Having regard to the AER's Guideline in determining growth rate assumptions for Ergon Energy

A Huegin review

huegin

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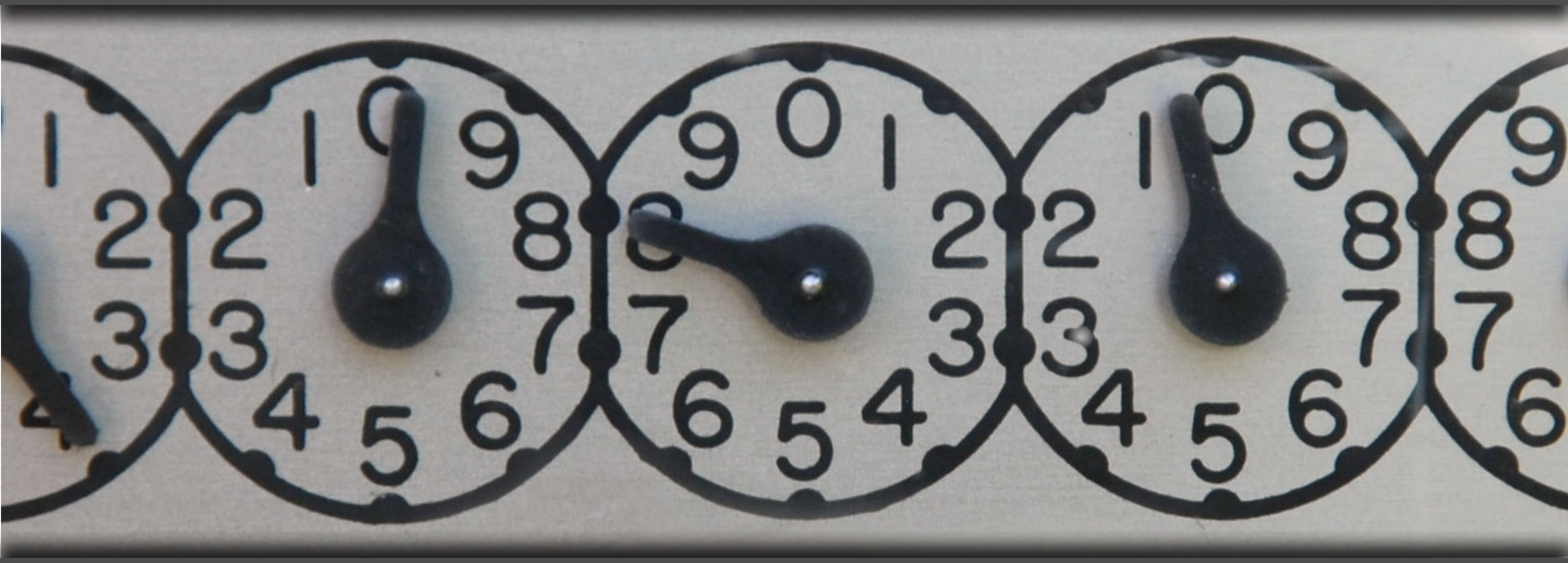

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Contents

The Australian Energy Regulator's new approach to benchmarking

As a result of changes to the National Electricity Rules, the Australian Energy Regulator must now produce an annual benchmarking report and have regard to this when evaluating the prudence and efficiency of a Distribution Network Service Provider's (DNSPs) forecast capital and operating expenditure.

The AER's Expenditure Forecast Assessment Guideline also provides some indication about how the AER intends to assess forecasts and determine a substitute forecast when required.

This chapter explains what we understand are the AER's objectives in using economic benchmarking, the techniques they have proposed and a brief overview of some of the difficulties in applying economic benchmarking in a regulatory context.

1

The AER has adopted a new approach to benchmarking DNSPs

Changes to the National Electricity Rules now mean that the AER must produce an annual report that describes "in reasonably plain language, the relative efficiency of each Distribution Network Service Provider in providing direct control services over a 12 month period[1]".

The AER has since released its Expenditure Forecast Assessment Guideline outlining both the techniques they will use to inform their annual benchmarking report and the objectives in conducting economic benchmarking. The AER have suggested that they will use economic benchmarking for three purposes in the context of regulatory oversight[2]. These are:

- To provide a "first pass" assessment of DNSP expenditure at the beginning of a regulatory determination;
- To review the relative efficiency of historic DNSP expenditure and the suitability of base year expenditure to be extrapolated into the future; and
- To forecast feasible rates of growth for both operational expenditure (opex) and capital expenditure (capex).

The AER has described the application of its assessment process as a "filtering" process[3], applying high level techniques followed by more detailed analysis as required. The high level techniques referenced by the AER include:

- Multilateral Total Factor Productivity (MTFP) analysis;
- Data Envelopment Analysis (DEA); and
- Econometric modelling.

The AER also states that it will rely upon "category analysis" - its term for partial productivity indicators of expenditure relative to a particular network output or attribute.

MTFP, DEA and econometric modelling are discussed in the next section.

The new techniques have advantages and disadvantages

The context of each of the new techniques and how they are intended to support the AER's objectives is shown in the table below.

Expenditure Type	Proposed technique	Objective
Total expenditure	MTFP DEA	First pass assessment Relative efficiency of historic expenditure Forecast a feasible rate of growth for total expenditure
Operational expenditure	Econometric analysis	Relative efficiency of historic opex Feasible rates of growth for opex

Each technique, the associated advantages and disadvantages and the potential application in the regulatory context are described in further detail following.

1 pg 725, National Electricity Rules Version 62, (clause 6.27(d) required that the first benchmarking report be published by 30 September 2014. However at the time of writing, no publication had been made.

2 pg 2, Economic Benchmarking Model: Technical Report, Regulatory Development Branch

3 pg 11, Expenditure Forecast Assessment Guideline, AER, November 2013

MTFP may be used to benchmark total expenditure

Total Factor Productivity analysis aggregates all outputs into a single output index and all inputs into a single input index. These indices can then be used to measure the aggregate output a DNSP produces per unit of input. MTFP uses the revenue share of outputs and cost of inputs to calculate an appropriate weight through which to aggregate outputs and inputs.

There are a number of benefits to using MTFP, these include:

- As a non-parametric approach, an industry cost function does not need to be assumed;
- DNSPs are directly compared to other DNSPs within the industry and not a regression line (econometric modelling) or a hypothetical frontier business that is a combination of different businesses (DEA);
- The amount of data required is less exhaustive than for other benchmarking techniques; and
- MTFP benchmarking is transparent and easy to replicate.

There are also a number of disadvantages of using MTFP to infer relative efficiency between DNSPs, these include:

- MTFP does not take into account environmental variables. This means that it is difficult to interpret whether the results are due to inefficiency or different operating environments;
- MTFP does not take into account economies of scale. As is the case with operating environments, this makes it difficult to distinguish between inefficiency and different levels of expenditure that are the result of scale differences between DNSPs;
- MTFP scores can change significantly depending on the choice of inputs and outputs; and
- MTFP does not produce any statistical results, which makes it difficult to determine if the results are valid and indicative of true efficiency differences between DNSPs.

The AER have stated an intention to use results from MTFP analysis to evaluate the historic total expenditure of DNSPs. Inferences from the MTFP results will be made to inform the relative efficiency of DNSPs - that is how close a business is to the efficient frontier (the distance of an individual firm from either the highest ranking firm, or number of firms). The MTFP model outlined by the AER is displayed below.

The multilateral Tornqvist index proposed by the AER

$$\ln(MTFP_{st}^{T*}) = \ln(Y_{st}^{T*}) - \ln(X_{st}^{T*})$$

$$= \left[\sum_{i=1}^{N}\left(\frac{\omega_{it}+\overline{\omega_i}}{2}\right)(\ln y_{it}-\overline{\ln y_i}) - \sum_{i=1}^{N}\left(\frac{\omega_{is}+\overline{\omega_i}}{2}\right)(\ln y_{is}-\overline{\ln y_i})\right]$$

$$-\left[\sum_{j=1}^{M}\left(\frac{\omega_{jt}+\overline{\omega_j}}{2}\right)(\ln x_{jt}-\overline{\ln x_j}) - \sum_{j=1}^{M}\left(\frac{\omega_{js}+\overline{\omega_j}}{2}\right)(\ln x_{js}-\overline{\ln x_j})\right]$$

Where:

Y_{st}^{T*} = an index of outputs

X_{st}^{T*} = an index of inputs

ω_{it} = weighting of inputs/outputs

$\overline{\ln y_i}$ = industry average (a bar above any variable indicates the industry average)

MTFP can also be applied to forecast feasible future total expenditure by applying the output growth rate, required productivity changes and an assumed input price growth rate as an annual rate of change to extrapolate out from the last known year of actual expenditure. This method relies on the assumption that historical output growth rate is representative of future growth rate. It also, obviously, requires confidence that the model specification is representative of the production function that translates inputs into outputs for an electricity business and that the productivity improvement potential is realistic. These issues are discussed in a later chapter.

DEA may be used as a cross-check of MTFP results[4]

DEA is a linear programming technique for measuring efficiency between businesses. DEA is a non-parametric approach which means that no assumptions are required regarding the relationship between inputs and outputs. DEA uses linear programming to choose weights that maximise the ratio of a linear combination of outputs over a linear combination of inputs. Relative efficiency of a business is then the distance between its output per unit of input (using weights that maximise this value) and that of a business on the frontier.

Advantages of using DEA to benchmark DNSPs include:

- Weights do not need to be arbitrarily assigned to inputs and outputs which can then bias the results, this is a criticism of MTFP which requires an estimation of the relative output weights that are used to aggregate outputs into a single output index;
- Assumptions do not need to be made about the relationship between inputs and outputs of a business; and
- The amount of data required is less exhaustive than for other benchmarking techniques such as ordinary least squares, stochastic frontier analysis and corrected least squares.

Disadvantages of using DEA to measure the relative efficiency of DNSPs include;

- DEA is sensitive to outliers;
- The lack of statistical results means it is difficult to say which variables should be included or omitted;
- DEA results can change significantly depending on which inputs and outputs are being used; and
- Businesses will appear more efficient as variables are added.

DEA is a technique that has been proposed by the AER to cross-check the results of MTFP analysis to determine whether the two techniques can provide a consistent set of results. In this sense, DEA may be used to confirm the results obtained from MTFP analysis.

Econometric modelling may be used to benchmark opex

Econometric modelling is a parametric approach used to estimate the relationship between inputs and outputs. In the context of benchmarking opex, this means estimating a relationship between opex (the output) and a number of different inputs that are both measurable and have an impact on opex, either directly or indirectly.

Advantages of using econometric modelling include;

- Econometric modelling estimates the relationship between different inputs and operational expenditure; and
- Econometric modelling produces statistical results that can be used to infer which variables have a significant effect on DNSP expenditure and how well the proposed model explains variations in DNSP expenditure.

Disadvantages of using econometric modelling are:

- The technique requires more data than DEA and MTFP;
- In the presence of multicollinearity coefficients can be unstable;
- A relationship between inputs and operational expenditure needs to be assumed; and
- With a wide range of functional forms and input variables to choose from there may be a number of different models that are statistically valid but produce different estimates.

The AER has proposed using econometric modelling to evaluate the efficiency of a DNSP's historic opex and the suitability of using a DNSP's revealed opex costs as a starting point from which to forecast future opex. Econometric modelling can also be used to forecast a feasible opex growth rate by estimating a partial productivity growth rate. This technique, using an econometric model to estimate a productivity growth rate, has been used in the past by the AER's advisor, Economic Insights[5] and is illustrated below.

4 pg 7, Economic Benchmarking Model: Technical Report, Regulatory Development Branch

5 Econometric Estimates of the Victorian Gas Distribution Businesses' Efficiency and Future Productivity Growth, Economic Insights

Estimating opex partial productivity growth

$$P\dot{F}P_{Opex} = \left(1 - \sum_i \varepsilon_{Y_i}\right) \cdot \dot{Y}^{\varepsilon} - \varepsilon_{X_k} \cdot \dot{X}_k - \varepsilon_{Z_1} \dot{Z}_1 - \dot{g}$$

Where;

$P\dot{F}P_{Opex}$ = opex partial productivity growth

ε_{Y_i} = effect of a change in output on opex, estimated using an econometric model

ε_{X_k} = effect of a change in capital on opex, estimated using an econometric model

ε_{Z_1} = effect of a change in an environmental variable on opex, estimated using an econometric model

$\dot{g}$ = change in opex over time, estimated using an econometric model

The uncertainty for DNSPs posed by the new techniques is material

The release of the AER's Expenditure Forecast Assessment Guideline represents a much more prescriptive guide on the benchmarking approach of the AER than has previously existed. Whilst this may be beneficial to the DNSPs in comparing their own expenditure forecasts to likely benchmark results, the degree of sensitivity of the techniques to as yet unknown assumptions and the infancy of the application of the approach presents significant uncertainty to those businesses who must submit their proposals prior to the release of the first annual benchmarking report from the AER.

Even if the uncertainty regarding the assumptions in applying the techniques is removed, there remains inherent issues with economic benchmarking in the context of the Australian electricity supply industry (small sample of businesses operating in diverse conditions) that will remain a challenge for any benchmarking effort. In Huegin's opinion, these issues are unlikely to be resolved adequately. Whilst the issues remain, the techniques proposed by the AER should not be afforded material weight in assessing the reasonableness of a DNSP's forecast, and certainly should not be used to determine an alternative forecast for a DNSP.

Reasons why Economic Benchmarking should not justify rejection or substitution of DNSP forecasts

- **Model specification**: there has been no consistent definition of what constitutes the outputs and inputs of a DNSP, either in regulatory applications or academic research. The AER's benchmarking techniques will produce different results for different specifications implying that some DNSPs are efficient using one specification and at the same time, inefficient using another specification.
- **Data validity**: Among the 13 DNSPs that are being benchmarked there is a variety of business structures, ownership differences, accounting differences and variations in the scope of responsibilities (for example, division of responsibility between DNSPs and councils for vegetation management and public lighting). Given that DNSPs account for costs differently it is unlikely, even if an accurate model specification could be defined, that the data used in the benchmarking analysis is robust enough to produce accurate results.
- **Industry heterogeneity**: Australian DNSPs operate in such a diverse environment that differences between businesses when using the techniques outlined by the AER are more likely to be driven by exogenous factors rather than inefficiency. In addition, it is unlikely that given the heterogeneity of Australian DNSPs there is only 1 efficient frontier against which a DNSP should be measured.

The first point in the callout box above is particularly important, as Huegin analysis has shown the sensitivity of MTFP models to changes in the specifications previously[6].

6 See, for example http://www.aer.gov.au/sites/default/files/Ausgrid%20-%205.33%20-%20Addressing%20the%20benchmarking%20factor%20for%20capex%20and%20opex%20-%202014.pdf

Understanding the practical limitations of economic benchmarking

The theoretical advantages and disadvantages of the benchmarking techniques proposed by the AER were discussed in the previous chapter. In this chapter, some of the more practical challenges in applying the techniques in the intended context are discussed.

Each of the issues raised will present varying degrees of problems for each DNSP - collectively they challenge both the AER and the industry in meeting their intended purpose.

2

Practical application of economic benchmarking of DNSPs highlight its limitations

There are numerous textbooks and articles on the benchmarking techniques adopted by the AER in its Expenditure Forecast Assessment Guideline and the majority of the work that culminated in the Guideline relied upon the economic theory of productivity analysis. However the practical application of the techniques is much more challenging. Some of the more significant issues are caused by the context of the application - these methods are not well suited to:

- Processes where the identification of inputs and outputs is unclear and open to interpretation and debate.
- Industries where all participants do not have the freedom of selecting the location or production technology to generate outputs.
- Industries where the participants do not have the freedom to choose their markets, customer segments, location or products.
- Industries with only 13 participant businesses.

The first of the issues above is well illustrated in the catalogue of academic research and papers over the last 20 years that document the many different variations on what constitutes an input and output of an electricity distribution business[7]; even with the amount of effort that has been expended on the topic, there remains no consensus. This is further highlighted by the experimental nature of specifying the productivity models in the AER's approach. There appears to be a tendency to test different combinations and declare a preferred model based on the answers the model provides. The scope for misleading inferences and erroneous conclusions inherent in such an approach is a material risk.

There is scope for misleading inferences

There is a tendency in the benchmarking of businesses to merge the identities of productivity and business efficiency. Productivity and efficiency are not the same, yet we often think of them as interchangeable.

The models employed by the AER in its Guideline have the ability to separate productivity growth into technological change and efficiency change, however this applies generally to the productivity change between time periods. Analysts still need to understand that the productivity difference between firms can be driven both technology and efficiency differences, and delineating between the two is difficult. Further, technological change of the type required to match the productivity results of another network is generally not possible. The nature of the AER's proposed models for MTFP analysis is that assets are measured by their length and capacity and outputs include customers and total system capacity. The inference in such a model is that if it takes longer assets of higher capacity to reach customers, then that business is inefficient. There is no doubt that such a scenario is less productive - no-one would argue that it takes more inputs to reach a customer in a remote area, as opposed to an urban area - however, it does not follow that this is less efficient. As an essential service most DNSPs like Ergon Energy have some legislative obligation to connect certain customers to the network. If 1,000 customers are at the end of a 100km feeder, this is going to be a less productive endeavour than distributing energy to 1,000 customers clustered around an urban environment. Using capacity and length measures in input and output specifications incorrectly infers that the length and capacity of assets to reach customers are the result of inefficient decisions of management, rather than inherent design issues. The length and capacity of distribution assets is much more dependent on the location and voltage level of the transmission connection points and the location of end users than it is on efficiency.

There is scope for erroneous conclusions

In ranking businesses based on the MTFP results, the inference is that they can be compared against that scale and that lower ranked businesses need to improve their productivity to climb the rankings. The erroneous conclusion that this thought process leads to is that every business has the same opportunity to change their business conditions and their input and output mix to move to the frontier over time. The MTFP results, but anchoring the assessment against the business with the highest output to input ratio, suggest that businesses should be capable of manipulating either their input volumes, output volumes, or both, to achieve the productivity ratio of the frontier firm(s). This assumption is critically dependent upon the model specification. DNSPs have little control over many of the input and output variables. Further, the distance between the individual business and the frontier is much more dependent upon the inherent business conditions of the network than it does on cost efficiency.

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7 See for example the Productivity Commission Inquiry Report into Electricity Networks Regulation Frameworks, http://www.pc.gov.au/__data/assets/pdf_file/0016/123037/electricity-volume1.pdf

Testing the Ergon Energy forecast

The AER may use econometric modelling to determine the relative efficiency of historic opex and to forecast an opex annual rate of growth. Another technique that can be used to examine the efficiency of Ergon Energy's base year operating expenditure is Opex Partial Factor Productivity (Opex PFP).

Using econometric modelling Ergon Energy's nominated base year opex appears to be close to the predicted level. The annual rate of change, and in particular the productivity change assumption, is dependent upon the modelling assumptions.

3

Applying the AER benchmarking framework

Despite the limitations and issues associated with the benchmarking methodology outlined in the Expenditure Forecast Assessment Guideline and associated documents and models, it is the published approach of the regulator and it therefore is in the interests of the DNSPs to understand their forecast in that context. With the delay in the release of the AER's first annual benchmarking report, it is difficult to apply the techniques using similar assumptions and specifications, as it is not clear what these will be. In lieu of that detailed guidance, Huegin have applied the economic modelling techniques outlined in the Guideline to Ergon Energy's costs using the best available information on specifications and assumptions. The objective was to test the reasonableness of the Ergon Energy forecast within the bounds of the benchmarking framework outlined by the AER.

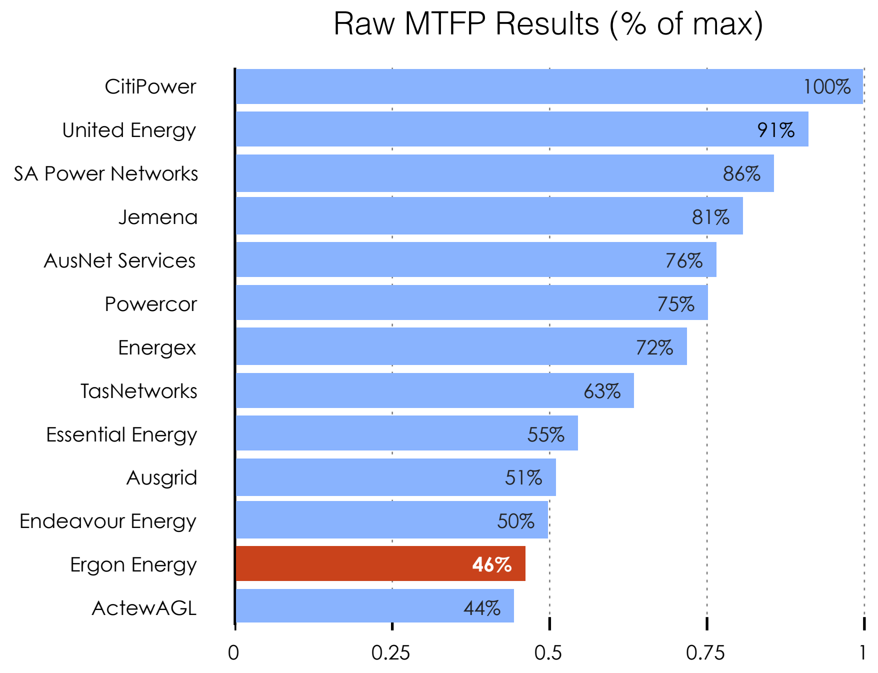
Total Expenditure

The AER have indicated in the Expenditure Forecast Assessment Guidelines that they will use their preferred model to obtain raw MTFP scores for DNSPs over time. Without the AER's annual benchmarking report, it is not possible to confirm that final specification of the MTFP that the AER intends to apply, however Huegin expects that the specification will change based on the AER's analysis and its expectations of the outcomes. For this exercise, Huegin have adopted the specification outlined in the Expenditure Forecast Assessment Guidelines, as no *formal* guidance has been given otherwise. The model variables are outlined below.

Quantity	Value	Price
Outputs		
Customers (no.)	Revenue*Cost share	Value/Customers
*System capacity (kVA*kms)*	Revenue*Cost share	Value/kVA*kms
Interruptions (customer minutes)	-1*Customer minutes*VCR per customer minute	-1*VCR per customer minute
Inputs		
Nominal opex/Weighted average price index	Opex	Weighted average of ABS EGWWS WPI and five ABS producer price indexes
Overhead lines (MVA-kms)	Annual user cost (return of and on overhead capital)	Overhead annual user cost/MVA-kms
Underground cables (MVA-kms)	Annual user cost (return of and on underground capital)	Underground annual user cost/MVA-kms
Transformers and other (MVA)	Annual user cost (return of and on transformers and other capital)	Transformers and other annual user cost/ MVA

Using this model specification and the data submitted by the businesses in the Regulatory Information Notices (RINs), Huegin have produced a MTFP model that generates the productivity scores for each business. An assumption that must be made to generate MTFP scores is the weightings for the output variables. Huegin have used a 75:25 weighting ratio (customer connections:system capacity). These weights were derived using a Leontief cost function, a technique outlined in "*Economic benchmarking of Electricity Network Service Providers*" - a report released by the AER. The results of this analysis are shown in part I of the Annex.

The normalised (setting the maximum to 100%), raw MTFP results are shown below.



What the MTFP raw results mean

If the model specification was a valid representation of the industry production function, and the differences in the outcomes were assumed to be caused only by productivity differences (not error, statistical noise or the influence of exogenous variables), then the results would indicate that Ergon Energy is 54% less productive than the most productive firm in the analysis, CitiPower. For the reasons we have outlined, none of these assumptions hold, and it would be unreasonable to rely upon this outcome.

Given that the stated objective of the Annual Benchmarking Report, as outlined in the National Electricity Rules, is to detail the relative *efficiency* of DNSPs it remains uncertain whether the AER will assume that a productive DNSP is an efficient one or whether MTFP scores will be adjusted to take into account exogenous factors that have an influence on productivity scores but are out of the control of DNSP management. As stated in an earlier part of this report, MTFP cannot account for environmental factors. Second stage regression is a technique that is often adopted in an attempt to account for this. We understand that Economic Insights proposed such an approach to the AER[8]. This approach involves two stages:

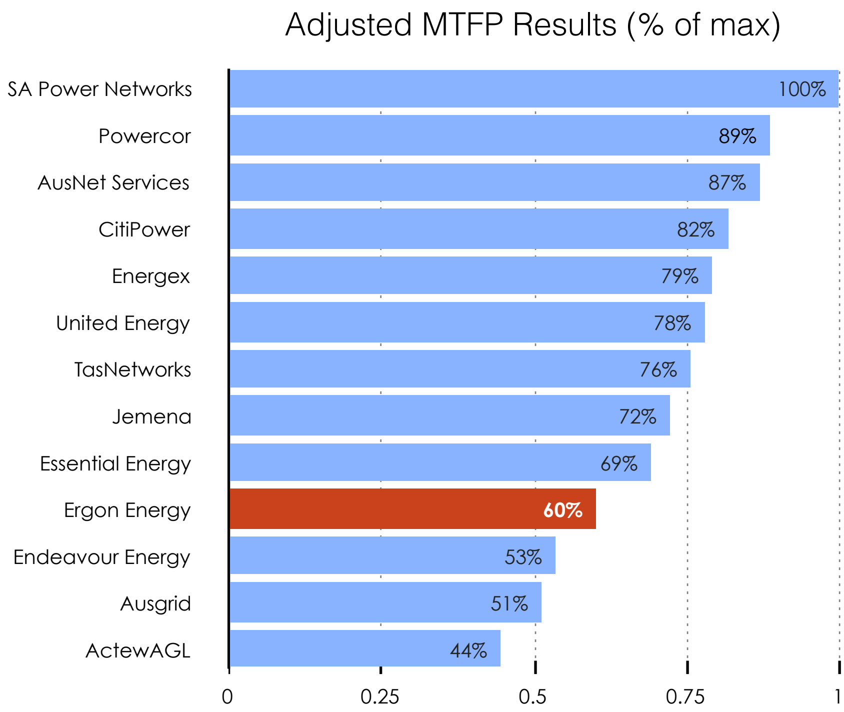
1) Econometric analysis is used to determine the relationship between the raw MTFP scores and different environmental variables; and

2) The raw MTFP scores are adjusted by adding the sum of the product between estimated coefficient and the difference between the sample average and a DNSP's actual value.

Huegin has also produced adjusted MTFP scores using customer density as the environmental variable[9]. The outcome of this analysis is shown on the following page.

8 pg 5, Economic Benchmarking Model: Technical Report, Regulatory Development Branch

9 For reasons we have already outlined, here and in other benchmarking reports, the application of customer density as the environmental variable improves but does not solve the inaccuracy of MTFP results in the NEM DNSP context.



As shown, Ergon Energy's position improves from 46% of the maximum productivity score to 60% of the maximum when adjusted for customer density. Huegin does not expect that the AER will accept these results, as they favour rural businesses and penalise the Victorian urban businesses. Whether that means that the model specification will change, the adjustment process will be omitted or both is unclear. Based on our interpretation of the Guideline and Explanatory material, Huegin expects that the AER will use the MTFP analysis to conclude that Ergon Energy is less productive than other businesses, and on this basis infer that it is therefore inefficient. For the reasons we have already outlined in this report, such an inference would be erroneous.

MTFP results expectation

Huegin expects that the AER will use the MTFP results to conclude that Ergon Energy is not as efficient as it should be. Despite the limitations in the techniques, and the biases in the models as specified, Huegin believe that the AER will infer inefficiency from the relative MTFP results. It will then need to provide its own assessment of an efficient level of expenditure.

Operating Expenditure

Two options are available to the AER for identifying allowable opex within the benchmarking framework described in the Expenditure Forecast Assessment Guideline, opex partial factor productivity generated from the MTFP model or econometric modelling. Each of these are described below.

Opex Partial Factor Productivity from MTFP analysis

The AER may choose to determine an opex partial factor productivity value from the MTFP analysis by omitting the capital inputs (lines and transformer capacity) from the model and dividing the output index by the remaining input variable (opex). Huegin has conducted this analysis and found that the results are very similar to the total expenditure MTFP results - that is, Ergon Energy ranks twelfth with an opex productivity score of 40% of the maximum. For the same reasons that the total expenditure MTFP results are unrealistic for the different types of businesses, this form of opex partial productivity analysis is also unreasonable.

Opex Partial Factor Productivity from econometric modelling

The AER has indicated that it may use econometric modelling to examine the relative efficiency of a DNSP's historic opex and also to forecast an annual rate of growth of opex. By estimating an industry opex cost function the AER will compare a DNSP's modelled opex with their actual opex to determine whether a revealed cost approach is appropriate or whether a base year adjustment is necessary. This means that if a DNSP's actual opex is below that predicted by an industry opex cost function then the base year can be used as the starting point from which an annual rate of growth can be applied.

The functional form chosen by the AER will be the result of running a number of different models and choosing one they believe is most reflective of the industry opex cost function. A major consideration will be the stability of each model. Models become unstable where two or more of the variables are highly correlated with each other - an issue known as multicollinearity. For the purpose of this report, we have selected a Cobb-Douglas expenditure function and used the random effects technique to estimate the model.

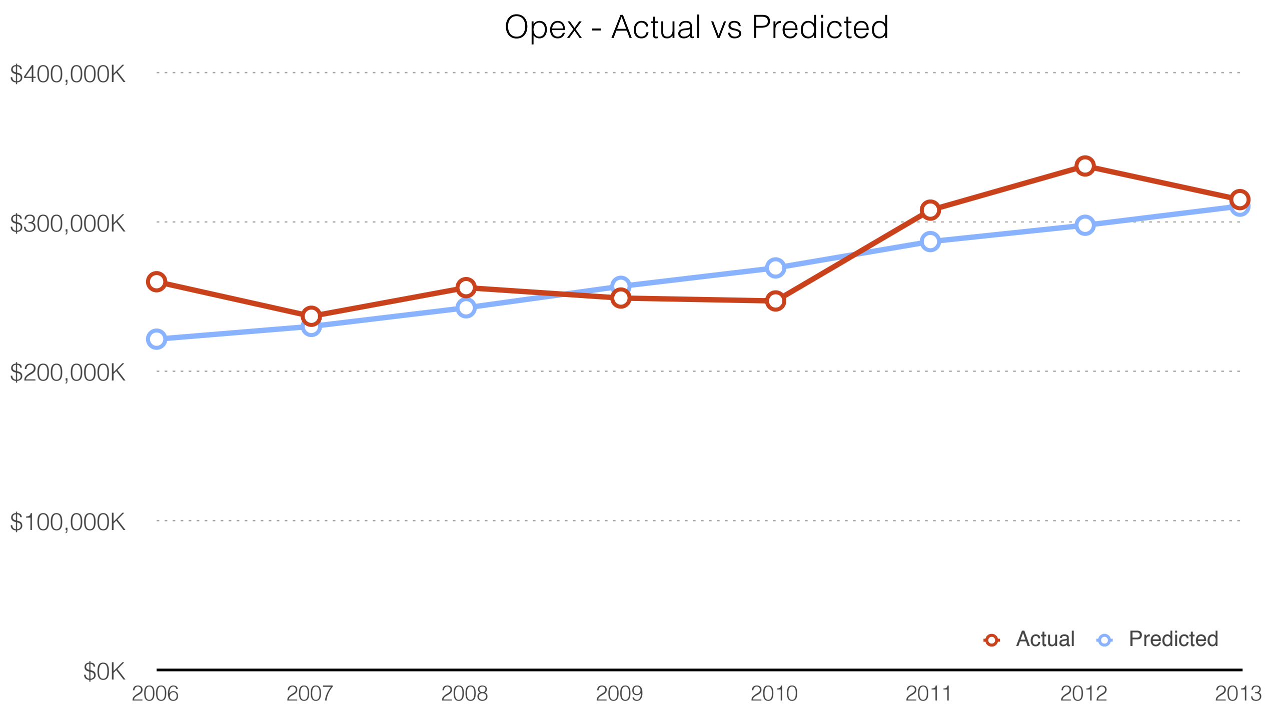
Huegin does not endorse using econometric modelling to infer relative levels of efficiency between DNSP operating expenditure. Sensitivity of model selection aside, we believe econometric modelling is unable to disentangle between cost differences driven by network heterogeneity and inefficiency. This is particularly relevant for distribution networks in which these heterogeneous conditions (such as network design, regulatory environment and network density measures) change little over time. As econometric modelling seeks to model the *change* in costs with the *change* in explanatory variables then it is unlikely, given the static nature of many DNSP cost drivers, that modelling can adequately account for cost differences due to heterogeneity and cost differences due to inefficiency.

Nonetheless, given the AER have indicated the use of econometric modelling to benchmark operating expenditure, Huegin has estimated an opex industry model. This model specification is represented below:

$$\ln Opex = b_0 + b_1 \ln System\ Capacity + b_2 \ln Customers + \ln W_{OM} + b_3 Share\ of\ single\ stage\ transformation + b_4 \ln RAB + b_5 \ln Demand\ density + b_6 Time$$

Linear homogeneity in opex price is imposed (a 1% increase in the price of opex results in a 1% increase on opex) and the RAB has been adjusted to $2013. The statistics for this model are presented at part II of the Annex.

The comparison of the historic actual expenditure and the predicted expenditure from the econometric model is shown below.



As shown, if the AER were to adopt this model with these assumptions and apply it as per the Expenditure Forecast Assessment Guideline, it would conclude that Ergon Energy's historic opex has fluctuated around the econometrically modelled efficient amount. It would also conclude that Ergon Energy's actual opex in 2013 was 1.4% above the model fitted amount - that is the base year was within a reasonable range of the model fitted amount, or above the model fitted amount by 1.4%. This is obviously a significantly different result than the MTFP opex partial factor productivity view.

Calculating an annual rate of change

Whatever the annual benchmarking report eventually shows, the AER must make a determination of the efficient level of expenditure for Ergon Energy's opex for the upcoming regulatory determination. If the AER uses the econometric modelling technique outlined above and applies it in the manner described in its Guideline, an annual rate of change can be calculated for Ergon Energy's opex using the equation below.

Calculating the annual opex growth rate

Opex annual growth rate = Output growth rate + Input price growth rate - Opex partial productivity growth rate

The input price growth rate is speculative and will be debated by the DNSP and the AER, however the output growth rate and opex partial productivity growth rate can be extracted from the econometric model. The econometric model partial productivity growth rate and output growth rate for Ergon Energy using the specification and assumptions outlined in this report are as follows.

Component	Rate of change (%)
Partial productivity growth	0.09%
Output growth rate	2.2%
Annual opex rate of change (net of input growth)	2.11%

That is, if the Guideline is followed and the specification and assumptions hold as per this report, Ergon Energy's operating expenditure would:

- Be adjusted by 1.4% down in the base year;
- Be allowed to escalate in future by 2.11% per annum for the combination of output growth and partial productivity; and
- Be allowed to escalate further by whichever input growth rate is agreed by the AER and Ergon Energy.

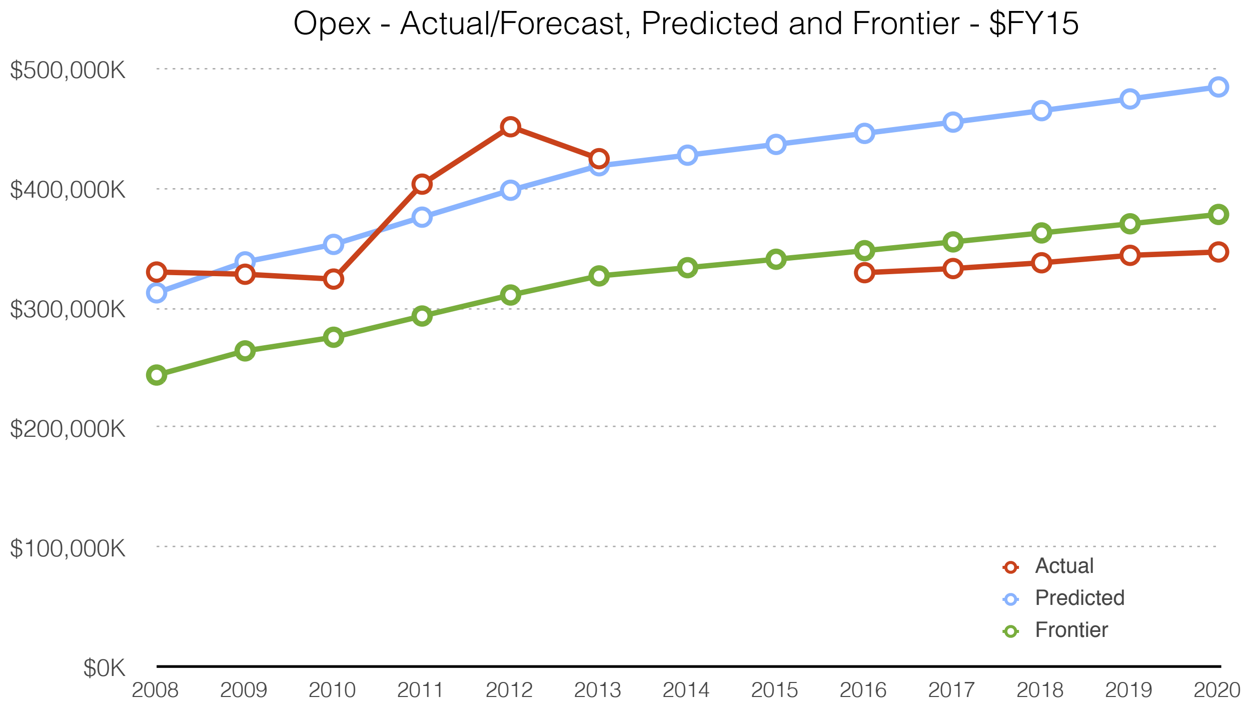
These results can be compared against Ergon Energy's forecast operating expenditure, which includes the following assumptions:

- Base year adjustments to $261M in direct opex (from an actual of $296M in direct opex);
- A 15% reduction in overheads, which reduces base year opex overheads to $85M;
- An average period output growth rate of 2.6%; and
- Productivity improvements of an annual average of 2.3%.

Huegin plotted the Ergon Energy actual and forecast opex (including overheads, excluding real price growth) against:

- The predicted opex using the econometric model describe in this section with:
  - A 1.4% reduction in the base year;
  - Output growth of 2.2% per annum; and
  - Productivity improvement of 0.09% per annum.
- Opex based on the econometric model frontier - that is, we corrected Ergon Energy's opex for the frontier data point based on the model residuals to determine the level of opex required for Ergon Energy to achieve frontier opex performance based on the model.

The comparison of the three models (Ergon Energy actual and forecast opex, econometrically fitted predicted opex and the econometrically modelled predicted frontier opex) is shown below. Note that these results are shown for comparison purposes only, the concerns Huegin has raised with the method of econometrically modelling operating expenditure remain.



What it all means

In our view the outcomes we have identified are consistent with a reasonable application of the Guideline (while noting our concerns with the Guideline itself). Of course we have outlined that the tools and techniques available to the AER avail it of an extremely broad spectrum of plausible and implausible outcomes. Based on our analysis of the AER's documentation and direction, we are concerned that the issues inherent with the benchmarking approach and the inclusion of several opposing modelling techniques within the framework will unduly influence the AER to reach an entirely different conclusion, closer to the MTFP-generated opex partial productivity result of 40% of the leading firm. We have already outlined why we think making inferences from this analysis is problematic and could lead to error.

If the AER accepts the MTFP opex partial factor productivity result (with the model specification and assumptions presented in this report) and assumes a 20 year period for adjustment, it would expect a 3% per annum productivity improvement in Ergon Energy's forecast operating expenditure. For the reasons outlined in chapter two of this report, Huegin believes that the logic that this conclusion must rely upon is indefensible. However if the AER were to use an econometric model as outlined in this chapter, a 0.09% productivity improvement would be expected. Whilst the 2.2% output growth rate from the econometric model seems reasonable, the expectation of only a 0.09% productivity improvement is unlikely.

The Ergon Energy assumption of productivity improvement in their base-step-trend model for future opex lies within the range of outcomes possible from the economic benchmarking. Whilst this is not a basis to accept the Ergon Energy assumption, given the limitations of the modelling outlined in this report, there is certainly no basis to reject the assumption based on the modelling techniques within the AER's Expenditure Forecast Assessment Guideline.

Annex - Supporting material

- Estimating output weights
- Econometric models statistics

A

I. Estimating output weights

Leontief cost function

This analysis uses the Leontief cost function to derive the output cost share weights. The model assumes that inputs are used in fixed proportions for each output, and costs are given by:

$$C(y^t, w^t, t) = \sum_{i=1}^{M} w_i^t \left[\sum_{j=1}^{N} (a_{ij})^2 y_j^t (1 + b_i t) \right]$$

where there are M inputs and N outputs, wi is an input price, yj is an output and t is a time trend representing technological change. The input/output coefficients aij are squared to ensure that the outputs are non-negative, i.e. that outputs cannot be increased by reducing an input.

The coefficients aij and bj were estimated by the input demand equations:

$$x_i^t = \sum_{j=1}^{N} (a_{ij})^2 y_j^t (1 + b_i t) .$$

The input demand equations were fitted separately by non-linear regression for each DNSP using data for the years 2006 to 2013, with 2006 corresponding to t=1 and 2013 corresponding to t=8.

The output cost shares were then calculated for each output using the formula:

$$h_j^t = \frac{\sum_{i=1}^{M} w_i^t \left[(a_{ij})^2 y_j^t (1 + b_i t) \right]}{\sum_{i=1}^{M} w_i^t \left[\sum_{j=1}^{N} (a_{ij})^2 y_j^t (1 + b_i t) \right]} .$$

Results

The tables below list the output cost shares for each DNSP for each year and output. The weighting of 75% customer connections and 25% system capacity is obtained by finding the weighted average of these cost shares.

DNSP	Year	H1	H2
Essential Energy	*2006*	0.721	0.279
Essential Energy	*2007*	0.671	0.329
Essential Energy	*2008*	0.592	0.408
Essential Energy	*2009*	0.565	0.435
Essential Energy	*2010*	0.489	0.511
Essential Energy	*2011*	0.466	0.534
Essential Energy	*2012*	0.467	0.533
Essential Energy	*2013*	0.423	0.577
ActewAGL	*2006*	0.858	0.142
ActewAGL	*2007*	0.829	0.171
ActewAGL	*2008*	0.784	0.216
ActewAGL	*2009*	0.78	0.22
ActewAGL	*2010*	0.722	0.278
ActewAGL	*2011*	0.726	0.274

ActewAGL	*2012*	0.739	0.261
ActewAGL	*2013*	0.71	0.29
Aurora	*2006*	0.751	0.249
Aurora	*2007*	0.687	0.313
Aurora	*2008*	0.681	0.319
Aurora	*2009*	0.701	0.299
Aurora	*2010*	0.684	0.316
Aurora	*2011*	0.671	0.329
Aurora	*2012*	0.66	0.34
Aurora	*2013*	0.665	0.335
Ausgrid	*2006*	0.866	0.134
Ausgrid	*2007*	0.853	0.147
Ausgrid	*2008*	0.846	0.154
Ausgrid	*2009*	0.831	0.169
Ausgrid	*2010*	0.836	0.164
Ausgrid	*2011*	0.825	0.175
Ausgrid	*2012*	0.813	0.187
Ausgrid	*2013*	0.816	0.184
CitiPower	*2006*	0.785	0.215
CitiPower	*2007*	0.757	0.243
CitiPower	*2008*	0.737	0.263
CitiPower	*2009*	0.746	0.254
CitiPower	*2010*	0.733	0.267
CitiPower	*2011*	0.746	0.254
CitiPower	*2012*	0.733	0.267
CitiPower	*2013*	0.716	0.284
Endeavour Energy	*2006*	0.977	0.023
Endeavour Energy	*2007*	0.972	0.028
Endeavour Energy	*2008*	0.968	0.032
Endeavour Energy	*2009*	0.962	0.038
Endeavour Energy	*2010*	0.958	0.042
Endeavour Energy	*2011*	0.956	0.044
Endeavour Energy	*2012*	0.953	0.047
Endeavour Energy	*2013*	0.946	0.054
Energex	*2006*	0.79	0.21
Energex	*2007*	0.751	0.249
Energex	*2008*	0.735	0.265
Energex	*2009*	0.714	0.286

Energex	*2010*	0.704	0.296
Energex	*2011*	0.699	0.301
Energex	*2012*	0.691	0.309
Energex	*2013*	0.687	0.313
Ergon	*2006*	0.969	0.031
Ergon	*2007*	0.98	0.02
Ergon	*2008*	0.982	0.018
Ergon	*2009*	0.988	0.012
Ergon	*2010*	0.989	0.011
Ergon	*2011*	0.99	0.01
Ergon	*2012*	0.992	0.008
Ergon	*2013*	0.992	0.008
Jemena	*2006*	0.853	0.147
Jemena	*2007*	0.809	0.191
Jemena	*2008*	0.744	0.256
Jemena	*2009*	0.735	0.265
Jemena	*2010*	0.673	0.327
Jemena	*2011*	0.648	0.352
Jemena	*2012*	0.619	0.381
Jemena	*2013*	0.565	0.435
Powercor	*2006*	0.893	0.107
Powercor	*2007*	0.864	0.136
Powercor	*2008*	0.831	0.169
Powercor	*2009*	0.813	0.187
Powercor	*2010*	0.778	0.222
Powercor	*2011*	0.772	0.228
Powercor	*2012*	0.756	0.244
Powercor	*2013*	0.741	0.259
SA Power	*2006*	0.599	0.401
SA Power	*2007*	0.507	0.493
SA Power	*2008*	0.495	0.505
SA Power	*2009*	0.429	0.571
SA Power	*2010*	0.408	0.592
SA Power	*2011*	0.408	0.592
SA Power	*2012*	0.356	0.644
SA Power	*2013*	0.346	0.654
SP AusNet	*2006*	0.304	0.696
SP AusNet	*2007*	0.336	0.664

SP AusNet	*2008*	0.424	0.576
SP AusNet	*2009*	0.372	0.628
SP AusNet	*2010*	0.498	0.502
SP AusNet	*2011*	0.492	0.508
SP AusNet	*2012*	0.509	0.491
SP AusNet	*2013*	0.56	0.44
United Energy	*2006*	0.715	0.285
United Energy	*2007*	0.714	0.286
United Energy	*2008*	0.715	0.285
United Energy	*2009*	0.718	0.282
United Energy	*2010*	0.729	0.271
United Energy	*2011*	0.744	0.256
United Energy	*2012*	0.723	0.277
United Energy	*2013*	0.719	0.281

II. Opex forecasting model

$$\ln Opex = b_0 + b_1 \ln System\ Capacity + b_2 \ln Customers + \ln W_{OM} + b_3 Share\ of\ single\ stage\ transformation + b_4 \ln RAB + b_5 \ln Demand\ density + b_6 Time$$

Coefficient	Estimate	t-statistic	Coefficient	Estimate	t-statistic
b_0	3.212	1.48	b_4	0.013	0.12
b_1	0.175	2.74	b_5	-0.258	-2.18
b_2	0.439	2.06	b_6	0.032	3.88
b_3	-0.885	-3.12			

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