the Australian sample of distribution network service providers (DNSPs). We have documented some of the sources of this heterogeneity in a number of past reports.[2] We comment in more detail on the operating environment challenges of Energex and Ergon Energy in our OEFs report.

As set out in further detail in our OEFs report, given the very large inherent differences in circumstances between DNSPs operating in Australia, it is particularly important that significant effort be made to identify, quantify and control for the relevant OEFs not accounted for by the explanatory variables in the AER's benchmarking models. Our recommendations for further work by the AER in this area is set out in Section 5 of our OEFs report.

1.4 The enhanced challenges of international benchmarking

Further complications arise when attempting to benchmark operators in different countries. In this instance, there could be material differences in a number of areas additional to those identified above, including:

- legislative framework (e.g., employment, environmental, planning, tax, procurement. health and safety law, etc.);
- regulatory arrangements (e.g., data collection processes, incentive frameworks, scope of licensed activities, boundary/interface with other businesses, etc.);
- cost of capital and other financing arrangements (which may affect planning and design decisions);
- differences in design standards (e.g., voltage levels), types of equipment and assets used, and the costs of those types of assets (e.g., including differences in transport costs); and
- exchange rates.

There are also likely to be more prodigious differences in operating environment when taking data from very different countries. Differences that can sometimes be safely assumed away within a region (e.g., assuming that climate may be sufficiently similar to require no adjustment) may become material in the context of a sample drawn from several countries.

[2] For a discussion of some of the very large differences between DNSPs in Australia, Ontario and New Zealand see, for example: Frontier Economics, *Review of the AER's Econometric Benchmarking Models and Their Application in the Draft Determinations for Networks NSW*, January 2015, Section 3.3. For a discussion of the material differences in operating circumstances between DNSPs in Australia alone, see for example: Frontier Economics, *Taking Account of Heterogeneity Between Networks When Conducting Economic Benchmarking Analysis*, February 2015, Section 2.

Designing a benchmarking methodology that accounts adequately for all of these factors is extremely challenging – and in our view is unlikely to be possible without significant effort.

1.5 The AER's benchmarking

Since November 2014, the AER has used economic benchmarking to assess the relative efficiency of the Australian DNSPs, and to inform its determination of expenditure allowances for DNSPs, as is required under the National Electricity Rules.[3] The aim of the AER's benchmarking analysis is to estimate ***differences in managerial and operating efficiency*** between the DNSPs, thereby obtaining an assessment of the scope for efficiency improvements.

The AER has published five annual DNSP benchmarking reports so far, with the seminal report published in 2014, and the most recent report published in November 2018. The annual benchmarking reports have presented economic benchmarking analysis using a range of techniques and models. These include:

- Four opex econometric models, which assess the performance of the Australian DNSPs against one another as well as overseas comparators (18 DNSPs from New Zealand and 36 DNSPs from Ontario).
- Three assessments of the productivity of the Australian businesses from 2006 – 2017, both at the DNSP level and the industry level:
  - **MTFP.** Multilateral total factor productivity
  - **Opex MPFP.** Opex partial factor productivity
  - **Capital MPFP.** Capital partial factor productivity.
- A number of partial performance indicators illustrating how total opex and components of opex of the Australian DNSPs compare against individual cost drivers (e.g., total opex per customer, total opex per kilometre of circuit line length, vegetation management opex per kilometre of route line length, average maintenance opex spend per circuit kilometre, etc.)

Until recently, the AER has relied on a single econometric benchmarking model when setting base year opex allowances for DNSPs. However, in the AER's most recently-released DNSP draft decisions for the NSW, ACT and TAS businesses, the AER has considered a wider set of evidence from four different econometric models. The AER has also sought to cross-check its econometric benchmarking results against trends in the DNSPs' costs over time and evidence from bottom-up unit cost analysis.

We welcome the AER's move away from its reliance on a single econometric model, and towards the consideration of a broader range of evidence. As set out in our terms of reference in Section 1.1 above, we have been commissioned to investigate the use of reasonable additional econometric models that can feasibly be estimated using the RIN data published by the AER. To add to the AER's range of econometric models, we propose the inclusion of the additional econometric models set out in Section 3 of our report. While the investigation of additional techniques other than econometrics (such as MTFP, DEA and bottom-up analysis) is outside of out terms of reference, we note in Section 2.3.5 that these additional techniques may be used by the AER to complement the evidence from its econometric models.

We note that all of the AER's econometric models, and the additional econometric models proposed in this report, are confounded by one key limitation at this stage – the lack of a detailed consideration of OEFs. Our proposed framework for further consideration of OEFs is set out in detail in our OEFs report.

[3] The AER uses a 'base-step-trend' approach to determine expenditure allowance for the DNSPs. A description of this approach can be found in Appendix A.

As there is significant further work to be done in this area, we recommend that the AER proceed with caution in its application of benchmarking, as discussed in Section 4.3 of this report.

1.6 Structure of the remainder of this report

The remainder of the report is structured as follows.

- In Section 2 we replicate the AER's latest econometric models and assess the efficiency of Energex's and Ergon's proposed base year opex using each of these models.
- In Section 3 we propose some additional econometric models to be considered by the AER.
- In Section 4 we outline our conclusions and recommendations for the AER.

2 AER'S ECONOMETRIC BENCHMARKING MODELS

In this section we replicate the AER's latest econometric models and assess the efficiency of Energex' and Ergon's proposed base year opex for the 2020–25 regulatory period using each of these models. We demonstrate that, owing to the significant opex reductions that Energex and Ergon have achieved since 2012–13 and 2011-12, respectively, Energex's and Ergon's proposed base year opex for the 2020–25 regulatory control period falls below the estimated target base year opex and hence does not require an efficiency adjustment.

The remainder of this section is structured as follows.

- In Section 2.1 we provide an overview of the AER's base year assessment approach.
- In Section 2.2 we discuss how the AER's models are used to assess the efficiency of base year opex.
- In Section 2.3 we set out the alternative approaches that have been considered by the AER to date.
- In Section 2.4 we outline the implications of the AER's analysis for Energex's and Ergon's base year assessment.

2.1 Overview of the AER's benchmarking models

In order to aid description of the AER's base year assessment approach, we have identified the following five key dimensions in which there are material choices to be made over how to benchmark the Australian DNSPs.

- **Technique**. Until recently, the AER has relied on a single econometric benchmarking model (the SFA CD model discussed below) when setting or assessing base year opex allowances for DNSPs. In the AER's most recently-released DNSP draft decisions for the NSW, ACT and TAS businesses, the AER has considered a wider set of evidence from four different econometric models, namely:
  - **SFA CD.** Stochastic Frontier Analysis using a Cobb-Douglas (CD) functional form;
  - **SFA TL.** Stochastic Frontier Analysis using a Translog (TL) functional form;
  - **LSE CD.** Least Square Estimation (LSE) using a Cobb-Douglas functional form; and
  - **LSE TL.** Least Square Estimation using a Translog functional form.

  While assessments of trends over time from Opex MPFP have been used as a cross-check, this technique has not been used by the AER to determine base year efficiencies. In Section 2.2 below, we replicate the results from the AER's four econometric benchmarking models.
- **Costs.** Each of the AER's four econometric models include total opex as the dependent variable. While the AER has attempted to cross-check its opex econometric benchmarking results against indicators derived using bottom-up unit-cost analysis, we note that the quality of the AER's bottom-up category analysis data is problematic at present. The AER is yet to consider the use of totex benchmarking, which would help with assessment of opex-capex trade-offs and neutralise the effects of differing capitalisation across DNSPs.

- **Sample.** The AER's latest 2018 annual benchmarking report includes data from 67 DNSPs over 12 years (804 observations in total).
  - **Sample of DNSPs.** The AER's analysis includes data from 67 DNSPs in total. This includes 13 Australian DNSPs, 18 New Zealand DNSPs and 36 Ontarian DNSPs. We note that the AER's original rationale for the inclusion of the international data was to increase the size of the dataset to enable robust estimation of the data-intensive econometric benchmarking models selected by the AER.
  - **Sample over time**. While the AER's preferred sample period is the five-year period from 2012 – 2017, results are also presented for the longer sample period from 2006 – 2017.
- **Cost drivers.** The set of explanatory variables included in the AER's models are:
  - customer numbers;
  - circuit length;
  - ratcheted maximum demand;
  - the share of network that is underground;
  - a time trend; and
  - country dummy variables to allow for country-specific differences, since the AER's models are estimated using data for DNSPs from New Zealand and Ontario.
- **OEF adjustments.**[4] To account for other cost drivers not included in the AER's benchmarking models, the AER makes adjustments for these factors. The AER refers to these adjustments as operating environment factor adjustments (OEFs), even though adjustments are also made for factors other than operating environment, such as differences in cost allocation practices, scope of activities, and legacy network configuration decisions. In its previous regulatory reset period for Energex and Ergon, from 1 July 2015 to 30 June 2020, the AER made an OEF adjustment of 17.1% for Energex and 26.2% for Ergon Energy.

  We note that the AER is currently undertaking further consultations on how OEFs can be quantified, and preliminary work in this area by Sapere-Merz (SM) has been published in September 2018.[5] Sapere-Merz's preliminary work includes an assessment of only four OEFs for Energex (compared to the 26 OEFs for which the AER provided adjustments) and only five OEFs that are relevant to Ergon Energy (compared to the 28 OEFs for which the AER provided adjustments). Sapere-Merz's preliminary work proposed an OEF adjustment of 3.5% for Energex and 13.6% for Ergon. As acknowledged by the AER, we note that the list of OEFs considered in Sapere-Merz's work is limited, and a number of important OEFs for Energex and Ergon are yet to be assessed by Sapere-Merz owing to data limitations at present. We agree with the AER's assessment that, at present, this work is too preliminary to be relied upon for base year assessment purposes.

In Section 2.2 below we set out in detail how the AER's approach described in this section is used for base year assessment purposes.

[4] A review of the AER's approach to OEFs can be found in our companion OEFs report.

[5] In October 2018 the AER has published a report by SM that identified a limited number of OEFs. The AER has recognised the limitations and preliminary nature of this analysis and has indicated that it intends to consult further with the industry to assess and quantify these OEFs. Frontier Economics' view on OEFs and on the SM report can be found in our companion OEFs report.

2.2 How these models are used to assess the efficiency of base year opex

As outlined in the AER's Expenditure Forecast Assessment Guideline,[6] for each DNSP, the AER's allowable opex for each year of the upcoming regulatory control period is obtained using a 'base-step-trend' approach.[7] Under this approach, a nominated year from the previous regulatory period is determined to be the 'base year' from which allowable opex for the upcoming regulatory period is rolled forward. A key step in the AER's approach is to determine the target opex for the regulated utility in the base year.

- If the DNSP's proposed opex in the base year is assessed as meeting the target efficiency level, then the DNSP's proposed opex in the base year will be rolled forward using a rate of change formula.
- If the DNSP's base year opex is assessed to be materially above the target efficiency level, then it may be adjusted downwards by the assessed amount of inefficiency – i.e. the 'efficient adjustment' – before the adjusted target amount is rolled forward using the rate of change formula.

The AER uses the econometric benchmarking models discussed in Section 2.1 to determine the target efficient level of opex in the base year. It then compares the target level of opex with the DNSP's proposed level of opex to assess whether an efficiency adjustment is required. In the remainder of this section, we replicate the AER's latest approach to assessing the efficiency of Energex's and Ergon's proposed level of base year opex. We are advised that:

- Energex and Ergon have both chosen the year 2018-19 to be the proposed base year for the 2020-25 regulatory period
- Energex's proposed base year opex is $371m ($2019-20)[8]
- Ergon's proposed base year opex is $376m ($2019-20).[9]

In the remainder of this section, we assess the efficiency of these base year opex levels proposed by Energex and Ergon by replicating the six steps used by the AER, which are summarised in **Figure 1** below.

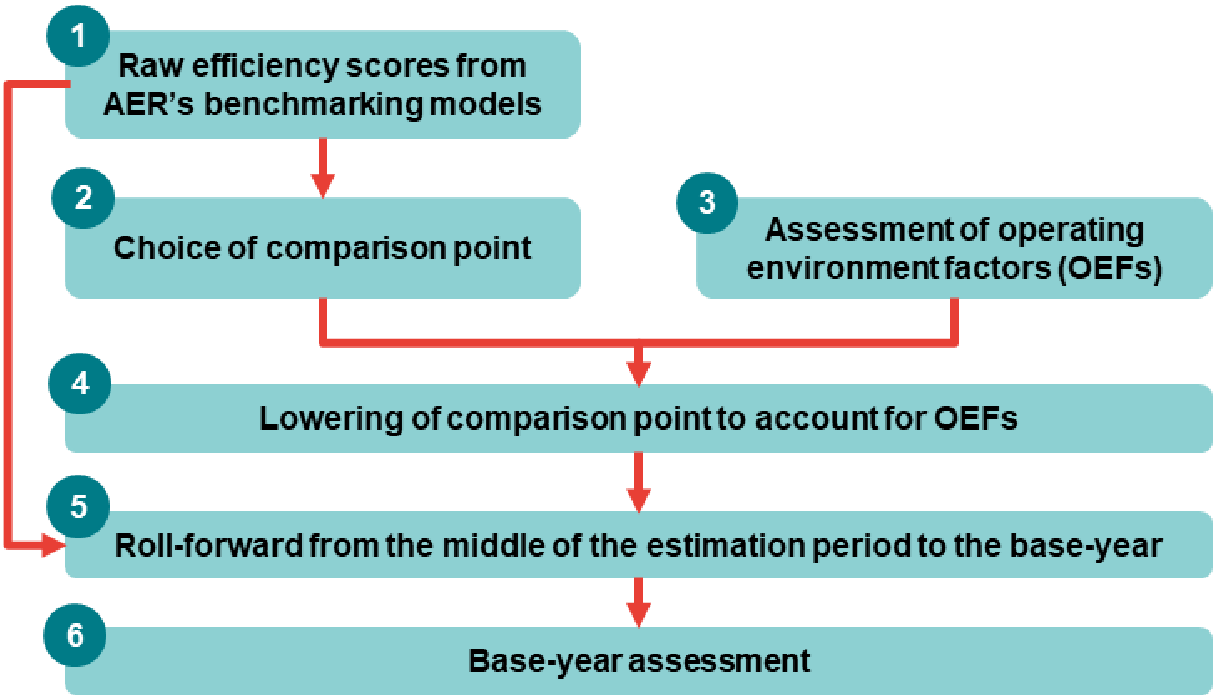
[6] AER, *AER Expenditure Forecast Assessment Guideline for Electricity Distribution*, November 2013; See: http://www.aer.gov.au/sites/default/files/Expenditure%20Forecast%20Assessment%20Guideline%20-%20Distribution%20-%20FINAL.pdf.

[7] An overview of the AER's 'base-step-trend' approach can be found in Appendix A.

[8] Energex's proposed base year opex in nominal dollars is $363m. Nominal opex was converted in real 2019-20 dollars by applying an inflation rate of 2.25%, i.e. $371m = $363m * (1 + 2.25%). Energy Queensland advised us on the inflation rate to be applied.

[9] Ergon's proposed base year opex in nominal dollars is $368m. Nominal opex was converted in real 2019-20 dollars by applying an inflation rate of 2.25%, i.e. $376m = $368m * (1 + 2.25%). Energy Queensland advised us on the inflation rate to be applied.

Figure 1: Steps used by the AER for base year assessment

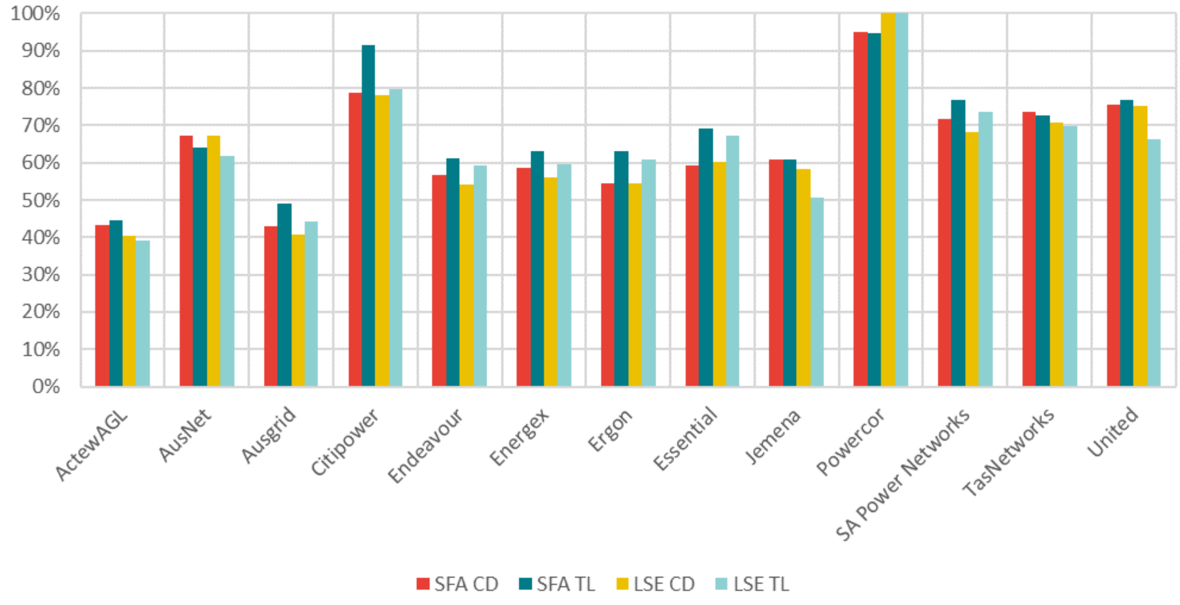


Source: Frontier Economics

2.2.1 Step 1: Raw efficiency scores from AER's benchmarking

In Step 1, 'raw' efficiency scores for each DNSP are obtained from each of the AER's four econometric models. These raw efficiency scores are average efficiency scores over the AER's 2012-2017 sample period. We refer to these as 'raw' scores, as these do not account for the vast differences in the operating environment of the DNSPs. These are shown in **Figure 2** below.

Figure 2: Raw efficiency scores from the AER's four econometric models over the 2012-2017 sample period



Source: AER's 2018 annual benchmarking report, Frontier Economics' calculations

It can be seen that Energex's average efficiency score over the 2012-2017 sample period is estimated to be between 56% and 63%, while Ergon's average efficiency score over 2012-2017 is estimated to be between 54% and 63%.

2.2.2 Step 2: Choice of comparison point

In Step 2, the AER chooses a target comparison point for each model, which in the latest draft determinations is 75%.[10] As can be seen from **Figure 2**, and as summarised in **Table 1** below, the DNSPs with a score above 75% vary score across the four models. These DNSPs are: Citipower, Powercor (for four models), United (for three models), and SA Power Networks (for one model).

[10] In the latest draft determinations for the NSW DNSPs the AER chose the comparison point to be 75%. However, in the draft determination for the ACT DNSP, and in the 2015 determinations, the AER chose the comparison point to be the top 5th DNSP's score.

Table 1: DSNP with a score greater or equal than 75%

SFA CD	SFA TL	LSE CD	LSE TL
Powercor	Powercor	Powercor	Powercor
Citipower	Citipower	Citipower	Citipower
United	United	United	
		SA Power Networks	

Source: Frontier Economics

2.2.3 Step 3: Assessment of operating environment factors (OEFs)

In Step 3, the AER makes an assessment of the adjustment that is required to account for differences in OEFs that are not accounted for in the AER's 'raw' efficiency scores. As discussed in Section 1.3, differences in the operating expenditures incurred by networks can arise from a number of potential sources, including (but not necessarily limited to) differences in:

- core cost drivers (e.g., network scale, demand);
- operating environment (e.g., density, climate, topography, soil properties, vegetation, and the urban/rural nature of certain areas);
- regulatory obligations;
- scope of activities (e.g., sharing of vegetation management roles with local councils);
- input prices (e.g., labour rates);
- cost allocation policies and reporting practices;
- past (legacy) network configuration decisions (e.g., ownership of subtransmission assets, historical choices in the way networks were constructed) and planning constraints that cannot be altered easily or efficiently within a short period of time; and
- current managerial and operating efficiency.

For the purposes of determining a base year efficiency adjustment, it is only excess cost due to the last type of underlying difference in the above list – genuine **differences in current managerial and operating efficiency** – that should be measured by the AER. This is important, as the AER's intention is the identify genuine inefficiencies in base opex, rather than differences driven by other exogenous factors. However, as set out in Section 2.1, the AER's econometric models include only a small subset of the drivers of differences in cost set out above (the six cost drivers included in the AER's models are customer numbers, circuit length, ratcheted maximum demand, the share of network that is underground, a time trend, and country dummy variables).

To account for other cost drivers not included in the AER's benchmarking models, the AER estimates an adjustment for these cost drivers. The AER refers to these adjustments as OEFs, even though adjustments are also made for other factors listed above, such as differences in cost allocation practices, scope of activities, and legacy network configuration decisions. In its previous regulatory reset period from 1 July 2015 to 30 June 2020, the AER made an OEF adjustment of 17.1% for Energex and 26.2% for Ergon Energy. The AER's estimated OEF adjustments for the other DNSPs are set out in Table 2 below. As can be seen from this table, the AER made adjustments both for factors that it considered to have a material impact on opex (greater than 0.5%), and those that it considered to have an immaterial impact on opex individually (less than 0.5%) but material in aggregate.

Table 2: OEF adjustments applied by the AER in 2015 final decisions

OEF	ACTEWAGL	AUSGRID	ENDEAVOUR	ENERGEX	ERGON
Material	18.1%	6.4%	6.1%	12.0%	20.1%
Immaterial	4.9%	5.2%	6.8%	5.1%	6.1%
Total	23.0%	11.7%	12.9%	17.1%	26.2%[11]

Source: AER final determinations for previous regulatory period: ActewAGL distribution determination 2015-16 to 2018-19 (April 2015), Ausgrid distribution determination 2015-16 to 2018-19 (April 2015), Endeavour Energy distribution determination 2015-16 to 2018-19 (April 2015), Energex determination 2015-16 to 2019-20 (October 2015), Ergon Energy determination 2015-16 to 2019-20 (October 2015).

Note: sum of parts is not equal to total due to rounding.

The AER's 26.2% OEF adjustment for Ergon comprises adjustments for the following 28 factors:

- **material factors:** cyclones, subtransmission, division of responsibility for vegetation management, extreme weather events, network accessibility, taxes and levies, termite exposure, and license conditions.
- **factors that are immaterial individually but material in aggregate:** asset age, building regulations, competition from mining, corrosive environments, cultural heritage, environmental regulations, environmental variability, grounding conditions, OH&S regulations, proportion of 11Kv and 22Kv lines, rainfall and humidity, skills required by different DNSPs, solar uptake, topography, traffic management, bushfires, capitalisation practices, private power poles, and transformer capacity owned by customers, and planning regulations.

The AER's 17.1% OEF adjustment for Energex comprises adjustments for the following 26 factors:

- **material factors:** subtransmission, division of responsibility for vegetation management, extreme weather events, taxes and levies, and termite exposure
- **factors that are immaterial individually but material in aggregate:** building regulations, capitalisation practices, corrosive environments, cultural heritage, environmental regulations, fire ants, grounding conditions, OH&S regulations, planning regulations, proportion of 11Kv and 22Kv lines, rainfall and humidity, skills required by different DNSPs, solar uptake, topography, traffic management, asset age, bushfires, environmental variability, private power poles, and transformer capacity owned by customers, and network accessibility.

2.2.4 Step 4: Lowering of comparison point to account for OEFs

In Step 4, the comparison efficiency point (also referred to as target score) estimated in Step 2 is lowered by the OEF adjustment in Step 3.[12] This is determined by the following formula: *Adjusted comparison point = comparison point / (1 + OEF).*

Figure 3 below shows Energex' and Ergon's average efficiency scores (light blue bars), the target score before the OEF adjustment (dashed red line) and the target score adjusted using the AER 2015 OEFs

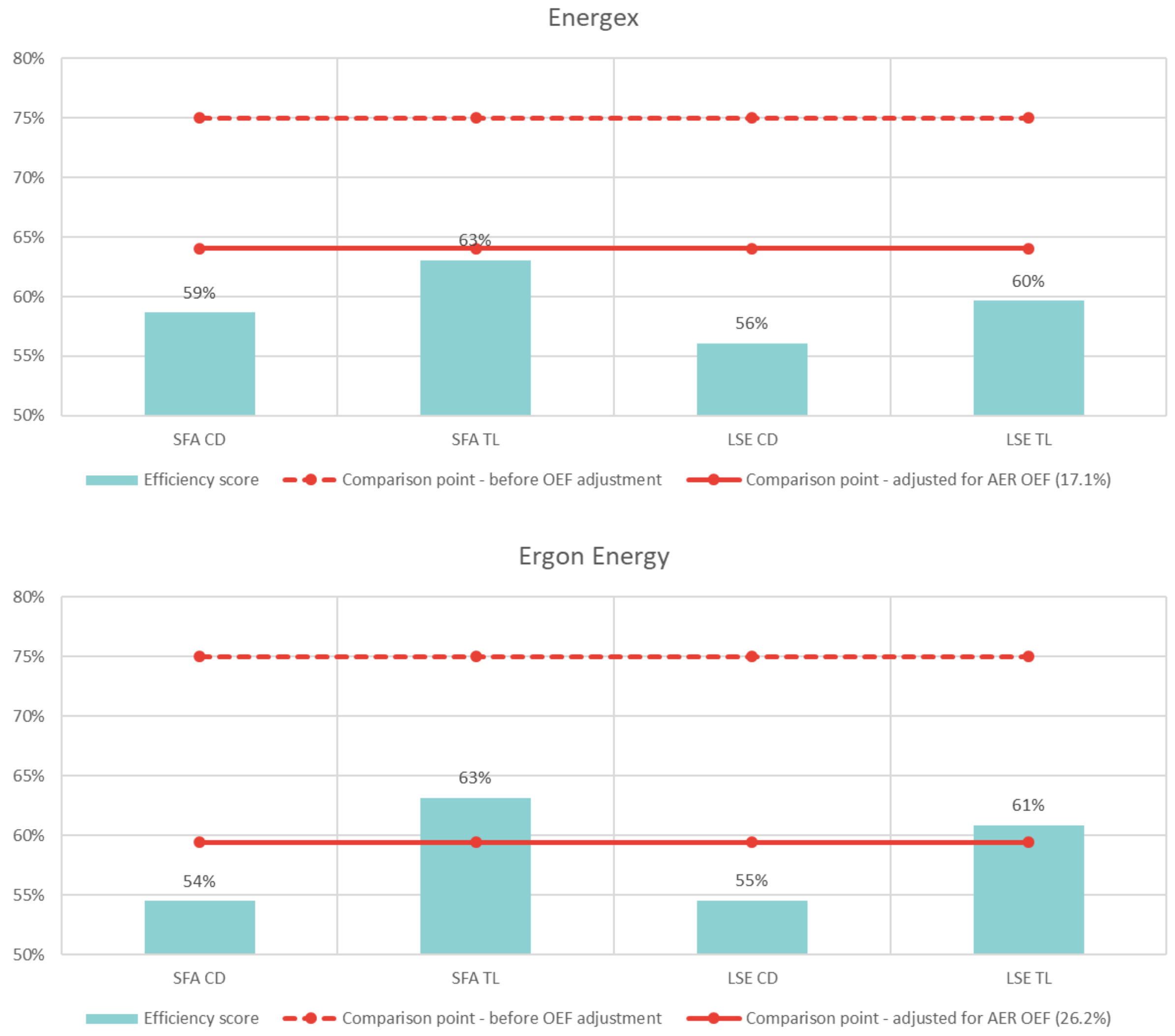
[11] Breakdown does not reconcile with total as the AER has not published a reconciliation.

[12] Note that if the OEF adjustment were negative, the comparison efficiency point would be increased.

(solid red line). The chart shows that the target score is lowered when adjustments are made for differences in operating environments across DNSPs.

In previous decisions, the AER has considered a DNSP whose score is above the target score to be efficient. It can be seen from the chart that when the AER OEFs are used Ergon is efficient for two out of four models.

Figure 3: Comparison of Energex's and Ergon's average efficiency scores and target scores adjusted for OEFs for the four AER's models over the shorter sample 2012-2017 period



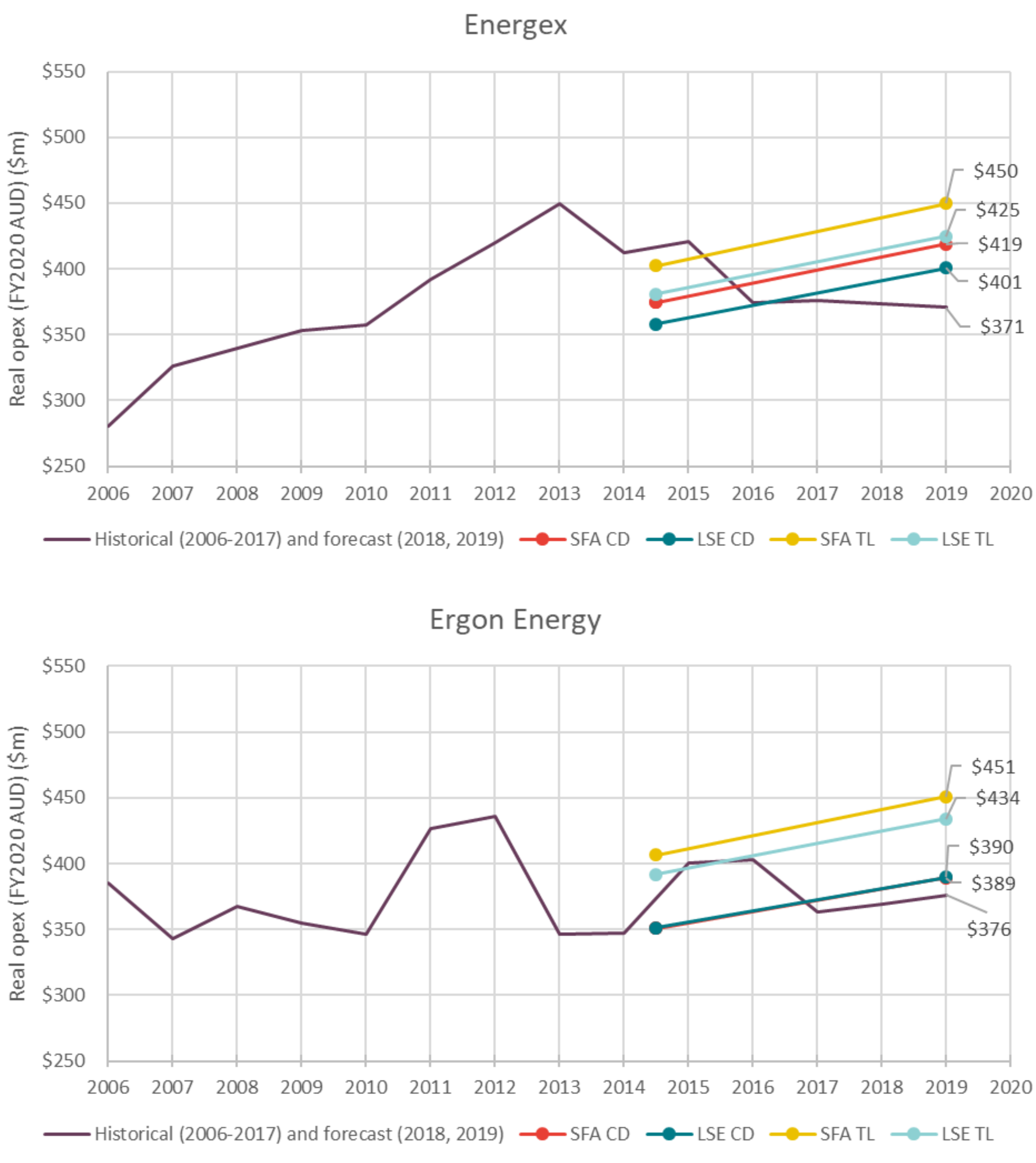
Source: Frontier Economics

2.2.5 Step 5: Roll-forward from middle of the estimation period to the base year

As Steps 1 – 4 above relate to average estimates over the 2012 – 2017 estimation period, in Step 5 the AER rolls these averages forward to the base year (which is proposed to be 2018-19 for Energex and Ergon for the forthcoming regulatory period), as illustrated in **Figure 4** below. Energex's and Ergon's historical opex (from 2006 to 2017) and forecast opex (for 2018 and 2019) are represented by the solid purple line. The roll-forward from the middle of the estimation period (2012 – 2017) to the base year

(2019) for each of the AER's four econometric models is represented by the solid red (SFA CD), blue (LSE CD), yellow (SFA TL), and light blue (LSE TL) lines.

Figure 4: Illustration of AER's roll-forward for base year assessment



Source: Frontier Economics

Note: 2018 opex has been interpolated between 2017 and 2019. The years reported in the chart are financial years. For example, the year 2019 corresponds to the 2018-19 financial year ending in June 2019.

The calculations in **Figure 4** above can be described in the following steps.

- **Calculate percentage opex reduction in middle of the period.** The percentage reduction in the middle of the 2012 to 2017 estimation period (which is between 2014 and 2015 in the figure above) is derived by the ratio of the average raw efficiency score (from Step 1 in Section 2.2.1) and the adjusted target score (from Step 4 in Section 2.2.4) using the following formula: *Percentage reduction in mid-year opex = 1 – (Raw efficiency score/Adjusted comparison point).*

- **Calculate target opex in middle of estimation period.** The target opex at the midpoint of the 2012 to 2017 estimation period is estimated by applying the percentage reduction calculated above to Energex' and Ergon's average opex over the 2012 – 2017 estimation period. This is determined by the following formula: *Mid-period target opex = (1 - Percentage reduction) * Average opex over the period.*
- **Roll-forward target opex from the middle of the period to the base year by applying a rate of change derived from the econometric model.**[13] This is determined by the following formula: *Base year target opex = Target opex in middle of estimation period * (1 + estimated growth rate).* The estimated growth rate is determined by estimating the impact on opex of changes in customer numbers, line length, ratcheted maximum demand, and share of undergrounding between the middle of the estimation period and the base year.

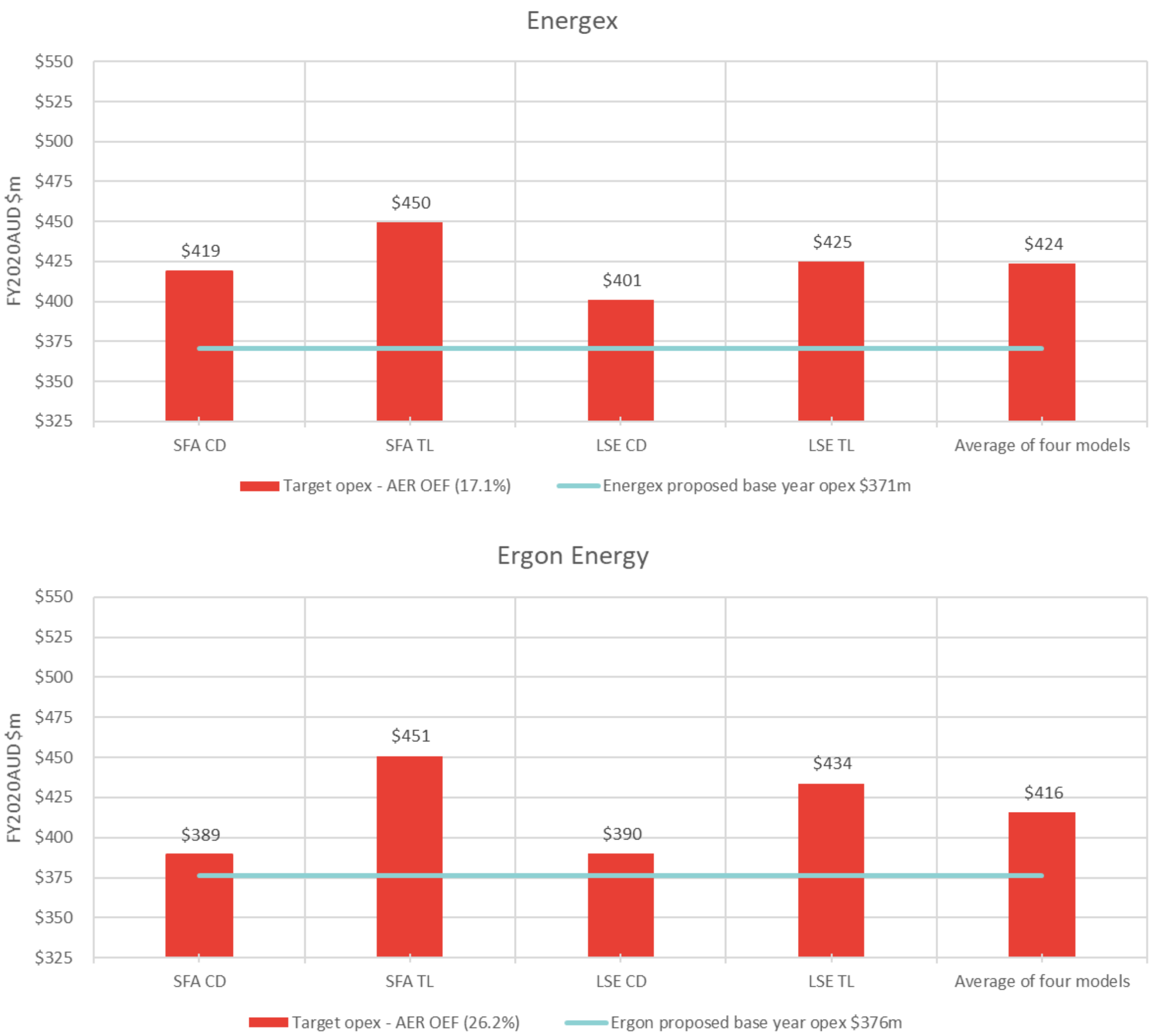
2.2.6 Step 6: Base year assessment

As discussed in the introduction to this section, the AER's base year assessment is based on a comparison of the target level of opex from each model with the DNSP's proposed level of opex to assess whether an efficiency adjustment is required. As can be seen from **Figure 4** above and **Figure 5** below:

- Energex's proposed base year opex of $371m ($2019-20) is below the range of target opex levels of $401m-$450m estimated by the AER's four econometric models
- Ergon's proposed base year opex of $376m ($2019-20) also falls below the range of target opex levels of $389m-$451m estimated by the AER's four econometric models.

[13] We note that the target opex in the base year can by estimated directly by evaluating the estimated econometric function at the values of the explanatory variables in the base year. The advantage of this approach is that it can be applied directly to alternative econometric functional forms, such as SFA TL, which are non-linear in logarithms and for which elasticities are not constant. By contrast, the AER's approach assumes constant elasticities even for those models for which elasticities are not constant. For the purpose of this report, we have been instructed by Energy Queensland to adopt the AER's roll-forward approach.

Figure 5: Assessment of Energex's and Ergon's proposed base year opex using the four AER's models over the shorter sample period



Source: Frontier Economics

This analysis shows that the AER's latest preferred approach to benchmarking provides no justification for a base year efficiency adjustment for either Energex or Ergon.

We note that Energex and Ergon are both efficient in the base year, despite their seemingly low raw efficiency scores over the 2012 – 2017 sample period. This is owing to two key factors:

- The AER's raw efficiency scores are misleading because they do not take account of OEFs.
- The average efficiency scores over the 2012 – 2017 period are misleading as they do not capture the significant efficiency savings that Energex and Ergon have achieved through substantial opex reductions since 2012-13 and 2011-12, respectively. In particular, Energex has reduced its opex by about 4.4% per annum from 2012-13 to 2016-17, while Ergon has reduced its opex by about 3.6% per annum from 2011-12 to 2016-17. Over these periods, Energex and Ergon have reduced their opex by 16% and 17%, respectively. This translates to savings for Energex of $73m ($2019-20) over the 4-year period from 2012-13, and savings for Ergon of $73m ($2019-20) over the 5-year period from 2011-12.

2.3 Alternative approaches that have been considered by the AER

We note that while the approach described in Section 2.2 reflects the AER's approach in its most recently-released draft decisions, we have identified the following five key decisions points for which the AER has considered alternative approaches to date.

2.3.1 Choice of sample period

Until recently, the AER's sample of benchmarking data used 2006 as the start of the sample period. In its more recent annual benchmarking report, and its most recently-released draft decisions, the AER has relied on the sample period starting in 2012 as its preferred sample, as – in its view – this provides a more accurate reflection of the most recent performance of the businesses. While we are supportive of the AER's consideration of more recent evidence, we recommend that the AER not disregard evidence from the longer sample period starting in 2006, as there are benefits to models estimated on a longer sample period of data. For example, models with a larger sample of data are likely to be less sensitive to small year-on-year variations in the data. The AER's larger sample of data also allows for valuable sensitivity analyses, such as excluding the international sample from the benchmarking analysis (see Section 3.1), and splitting the rural and urban DNSPs into two different sub-samples (see Section 3.2). We therefore recommend that the AER consider evidence from both the long and short samples. This evidence is presented in Section 2.4 below.

2.3.2 Sapere-Merz consultation on OEFs

While the AER has, to date, used its 2015 assessment of OEFs (26.2% for Ergon and 17.1% for Energex) for its base year assessment of the DNSPs' proposed opex (including in its most recently-released draft decisions), we note that the AER is currently engaged in further consultation on how OEFs can be quantified, and preliminary work in this area by Sapere-Merz has been published in October 2018.[14] Sapere-Merz' preliminary work includes:

- An assessment of five OEFs that are relevant to Ergon Energy, namely, subtransmission, taxes and levies, termite exposure, cyclones and OH&S regulations. We note that this is a small subset of the 28 OEFs previously considered by the AER in 2015, as set out above. The illustrative OEF adjustment proposed for these five OEFs is 13.6%.
- An assessment of four OEFs that are relevant to Energex, including subtransmission, taxes and levies, termite exposure, and OH&S regulations. We note that this is a small subset of the 26 OEFs previously considered by the AER in 2015, as set out above. The illustrative OEF adjustment proposed for these four OEFs is 3.5%.

As acknowledged by the AER, we note that the list of OEFs considered in Sapere-Merz's work is limited, and a number of important OEFs for Energex and Ergon are yet to be assessed by Sapere-Merz owing to data limitations at present. We therefore consider that Sapere-Merz' current preliminary OEF adjustments significantly underestimate the challenges associated with the operating environment of Energex and Ergon. More generally, in our view, Sapere-Merz' latest report significantly underestimates the OEF adjustments that are necessary to account for the vast differences in the operating environments of the different DNSPs in the NEM. At present, this work is too preliminary to be relied upon for base year assessment purposes. However, for the purposes of sensitivity analysis, and to demonstrate the efficiency of Energex's and Ergon's proposed base year opex even under a highly

[14] In October 2018 the AER has published a report by SM that identified a limited number of OEFs. The AER has recognised the limitations and preliminary nature of this analysis and has indicated that it intends to consult further with the industry to assess and quantify these OEFs. Frontier Economics' view on OEFs and on the SM report can be found in our companion OEFs report.

limited assessment of OEFs, we present results under the lower Sapere-Merz OEF adjustments (13.6% for Ergon and 3.5% for Energex) in Section 2.4 below.

2.3.3 Choice of target score

Since the first use of benchmarking for base year assessment purposes in 2015, the AER has described its choice of the target score or comparison point in the following three ways.

- the top 5th score
- the lowest of the efficiency scores in the top quartile of possible scores (i.e. the lowest score greater or equal than 75%)
- the 75% threshold.

We do not consider the latter two approaches to be appropriate as they are derived using a threshold (75%) which is not reflective of the efficiencies observed in the sample. These two approaches suffer from the following shortcomings:

- In theory, all DNSPs could be below the 75% threshold, or all DNSPs could be above the 75% threshold. In such cases, using a criterion such as 'the lowest score greater or equal than 75%' or 75% threshold would not be meaningful.
- The AER's LSE models assign, by construction, a score of 100% to the most efficient DNSP, while the AER's SFA models do not. For this reason, a threshold determined *a priori* has different implications for LSE and SFA models just because of the way the scores are constructed.

By contrast, the criterion of the top 5th score does not suffer from these shortcomings, and it provides a more stable classification of DNSPs that perform well compared to those that do not perform well. For these reasons, in Section 2.4 below we determine target scores using the top 5th score rather than the other two criteria.[15]

2.3.4 Choice of econometric models

We welcome the AER's move away from its previous reliance on a single econometric model (the SFA CD model), and towards the consideration of a broader range of evidence (including the four econometric models discussed in Section 2.1). We recommend that the AER's four econometric models be treated as a starting point for further discussion going forward. In particular

- We recommend that the AER have regard to the SFA TL results from the 2006 – 2017 sample period, which the AER has disregarded owing to statistical monotonicity[16] violations. In our view, owing to the larger number of explanatory variables included in TL models relative to CD models, SFA TL is more robustly estimated using larger samples than smaller ones. It is therefore counter-intuitive that the AER concludes that TL SFA is more robustly estimated in the short sample period. We recommend that the SFA TL model results for the longer sample period also be presented, with suitable caveats, to enable a fuller evaluation of the relative merits of the different econometric models. These results are presented in Section 2.4 below.
- We recommend that the AER have regard to our proposed sensitivity analyses of excluding the international sample from the benchmarking (see Section 3.1) and of splitting the rural and urban DNSPs into two different sub-samples (see Section 3.2). While this evidence has previously been

[15] We note that all three approaches to determining the target score are applied by the AER prior to making any OEF adjustments.

[16] Monotonicity is the requirement that an increase in any output involves an increase in cost.

submitted to the AER,[17] the AER is yet to comment on this analysis. These results are presented in Section 3.

2.3.5 Choice of techniques

As discussed in more detail in Section 3.4, we recommend that evidence from additional techniques, such as DEA and bottom-up analysis, be used to complement the AER's evidence from the econometric approach. In our view, the AER's evidence from econometrics can serve as a helpful starting point for further discussion with its stakeholders going forward, with the objective of seeking ongoing improvement to the AER's benchmarking.

As the AER describes multilateral total factor productivity (MTFP) and multilateral partial factor productivity (MPFP) as being its primary benchmarking technique in its 2018 annual benchmarking report, we briefly set out our proposed views on the limitations of this technique for the purposes of making assessments about the relative efficiencies of the DNSPs' base year opex.

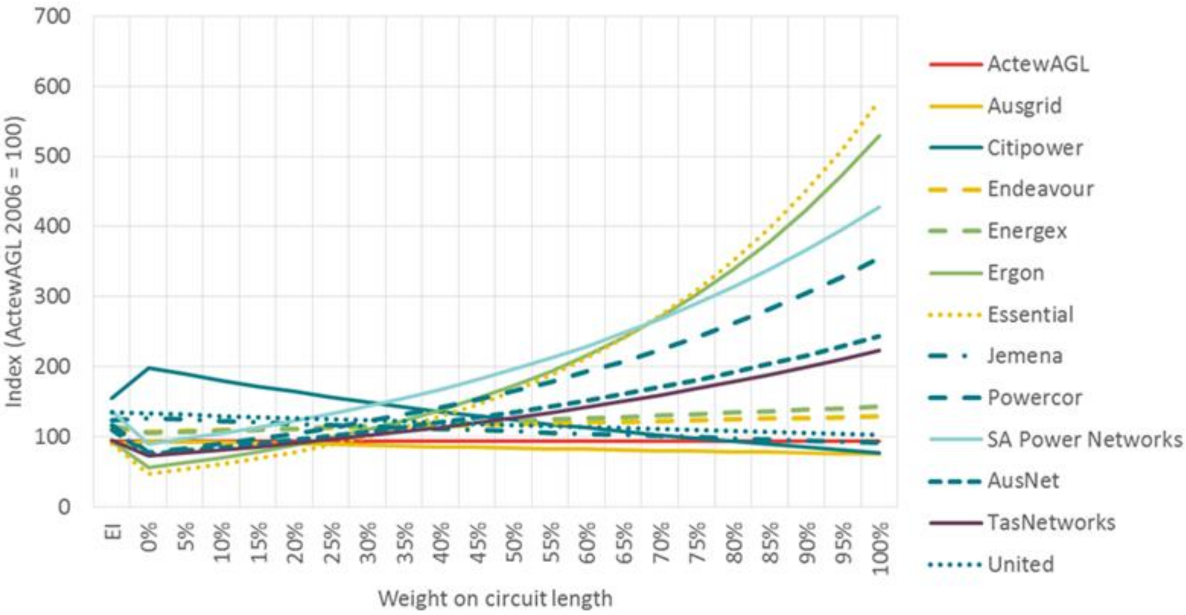
While a detailed review of the AER's latest MTFP and MPFP analysis is outside the scope of this engagement, we note that we had reviewed the AER's previous work in this area, and presented our assessment in our January 2018 benchmarking report submitted to the AER by Essential Energy.[18] As set out in Section 3 of that report, we consider that the AER's MTFP/MPFP analysis contains a number of serious shortcomings that render it unsuitable for the purposes of making conclusions about the relative efficiencies of the DNSPs' base year opex. Notably, as shown in **Figure 6** the AER's MTFP and MPFP scores are highly sensitive to the output weights used in constructing the indices. For example, in the 2017 annual benchmarking report Ergon ranked 11th according to the AER's MTFP results (based on a weight of 23.8% assigned to circuit length); we demonstrate that its rank would be higher than estimated by the AER when circuit length is given a greater weight than 23.8%.[19] If circuit length were assigned a weight of 35%, Ergon's MTFP ranking would improve to 4th out of 13 DNSPs. If circuit length were assigned a weight of above 75%, Ergon's MTFP ranking would improve to 2nd among the 13 DNSPs.

[17] Frontier Economics, *AER Benchmarking – A report prepared for Essential Energy*, April 2018. Frontier Economics, *Review of the AER's econometric benchmarking models and their application in the draft determinations for Networks NSW – A report prepared for Networks NSW*, January 2015.

[18] Frontier Economics, *AER Benchmarking – A report prepared for Essential Energy*, April 2018.

[19] In the simplified example where the residual output weight is split equally amongst the remaining three output variables.

Figure 6: Average MTFP – sensitivity to circuit length weight



Source: Frontier Economics analysis based on data from 2006 to 2016 and AER's MTFP model.

Note: In this figure, we show the average MTFP scores (y-axis) as a higher output weight is given to circuit length (x-axis), while splitting the remaining output weight equally amongst the remaining output variables. For example, at the left of the chart, if the weight given to circuit length is 10%, then the weight assigned to customer numbers, ratcheted maximum demand and energy delivered is 30% each. At the right of the chart, if the weight assigned to circuit length is 100%, then the weight given to customer numbers, ratcheted maximum demand and energy delivered is 0% each. Average MTFP values using Economic Insights (EI)' output weights used in the 2017 annual benchmarking report are plotted at the extreme left of this chart to provide a reference point for the possible alternative sets of average MTFP values corresponding to the alternative weights presented to the right of the chart. Following EI's convention, the observation for ActewAGL (now EvoEnergy) in 2006 is chosen as the base and is given the value 100. Note, however, that this is done for presentational purposes as the relative MTFP levels are invariant to which DNSP/year is chosen as the base.

Given how sensitive the relative DNSP rankings are to changes in output weights, and the fact that the importance of different cost drivers is likely to differ between rural and urban DNSPs, we do not consider the MTFP and MPFP results presented in the AER's 2018 annual benchmarking report to be a suitable basis for informing regulatory decisions on the relative efficiencies of the DNSPs. Furthermore, there are a number of issues with EI's econometric methodology used to derive its output weights as discussed in detail in our April 2018 report.[20]

Since a detailed assessment of additional techniques (other than econometrics) considered by the AER to date is outside our terms of reference for this report, we do not present an analysis of the AER's additional techniques, such as MTFP/MPFP and PPIs, in Section 2.4 below.

2.4 What the AER's analysis suggests for Energex and Ergon

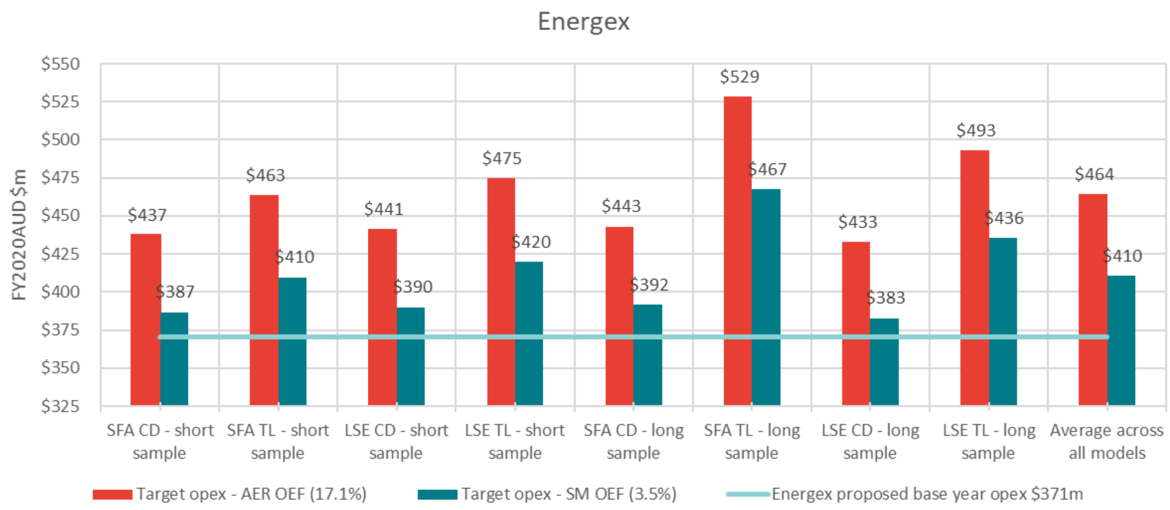
In **Figure 10** below we summarise how Energex and Ergon perform across the range of AER econometric models presented in this section. This figure presents results from the AER's models both over the 2012 – 2017 and the 2006 – 2017 sample periods (discussed in Section 2.3.1 above), and using both the AER’s 2015 OEF adjustments (26.2% for Ergon and 17.1% for Energex) and the limited OEF adjustments considered by Sapere-Merz in its preliminary work (13.6% for Ergon and 3.5% for Energex) (see Section 2.3.2 for a discussion on OEFs scenarios).

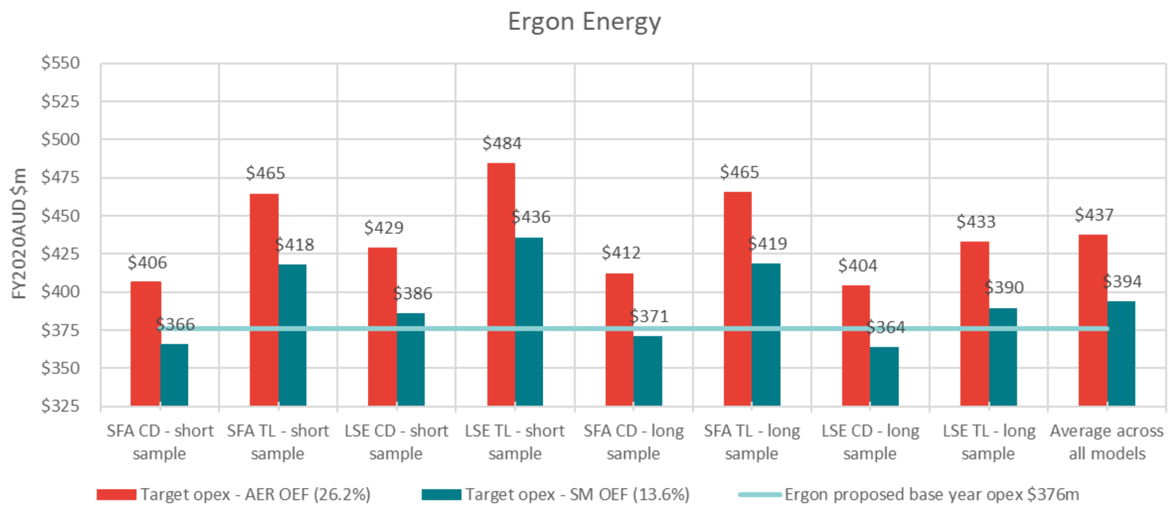
Energex’s and Ergon’s proposed base year opex is represented by the light blue horizontal line. Energex’s and Ergon’s target base year opex from each alternative model is represented as follows: red bars represent target opex derived using the AER’s 2015 OEFs, while blue bars represent target opex derived using the Sapere-Merz OEFs. The figure shows that Energex’s and Ergon’s proposed base year opex is below its target base year opex for the 2020–25 regulatory control period across the vast majority of the econometric models considered in this section.

- When the AER 2015 OEFs are used:
  - Energex’ proposed base year opex of $371m ($2019-20) is significantly below the range of opex levels of $433m-$529m estimated by the AER’s four econometric models.
  - Ergon’s proposed base year opex of $376m ($2019-20) falls also below the range of opex levels of $404m-$484m estimated by the AER’s four econometric models.
- When the preliminary and limited Sapere-Merz OEFs are used:
  - Energex’ proposed base year opex of $371m ($2019-20) is below the range of opex levels of $383m-$467m estimated by the AER’s four econometric models.
  - Ergon’s proposed base year opex of $376m ($2019-20) is towards the lower end of the range of opex levels of $364m-$436m estimated by the AER’s four econometric models.

These models do not provide any evidence to suggest that Energex’s and Ergon’s base year opex for the 2020–25 regulatory period requires any efficiency adjustments. Since this conclusion holds even under the limited set of OEF adjustments considered to date by Sapere-Merz, it holds even more strongly if a reasonable allowance is made for OEF adjustments in the estimation of Energex’ and Ergon’s target base year opex.

Figure 7: Energex's and Ergon's performance across the AER models and sensitivities





Source: Frontier Economics

3 ADDITIONAL ECONOMETRIC APPROACHES INVESTIGATED BY FRONTIER ECONOMICS

While the AER's latest approach discussed in Section 1.1 relies on evidence from four econometric models to assess the efficiency of the DNSPs in the base year, we note that there are additional econometric models that it would be appropriate to consider to test the robustness of the AER's models and/or complement its evidence. We propose two additional econometric model variations to be considered in the AER's body of evidence.

- In Section 3.1 we investigate statistically whether the sample of Australian DNSPs can validly be pooled with the DNSPs in New Zealand and Ontario. We also show how the AER's SFA CD results over the longer period from 2006[21] change when the DNSPs in Ontario and New Zealand are excluded from the sample.
- In Section 3.2 we show how sensitive the AER's SFA CD results over the longer period from 2006 are to splitting the sample of DNSPs into separate urban and rural sub-samples.
- In Section 3.3 we set out what this additional analysis means for Energex's and Egon's base year assessment.
- While the scope of our work excludes the investigation of additional techniques other than econometrics (such as MTFP, DEA and bottom-up analysis), in Section 3.4 we briefly comment on the extent to which additional techniques may be used by the AER to complement the evidence from its econometric models.
- Finally, in Section 3.5 we present an alternative approach to the AER's roll-forward to determine base year opex.

We note that in undertaking this exercise, we emphasise that we do not claim that the models presented in this section are the 'right' models, and that the AER should use these as 'preferred' models to set allowances at this reset. Rather, we recommend that the AER consider these as part of its range of benchmarking evidence when determining its target base year opex for the DNSPs. We propose that the evidence presented in this report should be used as a starting point for discussion and consultation with all 13 DNSPs. Doing so implicitly recognises some of the limitations with relying on a subset of reasonable benchmarking techniques, data inputs, and assumptions (such as the target score).

Our sensitivity analysis is discussed in the remainder of this section.

[21] Given small sample size problems, we focussed our sensitivity analysis and testing on the AER's SFA CD model estimated over the 2006-2017 sample period.

3.1 The use of international data: Can data be pooled across countries?

In all of the AER's models underlying Section 1.1, the Australian data sample is embedded within a much larger sample comprising data from New Zealand and Ontario. The aim of using the larger dataset is to increase the variation in the data to enable more robust estimation of the model's parameters. As shown in **Table 3** below, the Australian DNSPs account for only 19% of the estimation sample. The New Zealand DNSPs account for 27%, and the Ontarian DNSPs account for 54%, more than half of the sample.

Table 3: Number of companies in the AER's sample

	AUSTRALIA	NEW ZEALAND	ONTARIO
Number of companies	13	18	36
Proportion of sample	19.4%	26.9%	53.7%

Source: Economic Insights' dataset

This raises the question whether the impact of the different cost drivers on opex in these three jurisdictions is similar enough to enable these datasets to be pooled.[22] In a number of previous reports submitted to the AER,[23] we have tested statistically whether the impact of cost drivers on opex is similar enough across countries for the pooling of the samples to be justified. Poolability requires that there are no statistically significant differences between the values of the main parameters in the model across the sub-samples. To conduct the poolability test we re-estimated the AER's SFA CD model with the addition of dummy variables that could pick up any differences between the countries in the values of the elasticities on the four main drivers of costs (customer numbers, circuit length, ratcheted maximum demand and share of underground cables) as well as the time trends. The results from our pooability testing of the international sample using the latest data are presented in Appendix B. As in our previous analysis, our latest tests using the latest data indicate that the Ontario sample is statistically not poolable with the Australian/New Zealand sample, but that the Australian and New Zealand samples can be pooled. We have therefore re-estimated results from the AER's SFA CD model over the 2006 – 2017 period using the following three approaches:

- Using the full sample of data from all three jurisdictions but allowing the relationship between costs and cost-drivers to vary between Ontario (which the tests suggest cannot be pooled with Australia and New Zealand) and Australia and New Zealand
- Using the sample of Australian data and New Zealand (excluding data from Ontario)
- Using the sample of Australian data alone (excluding data from both New Zealand and Ontario).

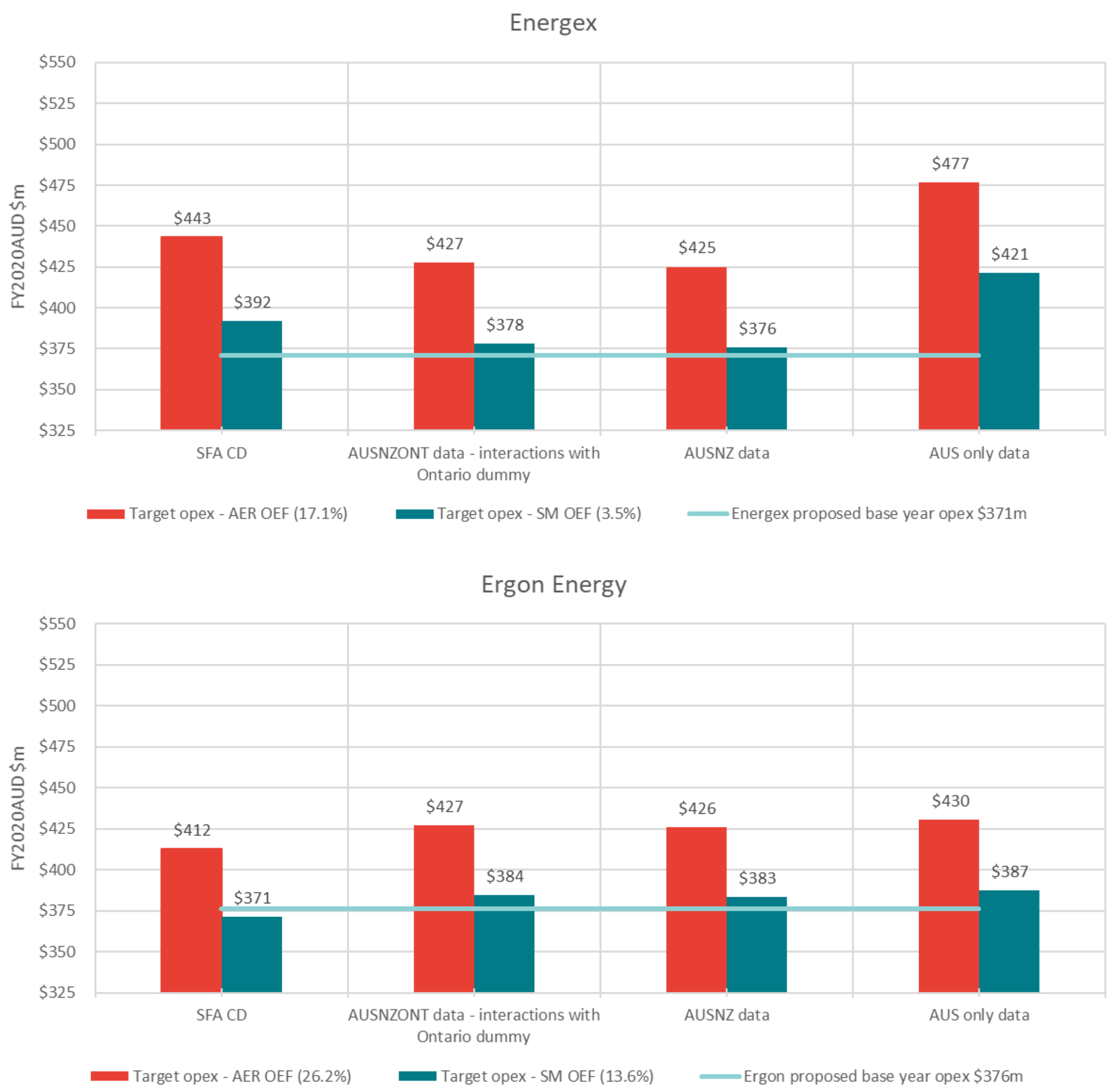
In **Figure 8** we present the assessment of Energex's and Ergon's proposed base year opex resulting from these additional models. For comparison, we have also included the estimates of the AER's SFA CD model (the first column of estimates). **Figure 8** shows that these additional models do not provide

[22] If the jurisdictions can be pooled we say that they are poolable. If one or more jurisdictions cannot be pooled, we say that they are not poolable.

[23] Frontier Economics, *AER Benchmarking – A report prepared for Essential Energy*, April 2018. Frontier Economics, *Review of the AER's econometric benchmarking models and their application in the draft determinations for Networks NSW – A report prepared for Networks NSW*, January 2015.

any evidence to suggest that Energex's and Ergon's base year opex for the 2020–25 regulatory period requires an efficiency adjustment. As these additional models obviate some of the limitation of the AER's model, they should be added to the AER's benchmarking evidence.

Figure 8: Assessment of Energex's and Ergon's proposed base year opex using the SFA CD models on different datasets and model specification



Source: Frontier Economics

3.2 Splitting of rural and urban samples

In this section, we investigate whether there may be merit in splitting the AER's sample of DNSPs into two different rural and urban sub-samples. The rationale for doing so is to account for the fact that the impact of different costs drivers on cost might differ across networks with different customer densities.[24]

[24] We note that the AER implicitly takes account of customer density in a fairly simplistic way: the model includes the logarithms of customer numbers and circuit length. This is algebraically equivalent to including the logarithms of customer density (number

Denser networks are likely to be able to serve a given number of customers with fewer assets than more sparsely populated networks and are also likely to have lower operating costs. To investigate whether there are differences in the elasticities between denser and less dense networks, we split the sample into rural and urban DNSPs based on customer density.[25]

As previously investigated in our January 2018 report,[26] submitted to the AER, we use a statistical test for poolability of rural and urban DNSPs[27] to show that differences between these two subsamples of DNSPs are statistically significant. Results of our test and the elasticities for rural and urban DNSPs are shown in Appendix C. Although some of these differences are not statistically significant individually, we note that they are jointly significant, and some of the differences are very significant from a business point of view. For example,

- while the elasticity of opex with respect to circuit length is 0.151 for urban DNSPs, the elasticity is 0.151 + 0.114 = 0.265 for rural DNSPs. In other words, while a 1% increase in circuit length would have a 0.151% increase in opex for urban DNSPs, the impact is 0.114% higher for rural DNSPs.
- Similarly, while the elasticity of opex with respect to customer numbers is 0.832 for urban DNSPs, the elasticity is 0.832 - 0.237 = 0.595 for rural DNSPs. In other words, while a 1% increase in customer numbers would have a 0.832% increase in opex for urban DNSPs, the impact is 0.237% lower for rural DNSPs.

Given that the pooling of rural and urban DNSPs in the SFA CD model does not pass the poolability test, we have also re-estimated the SFA CD model:

- Allowing the relationship between costs and cost-drivers to vary between rural and urban DNSPs (the middle column)
- On separate rural and urban sub-samples (column to the right).

In **Figure 9** we present the assessment of Energex's and Ergon's proposed base year opex resulting from these additional models. For comparison, we have also included the estimates of the AER's SFA CD model (the first column of estimates). **Figure 9** shows that these additional models do not provide any evidence to suggest that Energex's and Ergon's base year opex for the 2020–25 regulatory period requires an efficiency adjustment. As these additional models obviate some of the limitation of the AER's model, they should be added to the AER's benchmarking evidence.

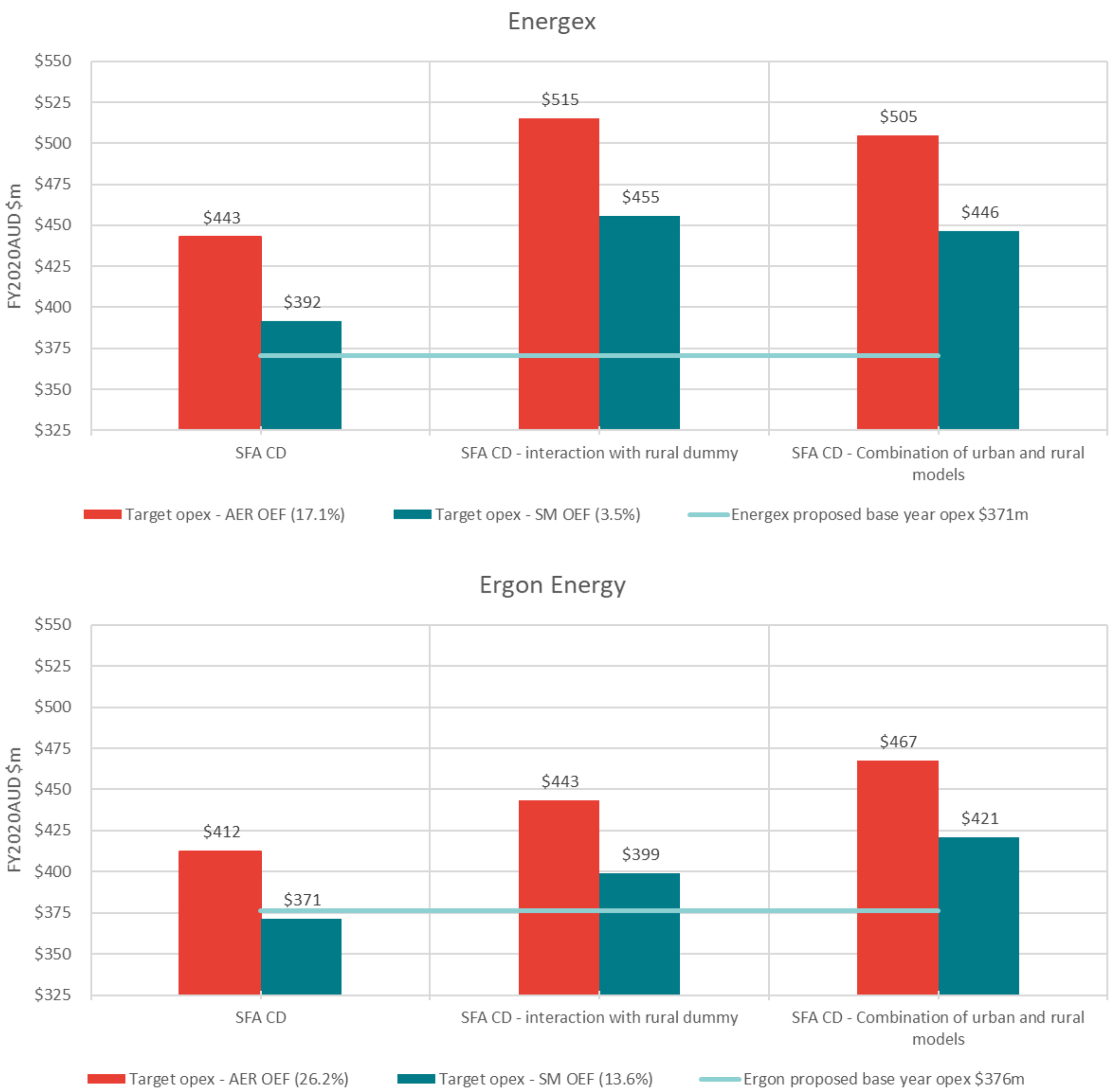
of customers per kilometre of circuit length) and circuit length. However, this does not account for the fact that the impact of different costs drivers on cost (measured via the elasticities) might differ across networks with different customer densities.

[25] DNSPs are designated as rural if they have less than 20 customers per km of circuit length, and as urban otherwise.

[26] Frontier Economics, *AER Benchmarking – A report prepared for Essential Energy, April 2018*. Frontier Economics, *Review of the AER's econometric benchmarking models and their application in the draft determinations for Networks NSW – A report prepared for Networks NSW*, January 2015.

[27] To test whether these two subsets of DNSPs have the same elasticities, we modified the SFA CD model by interacting all the variables with a rural dummy variable. This allows all the coefficients to differ between the rural and urban subsamples. A statistical test of whether the coefficients are different between rural and urban DNSPs show that the can be carried out by testing whether the 6 coefficients on the interacted variables are jointly significantly different from zero. This is referred as a test of poolability. The poolability test rejects the hypothesis that the rural and urban subsamples have the same coefficients at the 1% level of significance. This indicates that the impact of cost drivers on costs differ between rural and urban utilities.

Figure 9: Assessment of base year opex for models capturing rural versus urban differences

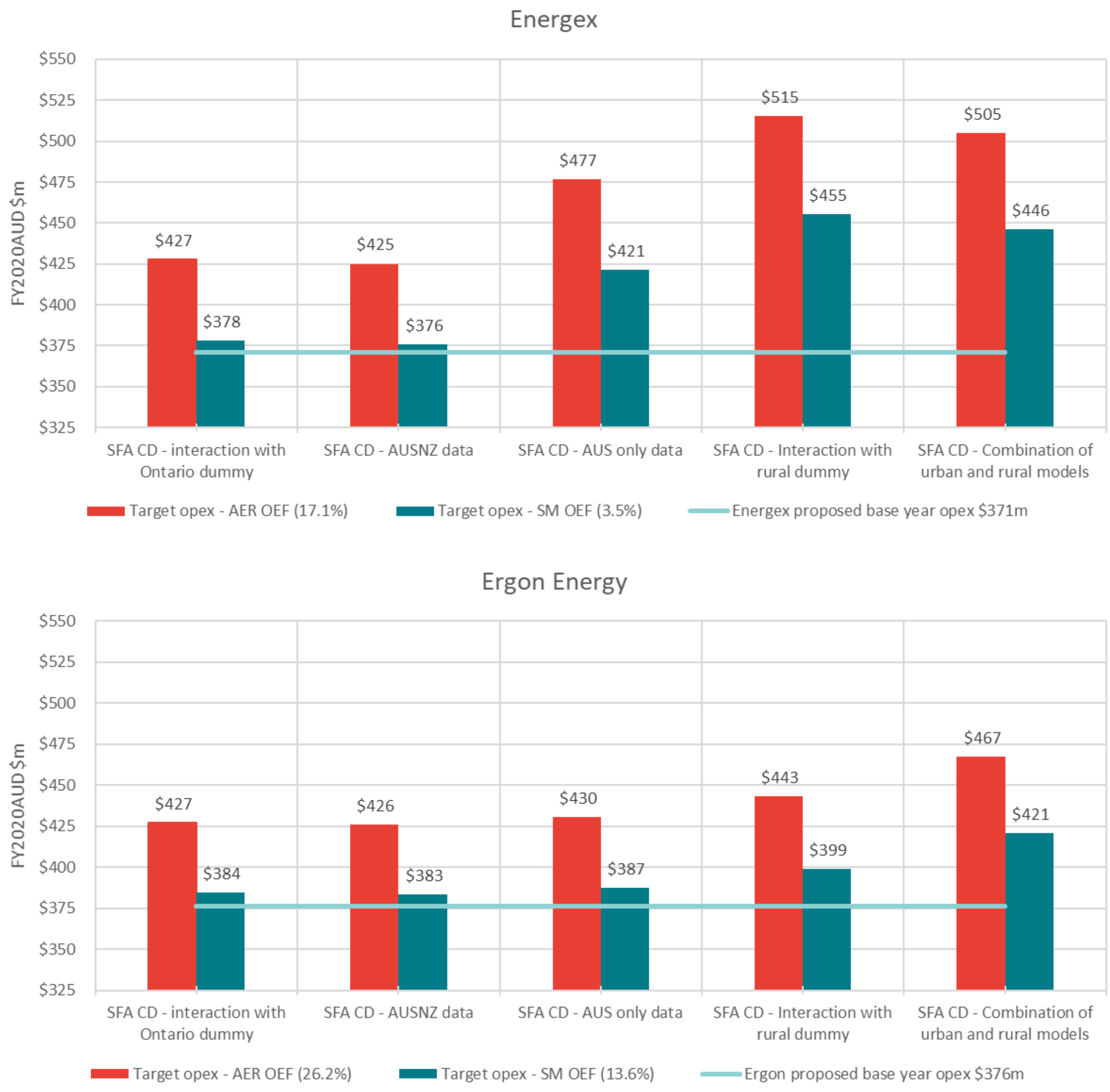


Source: Frontier Economics

3.3 What this additional econometric analysis suggests for Energex and Ergon

In Figure 10 below we summarise how Energex and Ergon performs across a range of additional econometric models presented in this section. Energex's and Ergon's proposed base year opex is represented by the light blue horizontal line. Energex's and Ergon's target base year opex from each additional model is represented by the bars: red bars represent target opex derived using the AER's 2015 OEFs, while blue bars represent target opex derived using the Sapere-Merz OEFs. The figure shows that Energex's and Ergon's proposed base year opex is below its target base year opex for the 2020–25 regulatory control period across all of the econometric models considered in section. These models do not provide any evidence to suggest that Energex's and Ergon's base year opex for the 2020–25 regulatory period requires an efficiency adjustment. Since this conclusion holds even under the limited set of OEF adjustments considered to date by Sapere-Merz, it holds even more strongly if a reasonable allowance is made for OEF adjustments in the estimation of Energex's and Ergon's target base year opex.

Figure 10: Energex's and Ergon's performance across the additional econometric models presented in this section



Source: Frontier Economics

3.4 Extent to which additional techniques may be used by the AER to complement the evidence from econometrics

Any model aimed at determining efficiency scores for regulated businesses is subject to a range of assumptions and data issues, and the estimated efficiency scores are sensitive to how these issues are handled. We note that overseas regulators who have decades of experience in economic benchmarking, such as Ofgem in Great Britain and Bundesnetzagentur in Germany, use a number of different approaches to mitigate the risk that regulatory decisions are influenced excessively or unfairly by model errors or assumptions.

We welcome the AER's move away from its previous reliance on a single econometric model (the SFA CD model), and towards the consideration of a broader range of evidence. We recommend that the AER's four econometric models be treated as a starting point for further discussion going forward. In future, we suggest that the AER rely on an even broader range of evidence to determine its target base year opex and efficiency adjustments for Energex and Ergon, including evidence from:

- a further, more comprehensive assessment of OEFs, our recommendations for which are set out in our companion OEFs report
- the use of additional techniques, such as data envelopment analysis (DEA), to complement the evidence from econometrics. We note that while DEA was outside the terms of reference for this report, we have demonstrated the feasibility of using DEA in the AER's context in our previously-submitted January 2018 report[28]
- the use of bottom-up benchmarking and engineering assessments; and
- evidence on other factors that affect opex such as the safety and reliability of the network.

Evidence from additional techniques, such as those mentioned above, can be used to complement the AER's evidence from econometrics, which in our view serve as a helpful starting point for further discussion with stakeholders going forward with the objective of seeking ongoing improvement to the AER's benchmarking.

3.5 Alternative approach to AER's roll-forward to base year

We note that the efficiency of Energex's and Ergon's base year opex can also be assessed directly by evaluating the estimated econometric function (such as the AER's four econometric models and the additional models in this section) at the values of the explanatory variables in the base year. This would be an alternative to the AER roll-forward approach described in Section 2.2 and applied in this report.

The advantage of the alternative approach of evaluating the estimated econometric function at the values of the explanatory variables is that it can be applied directly to those econometric functional forms, such as TL, which are non-linear in logarithms and for which the elasticities are not constant but vary according to the DNSPs' outputs. By contrast, the AER's approach to rolling forward the target opex from the middle of the estimation period to the base year cannot be applied directly to the TL functional form as the TL elasticities are not constant and the AER's approach uses constant elasticities. Hence, in order to make its roll-forward operational for its SFA TL and LSE TL models, the AER makes the TL elasticities constant by calculating the elasticities of a hypothetical DNSP whose outputs are equal to the average outputs across all DNSPs in the sample, including New Zealand and Ontarian DNSPs.

As the alternative approach described in this section requires fewer assumptions than the AER's approach and eases comparison across alternative models, we recommend that the AER considers this as a possible alternative approach for estimating target opex in the base year.[29]

[28] Frontier Economics, *AER Benchmarking – A report prepared for Essential Energy*, April 2018.

[29] Note that for the purpose of this report, we have been instructed by Energy Queensland to adopt the AER's roll-forward approach. However, we note that we have tested the alternative approach described in this section and can confirm that our conclusions in relation to Energex's and Ergon's base year efficiency would be the same under the alternative approach.

4 CONCLUSIONS AND RECOMMENDATIONS

We have assessed the efficiency of Energex's and Ergon's proposed base year (FY2018) opex using a range of econometric benchmarking approaches, including those investigated by Economic Insights on behalf of the AER (see Section 1.1) and other approaches that could feasibly be estimated using the available RIN data (see Section 3). Our conclusions and recommendations for the AER are presented in the remainder of this section, which is structured as follows.

- In Section 4.1 we outline the known limitations of the benchmarking approaches investigated in this report;
- In Section 4.2 we outline the implications for Energex's and Ergon's base year opex assessment at present; and
- In Section 4.3 we outline different ways in which the AER could adopt a cautious approach in the application of benchmarking results.

4.1 Limitations of benchmarking at present

We consider that the AER's benchmarking has a number of limitations at present, including the following.

- First, there is a need for longer-term engagement on OEFs in particular, as there is little agreement on which OEFs should be accounted for within the benchmarking analysis, and how these should be quantified. We recommend that efforts to improve the AER's benchmarking analysis and approach to OEFs should be viewed as an iterative process that improves gradually the quality of information and analysis available to the regulator.
- Second, both the benchmarking and OEFs work undertaken to date has been restricted by the data that is publicly available. We recommend that the AER attempt to improve the data available for benchmarking in the longer term in collaboration with the DNSPs.
- Third, the AER's results are highly sensitivity to model specification. Given the sensitivity of the DNSPs' efficiency scores and target scores to the alternative approaches outlined in this report, we recommend that the AER consider a range of evidence on benchmarking and not mechanistically apply the results from any single approach when determining efficient base year opex.
- Fourth, there are a number of challenges associated with including the international data in the AER's sample. We recommend the development of new models excluding the international samples as a medium-term objective for the AER.

We discuss each of the above in-turn.

4.1.1 Need for longer-term consultation on OEFs

At present, there is little agreement on which OEFs should be accounted for within the benchmarking analysis, and how these should be quantified. Whilst the AER's current consultation process takes a step towards addressing this question, in our view a much more extensive consultation and engagement process (between the AER and relevant stakeholders) is required in order to determine the most important factors that could be driving differences in DNSPs' opex that are not accounted for within the AER's benchmarking models.

Clearly, the factors not accounted for in the AER's benchmarking models will depend on *how* those models are specified. The AER itself has indicated that more work needs to be done to improve its benchmarking models and techniques. Therefore, the question of what OEFs should be quantified and adjusted for cannot be divorced from the process of reviewing and improving the AER's benchmarking models: these two processes need to occur together.

We recommend that efforts to improve the AER's benchmarking analysis and approach to OEFs should not be viewed by DNSPs or the AER as a one-off investment but, rather, as an iterative process that improves gradually the quality of information and analysis available to the regulator, the businesses and consumers as a means of promoting better regulatory outcomes. A detailed discussion on our proposed framework for accounting for OEFs is provided in our OEFs report.

4.1.2 The benchmarking and OEFs work undertaken to date has been restricted by the data that is available

The benchmarking analysis undertaken by the AER will only be as reliable as the data used to undertake the analysis. Unless the data are reliable, it will not be possible to discern whether the differences in measured performance between DNSPs are due to true differences in efficiency or simply due to reporting errors or inconsistencies. Therefore, careful attention should be given to the reliability of the data used in the benchmarking analysis – including the data used to quantify and adjust for OEFs.

The benchmarking and OEFs work undertaken to date has been restricted by the data that is publicly available. While we have been able to investigate the sensitivity of the AER's benchmarking results to changes in model specification, changes in the sample of comparator firms, and changes in approach, we have not been able to investigate the inclusion of additional/alternative cost driver variables in our analysis, owing to a lack of reliable data available on additional variables.

By way of example, Sapere-Merz concludes that there is insufficient reliable data at the present time in the RIN data to quantify an OEF adjustment related to vegetation management even though vegetation management is likely to represent a material OEF. We note that vegetation management opex comprises of over 30% of the total opex for some DNSPs, and the exclusion of an OEF adjustment or vegetation management is likely to materially confound the AER's base year efficiency assessment.

We recommend that the AER attempt to improve the data available for benchmarking in the longer term in collaboration with the DNSPs. This could be facilitated through the collection of additional variables and ensuring data are reported in a consistent manner across DNSPs. This could be achieved by creating a working group, in collaboration with the networks, tasked with developing, defining and collecting additional measures, or considering methodologies to justify firm-specific adjustments to benchmarked costs, or adjustments to the outcome of benchmarking models.

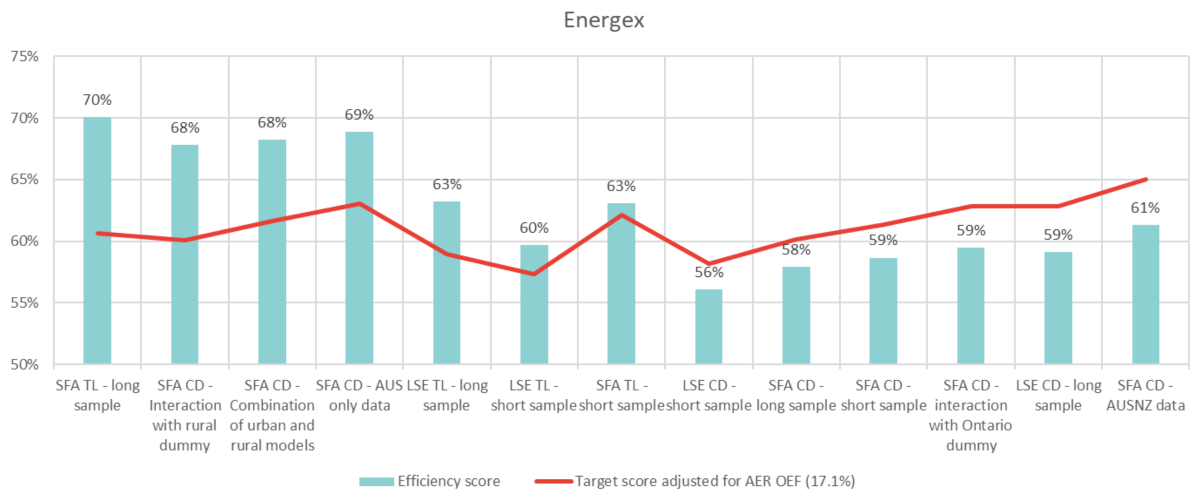
4.1.3 Results are highly sensitive to model specification

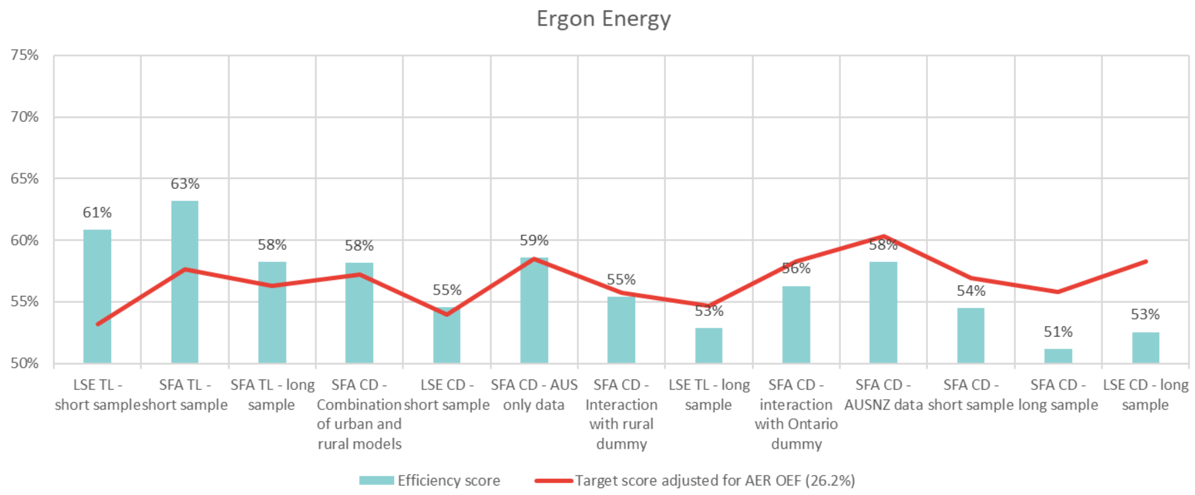
Figure 11 below shows Energex's and Ergon's efficiency scores estimated using a range of benchmarking approaches, including those investigated by the AER (see Section 1.1) and other approaches that could feasibly be estimated using the available RIN data (see Section 3). It can be seen that Energex's and Ergon's efficiency scores are highly sensitive to changes in model specification, changes in the sample of comparator firms, and changes in modelling approach. Across the range of models shown:

- Energex's raw efficiency score ranges from as low as 56% to as high as 70%
- Ergon's raw efficiency score ranges from as low as 51% to as high as 63%

- The estimated target base year opex for Energex ranges from 57% to 65%
- The estimated target base year opex for Ergon ranges from 53% to 60%

Figure 11: Energex's and Ergon's performance across a range of approaches investigated in this report





Source: Frontier Economics

Table 4 below also shows that the target DNSP (the top 5th service provider's in the sample of 13 DNSPs) is also highly sensitive to changes in model specification.

Table 4: Top 5th DNSPs across a range of approaches investigated in this report

	TOP 5TH DNSP
SFA CD - short sample	SA Power Networks
SFA TL - short sample	TasNetworks
LSE CD - short sample	SA Power Networks
LSE TL - short sample	Essential
SFA CD - long sample	TasNetworks
SFA TL - long sample	AusNet
LSE CD - long sample	AusNet
LSE TL - long sample	United
SFA CD - interaction with Ontario dummy	United
SFA CD - AUSNZ data	United
SFA CD - AUS only data	United
SFA CD - Interaction with rural dummy	SA Power Networks
SFA CD - Combination of urban and rural models	Jemena

Source: Frontier Economics

Given the sensitivity of the DNSPs' efficiency scores and target scores to the alternative approaches outlined in this report, we recommend that the AER consider a range of evidence on benchmarking and not mechanistically apply the results from any single approach. We recommend that the approaches considered in this report be used as a basis for constructive engagement between the AER and the DNSPs aimed at improving the AER's benchmarking approach over the longer term.

4.1.4 Challenges associated with including the international data in the AER's sample

As discussed in Section 1.4, there are a number of challenges associated with attempting to benchmark operators across different countries as it is difficult to account for differences in legislative framework, regulatory arrangements, and operating environment across countries. As discussed in Section 3.1 we have tested statistically whether the impact of cost drivers on opex is similar enough across countries for the pooling of the samples to be justified, and we find that this test is rejected.

We also note that the inclusion of the international DNSPs in the AER's sample considerably restricts the feasibility of accounting for operating environment variables in the AER's benchmarking model. Should the AER choose to continue to include the international DNSPs in its sample in the future, it would need to collect a considerable amount of additional data on these DNSPs to ensure that they are compared with the Australian DNSPs on a like-for-like bases. Alternatively, the AER should seek to develop benchmarking models excluding the international DNSPs (which we have demonstrated to be feasible, as set out in Section 3.1) to facilitate a meaningful assessment of the impact of OEFs on relative performance. As the collection of additional data on the Ontarian and New Zealand DNSPs is unlikely to be practicable, we recommend the development of new models excluding the international samples as a medium-term objective for the AER.

4.2 Implications for Energex's and Ergon's base opex at this stage

4.2.1 No justification for a base year efficiency adjustment

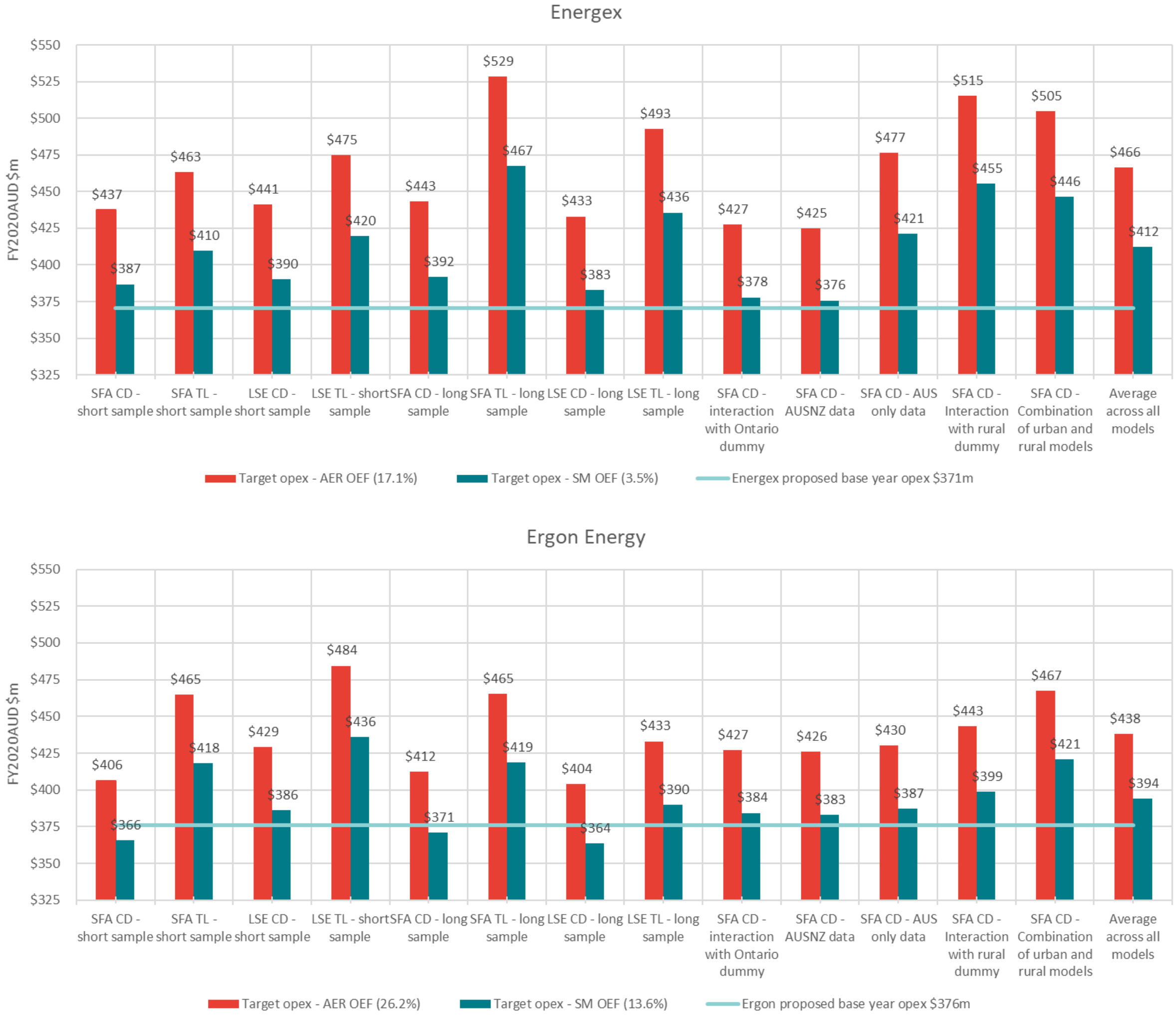
In **Figure 12** below we summarise how Energex and Ergon perform across a range of approaches investigated in this report. Energex's and Ergon's proposed base year opex is represented by the light blue horizontal line. Energex's and Ergon's target base year opex from each alternative model is represented by the bars: red bars represent target opex derived using the AER's 2015 OEFs, while blue bars represent target opex derived using the Sapere-Merz OEFs. The figure shows that Energex's and Ergon's proposed base year opex is below its target base year opex for the 2020–25 regulatory control period across the majority of the benchmarking models considered in this report, including the AER's preferred benchmarking model.

- When the AER 2015 OEFs are used:
  - Energex' proposed base year opex of $371m ($2019-20) is significantly below the range of opex levels of $425m-$529m.
  - Ergon's proposed base year opex of $376m ($2019-20) falls also below the range of opex levels of $404m-$484m.
- When the preliminary and limited Sapere-Merz OEFs are used:
  - Energex' proposed base year opex of $371m ($2019-20) is below the range of opex levels of $376m-$467m.
  - Ergon's proposed base year opex of $376m ($2019-20) falls in the lower end of the range of opex levels of $364m-$436m.

Hence, neither the AER's preferred models, nor the alternative models investigated in this report, provide any strong evidence to suggest that Energex's and Ergon's base year opex for the 2020–25 regulatory period requires an efficiency adjustment.

Since this conclusion holds even under the limited set of OEF adjustments considered to date by Sapere-Merz, it holds even more strongly if a reasonable allowance is made for OEF adjustments in the estimation of Energex's and Ergon's target base year opex.

Figure 12: Energex’s and Ergon’s performance across a range of approaches investigated in this report



Source: Frontier Economics

4.2.2 Poor relationship between average efficiency scores and base year efficiency

Table 5 shows that, despite Energex’s and Ergon’s apparently low average efficiency scores over the estimation period (2012 – 2017 period in the case of some models, 2006 – 2017 period in the case of others), Energex’s and Ergon’s proposed base year opex is lower that the estimated target base year opex across the vast majority of econometric models underlying this report (see **Figure 12** above). It can be seen that both Ergon’s and Energex’s proposed base year opex are below target opex across all 13 econometric models underlying this report, despite having apparently low average efficiency scores across half of these models. This is owing to the significant opex reductions that Energex and Ergon have achieved since 2012–13 and 2011-12, respectively.

This illustrates that the estimated average efficiency scores over the 2012 – 2017 (or 2006 – 2017 in the case of some models) period are a poor indicator of the efficiency of base year opex and means that the roll-forward approach used by the AER has an important role to play when assessing base opex efficiency.

Table 5: Illustration of poor relationship between average efficiency score and base year efficiency when AER 2015 OEFs are used

	ENERGEX		ERGON	
	Average score above target score?	**Proposed base year opex below target opex?**	**Average score above target score?**	**Proposed base year opex below target opex?**
SFA CD - short sample	No	Yes	No	Yes
SFA TL - short sample	Yes	Yes	Yes	Yes
LSE CD - short sample	No	Yes	Yes	Yes
LSE TL - short sample	Yes	Yes	Yes	Yes
SFA CD - long sample	No	Yes	No	Yes
SFA TL - long sample	Yes	Yes	Yes	Yes
LSE CD - long sample	No	Yes	No	Yes
LSE TL - long sample	Yes	Yes	No	Yes
SFA CD - interaction with Ontario dummy	No	Yes	No	Yes
SFA CD - AUSNZ data	No	Yes	No	Yes
SFA CD - AUS only data	Yes	Yes	Yes	Yes
SFA CD - Interaction with rural dummy	Yes	Yes	No	Yes
SFA CD - Combination of urban and rural models	Yes	Yes	Yes	Yes

Source: Frontier Economics

4.3 Need for a cautious application of benchmarking

We recommend that the AER apply the results from any benchmarking analysis with an appropriate degree of caution, recognising the significant practical challenges involved in performing benchmarking analysis, and taking account of issues relating to RIN data reporting and consistency, and issues with the quantification of OEFs in particular. Owing to the limitations of even the best and most reliable benchmarking analyses, the great majority of overseas regulators do not impose the outcome of their benchmarking directly or mechanistically as reductions to allowed costs. Most will make allowances for data errors, the range of results derived from different models, and the imperfect assessment of different circumstances. Some examples of how overseas regulators apply the results from benchmarking analysis are presented below.

- Ofgem, in its recently completed RIIO-ED1 investigation has made use of an interpolation procedure where final allowances are made up of 25% of the firms' submitted costs and 75% of its benchmarking models.
- Ofgem in its previous electricity regulatory price review, varied its approach to determining the 'target' DNSPs on the basis of its view of the robustness of different benchmarking models. For example, a higher upper quartile target was used for its benchmarking of 'indirect' costs (such as overhead costs and network planning, which were considered less prone to year-to-year volatility and hence easier to benchmark). On the contrary, a lower upper third target was used for its benchmarking of network operating costs (which were considered both volatile and less fully explained by the available cost drivers).
- The Ontario Energy Board (as we discuss below) uses its benchmarking to inform on relatively modest differences in 'stretch factors' for the firms it regulates, with the best performers provided with a stretch factor of 0.0% per annum, and the worst performers with a stretch factor of 0.6% per annum.
- Ofwat (the regulator of water companies in England and Wales) has in the past used its benchmarking to split the water and sewerage companies into five efficiency bands that each received the same moderated efficiency discount subject to a glide path.
- The regulator in Norway moderates the results of its benchmarking by setting allowed cost in line with 40% of the firms' submitted costs, and 60% of the 'efficient' benchmarked costs derived from its model.

While the benchmarking results presented in this report provide no evidence to suggest that Energex's and Ergon's base year opex for the 2020–25 regulatory period requires any efficiency adjustments, we nevertheless recommend that the AER adopt a conservative application of its benchmarking analysis should it decide to make base year efficiency adjustments for any of the DNSPs. This can be done in a combination of ways. For example, the AER could potentially:

- consider changing its criterion for choosing the target DNSP from the top 5th DNSP to a more conservative target owing to the limitations of the benchmarking approaches that are presently feasible
- consider determining base year allowances on the basis of a weighted average of the DNSPs' proposed base year opex and target base year opex; and/or
- consider splitting the 13 DNSPs into groups or cohorts, determined by evidence on their base year efficiency, and apply different levels of base year opex reductions to each cohort.

The examples above are different ways for the AER to recognise that there are many reasons why the efficiency estimates derived from its benchmarking analysis are not be a perfectly accurate representation of the relative efficiencies across the DNSPs.

A OVERVIEW OF THE AER'S 'BASE-STEP-TREND' APPROACH

As outlined in the AER's Expenditure Forecast Assessment Guideline,[30] the allowable opex in each year of the upcoming regulatory control period is obtained using a 'base-step-trend' approach.

Under this approach, a nominated year from the previous regulatory period is determined to be the 'base year' from which allowable opex for the upcoming regulatory period is rolled forward for each DNSP. A key step in the AER's approach is to determine the target opex for the regulated utility in the base year. If the DNSP's proposed opex in the base year is assessed as meeting the target efficiency level then the DNSP's proposed opex in the base year will be rolled forward using a rate of change formula. If the DNSP's base year opex is assessed to be materially below the target efficiency level, then it may be adjusted downwards by the assessed amount of inefficiency, before the adjusted target amount is rolled forward using the rate of change formula.

The formula for obtaining the allowable opex in year t can be written as:

$$Opex_t = \left[\left(A_f^* - efficiency\ adjustment\right) \times \prod_{i=1}^{t}(1 + rate\ of\ change_i)\right] \pm step\ changes_t$$

where:

- The expression (A_f^* - *efficiency adjustment*) represents target opex in the base year, where:
  - it is assumed that the base year is $t = 0$
  - A_f^* is the proposed opex in the base year
  - *efficiency adjustment* is the adjustment that needs to be applied to proposed opex in the base year to bring it in line with the target opex in the base year.
- $rate\ of\ change_i$ is the rate of change in year i. This is obtained by combining the rates of change in real prices, output and productivity in year i.
- $step\ changes_t$ represents any step changes that may be applied to allowed opex in year t to account for efficient expenditures not captured in the target base year opex or the rate of change.

As can be seen in the formula above, the AER's starting point for determining base year opex is A_f^*, which is the proposed opex in the nominated base year.

The AER's Expenditure Forecast Assessment Guideline states that the 'revealed cost' approach is the AER's preferred approach to assessing base year opex. If proposed opex for the base year reasonably reflects the AER's opex criteria, the AER will set the allowed base year opex equal to proposed opex. On the other hand, should the AER find a material difference between the DNSP's proposed opex in the in the base year and its own estimate of target opex for the base year, it may apply an efficiency adjustment to the DNSP's proposed base year opex.

[30] AER, *AER Expenditure Forecast Assessment Guideline for Electricity Distribution*, November 2013; See: https://www.aer.gov.au/system/files/Expenditure%20Forecast%20Assessment%20Guideline%20-%20Distribution%20-%20FINAL.pdf.

B POOLABILITY OF INTERNATIONAL DATA

To test whether the Ontarian data is poolable with the Australian and New Zealand we created a dummy variable for Ontario ad interacted this with each of the five variables of interest. The coefficients on these so-called 'interaction' terms are estimates of the differences between the parameter values for Ontario and the corresponding parameter value for the combined Australia/New Zealand sample. We also test whether the New Zealand sample is poolable with the Australian sample if Ontario is excluded from the dataset.

Table 6 shows the results of these estimations and tests. The first column of estimates is the AER's SFA CD model on the pooled sample without any interactions, the middle column tests the poolability of the Ontarian data with the Australia/New Zealand sample, and the last column tests whether the New Zealand sample is poolable with the Australian sample in the absence of Ontarian data.

The last few rows in the table show the results of the poolability tests. The tests indicate that the Ontario sample is statistically not poolable with the Australian/New Zealand sample, but that the Australian and New Zealand samples can be pooled.

Given that the Ontario sample is statistically not poolable with the Australian/New Zealand sample, but the Australian and New Zealand samples can be pooled, we have re-estimated the results from the AER's SFA CD model over the 2006 – 2017 period using the following two approaches:

- Using the full sample of data from all three jurisdictions but allowing the relationship between costs and cost-drivers to vary between Ontario (which the tests suggest cannot be pooled with Australia and New Zealand) and Australia and New Zealand
- Using the sample of Australian data and New Zealand (excluding data from Ontario)
- Using the sample of Australian data alone (excluding data from both New Zealand and Ontario).

Estimates for these models are shown in the last three columns of **Table 7**.

Table 6: Tests for poolability of international data in the AER's SFA CD model over 2006 – 2017

	AER'S SFA CD MODEL	IS ONT POOLABLE WITH AUS+NZ?	IS NZ POOLABLE WITH AUS?
Log (customer numbers)	0.709***	0.379***	0.340
Log (circuit length)	0.126***	0.194***	0.246***
Log (ratcheted maximum demand)	0.164***	0.374***	0.462**
Log (share of underground cables)	-0.150***	-0.088	0.003
Time trend	0.018***	0.018***	0.011***
Constant	-27.799***	-26.510***	-12.339*
Log (customer numbers) * country dummy		0.526***	0.149
Log (circuit length) * country dummy		-0.091	-0.024
Log (ratcheted maximum demand) * country dummy		-0.356***	-0.207
Log (share of underground cables) * country dummy		-0.068	-0.137
Time trend * country dummy		-0.001	0.011**
Country dummies			
New Zealand	0.096	-0.048	-23.070**
Ontario	0.289***	2.567	
Variance parameters			
mu	0.455	0.412	0.224
sigma_u	0.173	0.174	0.252
sigma_v	0.105	0.104	0.116
Poolability test			
Test statistics (Chi-squared)		14.35	7.312
Degrees of freedom of test statistics		5	5
p-value of test statistics		0.014	0.198
Test rejected?		Yes, at 1% significance level	No
N	804	804	372

Source: Frontier Economics

*Note: *** denotes significance at 1%, ** significance at 5%, and * significance at 10%.*

Table 7: Comparison of models on different datasets and with interaction with Ontarian dummy

	AER'S SFA CD MODEL	INTERACTION WITH ONTARIAN DUMMY	AUSNZ DATA	AUS ONLY DATA
Log (customer numbers)	0.709***	0.379***	0.365**	0.321
Log (circuit length)	0.126***	0.194***	0.188**	0.238**
Log (ratcheted maximum demand)	0.164***	0.374***	0.396***	0.480**
Log (share of underground cables)	-0.150***	-0.088	-0.094	-0.012
Time trend	0.018***	0.018***	0.018***	0.011***
Constant	-27.799***	-26.510***	-26.462***	-13.517
Log (customer numbers) * country dummy		0.526***		
Log (circuit length) * country dummy		-0.091		
Log (ratcheted maximum demand) * country dummy		-0.356***		
Log (share of underground cables) * country dummy		-0.068		
Time trend * country dummy		-0.001		
Country dummies				
New Zealand	0.096	-0.048	0.046	
Ontario	0.289***	2.567		
Variance parameters				
mu	0.455	0.412	0.271	0.327
sigma_u	0.173	0.174	0.256	0.262
sigma_v	0.105	0.104	0.117	0.122
Measures of fit				
LLF	554.683	561.780	215.669	83.864
AIC	-1087.367	-1091.559	-411.338	-149.728
BIC	-1035.781	-1016.526	-372.149	-122.279
N	804	804	372	156

Source: Frontier Economics

*Note: *** denotes significance at 1%, ** significance at 5%, and * significance at 10%.*

C POOLABILITY OF RURAL AND URBAN DNSPS

A statistical test of whether the coefficients are different between rural and urban DNSPs can be carried out by testing whether the six coefficients on the interacted variables are jointly significantly different from zero. This is referred as a test of poolability. The estimation results and the poolability test details are shown in **Table 8**.

The poolability test rejects the hypothesis that the rural and urban subsamples have the same coefficients at the 1% level of significance. This indicates that the impact of cost drivers on costs differ between rural and urban utilities. Although some of these differences are not statistically significant individually, they are jointly significant, and some of the differences are very significant from a business point of view.

Given that the pooling of rural and urban DNSPs in EI's preferred model does not pass the poolability test, we have also estimated the AER's SFA CD model on separate urban and rural subsamples. Estimates for these models are shown in the last two columns of **Table 9**.

Table 8: Test for poolability of rural and urban DNSPs in the SFA CD model over 2006-2017

MODEL WITH VARIABLES INTERACTED WITH RURAL DUMMY	PARAMETER ESTIMATES
Log (customer numbers)	0.832***
Log (circuit length)	0.151**
Log (ratcheted maximum demand)	0.050
Log (share of underground cables)	-0.153***
Time trend	0.016***
Constant	-22.648***
Log (customer numbers) * rural dummy	-0.237
Log (circuit length) * rural dummy	0.114
Log (ratcheted maximum demand) * rural dummy	0.041
Log (share of underground cables) * rural dummy	-0.039
Time trend * rural dummy	0.009***
Constant * rural dummy	-17.596***
Country dummies	
New Zealand	0.062
Ontario	0.333***
Variance parameters	
mu	0.401
sigma_u	0.171
sigma_v	0.104
Poolability test	
Test statistic (Chi-squared)	16.88
Degrees of freedom	6
p-value of test statistic	0.010
Test rejected?	Yes, at 1% significance level
N	804

Source: Frontier Economics

*Note: *** denotes significance at 1%, ** significance at 5%, and * significance at 10%.*

Table 9: Comparison of models capturing rural versus urban differences

	AER'S SFA CD MODEL	INTERACTION WITH RURAL DUMMY	SFA CD - URBAN DNSPS	SFA CD - RURAL DNSPS
Log (customer numbers)	0.709***	0.832***	0.822***	0.600***
Log (circuit length)	0.126***	0.151**	0.147***	0.297***
Log (ratcheted maximum demand)	0.164***	0.050	0.052	0.073
Log (share of underground cables)	-0.150***	-0.153***	-0.142***	-0.161***
Time trend	0.018***	0.016***	0.016***	0.024***
Constant	-27.799***	-22.648***	-22.569***	-38.724***
Log (customer numbers) * rural dummy		-0.237		
Log (circuit length) * rural dummy		0.114		
Log (ratcheted maximum demand) * rural dummy		0.041		
Log (share of underground cables) * rural dummy		-0.039		
Time trend * rural dummy		0.009***		
Constant * rural dummy		-17.596***		
Country dummies				
New Zealand	0.096	0.062	0.017	0.171
Ontario	0.289***	0.333***	0.277***	0.548***
Variance parameters				
mu	0.455	0.401	0.406	0.246
sigma_u	0.173	0.171	0.167	0.195
sigma_v	0.105	0.104	0.097	0.116
Measures of fit				
LLF	554.683	563.240	387.762	182.124
AIC	-1087.367	-1092.480	-753.523	-342.248
BIC	-1035.781	-1012.757	-707.075	-301.507
N	804	804	504	300

Source: Frontier Economics

*Note: *** denotes significance at 1%, ** significance at 5%, and * significance at 10%.*

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