Scoping Study into Data Collection Issues for Incentive Regulation

Report prepared for
Australian Competition and Consumer Commission

19 November 2003

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EXECUTIVE SUMMARY

The Australian Competition and Consumer Commission (ACCC) has engaged Meyrick and Associates to undertake a scoping study into data collection issues associated with the implementation of incentive regulation in electricity transmission and distribution. Interest in incentive regulation and productivity measurement has increased following support by the Productivity Commission (2001a) and Parer (2002) for a move to regulatory approaches making greater use of industry wide information rather than detailed company specific information.

Incentive regulation generally makes use of CPI–X price or revenue caps where the X factor is set as the sum of differences between the industry's and the economy's productivity growth rates and between the industry's and the economy's input price growth rates. Robust measures of firm and industry productivity levels and growth rates are, thus, central to implementing incentive regulation.

There are several alternative quantitative approaches to measuring productivity. These include the non–parametric methods of index numbers and data envelopment analysis and the econometric methods of stochastic frontier analysis and cost function estimation. All these techniques require the same basic data set – the price and quantity (or, alternatively, value and quantity) of all major output and input components as well as information on key operating environment characteristics that may be beyond management control.

The main challenge in calculating productivity for an electricity network service provider is the specification of exactly what a network service provider's outputs are and how to measure the quantity and value of each of them. Early electricity supply productivity studies simply measured output by system throughput. However, this simple measure ignores important aspects of what network service providers really do.

Like all network infrastructure industries, a major part of network service provider output is providing the capacity to supply the product. In this sense, there is an analogy between electricity transmission and distribution systems and a road network. The network service provider has the responsibility of providing the 'road' and keeping it in good condition but has little, if any, control over the amount of 'traffic' that goes down the road. Consequently, the network service provider's output should also be mainly measured by the availability of the infrastructure it has provided and the condition in which it has maintained it. For distribution other outputs are directly related to the number of connections and include provision of local transformers ('local access roads') as well as call centre operations responding to queries, connection requests, etc.

Service quality is also an important output dimension and assumes particular importance in any move to incentive regulation as network service providers may have an incentive to cut costs at the expense of service quality.

To capture these multiple dimensions of network service provider output it is necessary to have data on throughput, system line capacity, connection numbers and service quality. Inputs can be broken into six broad categories: labour, materials and services, overhead lines, underground cables, transformers, and other capital.

Operating environment conditions can have a significant impact on transmission and distribution costs and productivity and in many cases are beyond the control of managers. Consequently, to ensure reasonably like–with–like comparisons it is desirable to 'normalise' for at least the most important operating environment differences. Likely candidates for normalisation include energy density (energy delivered per customer), customer density (customers per kilometre of line), customer mix, the degree of undergrounding, and climatic and geographic conditions.

In this report we specify a long list of desirable data series designed to keep future options open regarding the exact specification of the key output, input and operating environment variables. A review of the availability of the identified data series has indicated that some of the higher level data are likely to be currently available to regulators, either in the public domain or in their own regulatory data holdings. Most of the remaining information should be available with the cooperation of utilities and only a small number of variables are likely to be currently unavailable although extensive definitional and comparability issues currently exist both between utilities and over time.

The best model for future collection, holding and dissemination of data appears to be a process similar to that followed by the Utility Regulators' Forum on service quality statistics. This would involve setting up a consultation process among key stakeholders to reach a consensus on the range of variables included and the definition of each variable. Each regulator would then collect and publish the agreed data set for utilities under its coverage. If some data are considered commercially sensitive then options that allow tiered access to data may be a second best solution.

While a number of consistency issues arise with historic data and care would need to be exercised in the interpretation of results, there appears to be enough data available to make a worthwhile start on transmission and distribution productivity studies. These studies would start off at a higher level using currently available data and give regulators experience with the construction and use of productivity information and its strengths and weaknesses. At the same time these studies could inform the parallel process of consultation on the coverage of required data and the definition of each variable.

The highest payoff initially will come from studies looking at transmission and distribution within Australia. Once data and measurement issues have been advanced within Australia, there will be a return from extending comparisons to overseas utilities. At this stage the US and New Zealand appear to offer the best prospects for comparison due to better availability of the necessary data at the firm level.

Regardless of whether productivity information is ultimately used in a move to greater use of incentive regulation or not, it is critical to start the process of data collection and dissemination now. It takes time to develop agreed definitions and to get the necessary collection mechanisms in place but they are an important investment in keeping future regulatory options open. If the process is started now, by the time the next round of regulatory reviews start for the regulatory periods commencing around 2010, several years of reliable data will be available for productivity analysis should regulators wish to consider the use of incentive regulation at that time. If a start is not made now, insufficient data of an agreed and consistent quality will be available at that time to support such a move. The marginal cost of developing the necessary data collection mechanisms is low compared to the option value it provides for future regulatory decision making, quite apart from the other public policy advantages of having such data available.

This report also highlights the effective demise of the Electricity Supply Association of Australia data series that formed the basis of early Australian electricity industry productivity studies. A major flaw in the Australian infrastructure reform process to date has been the lack of requirements built in to require the supply of key data to independent agencies. This contrasts markedly with practice in the US which actually has a much higher level of private ownership but also a much higher level of public data disclosure. The current process offers a chance to redress this situation.

The highest payoffs will result from ensuring as much of the data collected as possible is in the public domain. Common access to data by all interested parties ensures that the benefits of data collection are shared amongst all – regulators (in terms of improved data on which to make well informed regulatory decisions), the businesses (by providing greater understanding of what has driven regulatory decisions and making available important comparative data for benchmarking purposes) and the public (by enabling higher levels of scrutiny for important public policy decisions).

1 INTRODUCTION

The Australian Competition and Consumer Commission (ACCC) has engaged Meyrick and Associates to undertake a scoping study into data collection issues associated with the implementation of incentive regulation.

Interest in increased use of incentive regulation has been heightened by the Productivity Commission (2001a) review of the National Access Regime which advocated the greater use of productivity based approaches for setting price caps for access to essential infrastructure services. Specifically, the Productivity Commission (2001a, p.351) recommended:

> 'The Commonwealth, States and Territories, through the Council of Australian Governments, should initiate a process to develop further the productivity measurement and benchmarking techniques necessary for regulators to make greater use of productivity–based approaches to setting access prices.'

The Parer Review of Energy Market Reform (2002, p.81) also observed the conflicting views on the type of regulation that should apply and recommended:

> '… the future debate would be most effective if it focussed on moving regulation to a less intrusive form. This may best be brought about by giving further consideration to regulators relying more on industry wide rather than detailed company specific information.'

To further debate on the best approach to deriving CPI–X price and revenue caps applying to electricity and gas transmission and distribution, the Utility Regulators Forum (URF) commissioned Farrier Swier Consulting (2002) to explore the feasibility and relative merits of alternative approaches to the current 'building blocks' methodology applied by most regulators in Australia. The report examined, in broad terms, the case for making greater use of total factor productivity (TFP) information in setting price and revenue caps. The main findings were:

- with respect to the assessment of the alternative approaches to CPI–X regulation, the TFP based approaches appear to create superior economic efficiency incentives as they do not distort capital and operating decisions;
- TFP approaches provide superior market–like incentives to provide other services, adopt efficient business and capital structures, and to pursue efficiencies in economies of scope and scale;
- although TFP analysis is complex, regulatory analysis is more aggregated than that required for building blocks and frontier approaches, and the decision making process can be designed to be simpler;

- TFP approaches have lower regulatory costs than other approaches, and avoid the need for detailed analysis of projected costs and efficiency gains over the regulatory period; and,
- TFP studies could be used for a number of purposes ranging from cross checking the outcome of the current building block approach, through to being the primary means for setting 'X'. Furthermore, a decision to establish a system of TFP studies could be seen as a worthwhile investment to improve the options available to regulators in the future.

The ACCC, on behalf of the Utility Regulators Forum, held a one day workshop in Melbourne on 9 May 2003 to give industry the opportunity to comment on approaches to incentive regulation and its implementation. Following the workshop, the ACCC formed an internal working group to discuss the feasibility of approaches to incentive regulation including TFP, data envelopment analysis (DEA) and stochastic frontier analysis (SFA). The group's initial concerns have been with issues of data collection and it has initiated the current scoping study with the following terms of reference:

> Provide analysis and report on the data collection issues arising from the implementation of different approaches to incentive regulation. In particular, what data are currently available nationally and internationally, what data the internal working group should be looking for whether that data is available of not. What processes the internal working group could put into place to compile such data. And finally, in the consultant's view, which approach would best be suited to incorporate this data.

1.1 Structure of the report

The following section of the report reviews the rationale for using productivity results in forming the parameters of CPI–X regulation, the strengths and weaknesses of alternative quantitative approaches to measuring productivity and past studies of electricity supply industry productivity in Australia. The third section reviews the main data requirements for electricity transmission and distribution productivity studies including output, input and operating environment variables and reviews the data sources used by past Australian studies. The relevant data available from public sources and other information held by regulators is examined in section four and major data gaps are identified. The availability of relevant overseas data is also examined. Section five reviews alternative models for collecting and storing the data necessary to support credible productivity studies on an ongoing basis while conclusions are drawn in section six.

2 INCENTIVE REGULATION

2.1 The theory behind incentive regulation

Before reviewing the data needs of alternative approaches to measuring productivity, we will briefly review the principles behind CPI–X regulation to put subsequent discussion in context. The principal objective of CPI–X regulation is to mimic the outcomes that would be achieved in a competitive market. Competitive markets normally have a number of desirable properties. The process of competition leads to industry output prices reflecting industry unit costs, including a normal rate of return on the market value of assets after allowing for the risk. Because no individual firm can influence industry unit costs, each firm has a strong incentive to maximise its productivity performance to achieve lower unit costs than the rest of the industry. This will allow it to keep the benefit of new, more efficient processes that it may develop until such times as they are generally adopted by the industry. This process leads to the industry operating as efficiently as possible at any point in time and the benefits of productivity improvements being passed on to consumers relatively quickly.

Because infrastructure industries such as the provision of electricity transmission and distribution networks are often subject to decreasing costs, competition is normally limited and incentives to minimise costs and provide the cheapest and best possible quality service to users are not strong. The use of CPI–X regulation in such industries attempts to strengthen the incentive to operate efficiently by imposing similar pressures on the network operator to the process of competition. It does this by constraining the operator's output price to track the level of estimated efficient unit costs for that industry. The change in output prices is 'capped' as follows:

(1) $$\Delta P = \Delta W - X \pm Z$$

where Δ represents the proportional change in a variable, P is the maximum allowed output price, W is a price index taken to approximate changes in the industry's input prices, X is the estimated productivity change for the industry and Z represents relevant changes in external circumstances beyond managers' control which the regulator may wish to allow for. There are several alternative ways of choosing the index W to reflect industry input prices. Perhaps the best way of doing this is to use a specially constructed index which weights together the prices of inputs by their shares in industry costs. However, this price information is often not readily or objectively available, particularly in regulatory regimes that have yet to fully mature. A commonly used alternative is to choose a generally available price index such as the consumer price index or GDP deflator.

In choosing a productivity growth rate to base X on, it is desirable that the productivity growth rate be external to the individual firm being regulated and instead reflect industry trends at a national or even international level. This way the regulated firm is given an incentive to match (or better) this productivity growth rate while having minimal opportunity to 'game' the regulator by acting strategically. The latter can be a problem with the 'building blocks' method for setting X which relies more heavily on information on the firm's own costs and likely best practice for that firm. External factors beyond management control that the regulator may wish to allow for in the Z factor include changes in government policy such as community service obligations and tax treatment.

While the CPI–X framework can provide incentives to reduce costs, it may need to be accompanied by measures to stop firms from achieving those cost reductions by reducing quality. This may take the form of an 'S' factor introduced to provide incentives to maintain or improve quality (so that the formula becomes CPI–X+S) or the setting of minimum service standards.

The framework that underlies the CPI–X approach can be illustrated as follows. We start with the index number definition of TFP growth:

(2) $$\Delta TFP \equiv [Y^1/Y^0]/[X^1/X^0]$$

$$= \{[R^1/R^0]/[P^1/P^0]\}/\{[C^1/C^0]/[W^1/W^0]\}$$

$$= \{[M^1/M^0][W^1/W^0]\}/[P^1/P^0]$$

where the superscripts represent different time periods, R^t (C^t) is revenue (cost) in period t, M^t is the period t markup and $R^t = M^t C^t$. As a normal return on assets (after allowing for risk) is included in the definition of costs, a firm earning normal returns will have a markup factor of one while a firm earning excess returns will have a markup of greater than one. Rearranging the above equation gives:

(3) $$P^1/P^0 = \{[M^1/M^0][W^1/W^0]\}/\ \Delta TFP$$

where W^1/W^0 is the firm's input price index (which includes intermediate inputs). Equation (3) is approximately equal to:

(4) $$\Delta P = \Delta M + \Delta W - \Delta TFP.$$

Thus, the admissible rate of output price increase ΔP is equal to the rate of increase of input prices ΔW less the rate of TFP growth ΔTFP provided the regulator wants to keep the monopolistic markup constant (so that $\Delta M = 0$). Equation (3) or its approximation (4) is the key equation for setting up an incentive regulation framework: the term W^1/W^0 would be an input price index of the target firm's peers and the term ΔTFP would be the average TFP growth rate for the target firm's peers. The markup growth term could be set equal to zero under normal circumstances but if the target firm was making an inadequate return on capital due to factors beyond its control, this term could be set equal to a positive number. On the other hand, if the target firm was making monopoly profits or excessive returns, then this term could be set negative. This effectively sets a ‘glide path’ to bring firms closer to earning a normal or average rate of return.

The next issue to be considered in operationalising (4) is the choice of the price index to reflect changes in the industry’s input prices, W. The most common choice for this index is the consumer price index (CPI). But this is actually an index of output prices for the economy rather than input prices. Normally we can expect the economy’s input price growth to exceed its output price growth by the extent of economy–wide TFP growth (since labour and capital ultimately get the benefits from productivity growth). We assume that the markup factors for the economy as a whole are one so that the counterpart to equation (2) applied to the entire economy becomes:

(5) $$P_E^1/P_E^0 = [W_E^1/W_E^0]/\ \Delta TFP_E.$$

Substituting the rate of change of the CPI for the economy–wide output price index on the left hand side of (5) and rearranging terms leads to the following identity:

(6) $$1 = [CPI^1/CPI^0]\ \Delta TFP_E/[W_E^1/W_E^0].$$

Substituting the right hand side of (6) into (2) produces the following equation:

(7) $$P^1/P^0 = \{[CPI^1/CPI^0]\Delta TFP_E\ /[W_E^1/W_E^0]\}\{[M^1/M^0][W^1/W^0]\}/\ \Delta TFP$$
$$= [CPI^1/CPI^0][\Delta TFP_E\ /\Delta TFP]\{[W^1/W^0]/[\ W_E^1/W_E^0]\}[M^1/M^0].$$

Approximating the terms in (7) by finite percentage changes leads to the following:

(8) $$\Delta P = \Delta CPI + \Delta M + [\Delta W - \Delta W_E] - [\Delta TFP - \Delta TFP_E]$$

so that the X factor is defined as:

(9) $$X \equiv [\Delta TFP - \Delta TFP_E] - [\Delta W - \Delta W_E] - \Delta M.$$

What equation (9) tells us is that the X factor can effectively be decomposed into three terms. The first differential term takes the difference between the industry’s TFP growth and that for the economy as a whole while the second differential term takes the difference between the firm’s input prices and those for the economy as whole. Thus, taking just the first two terms, if the regulated industry has the same TFP growth as the economy as a whole and the same rate of input price increase as the economy as a whole then the X factor in this case is zero. If the regulated industry has a higher TFP growth than the economy then X is positive, all else equal, and the rate of allowed price increase for the industry will be less than the CPI. Conversely, if the regulated industry has a higher rate of input price increase than the economy as a whole then X will be negative, all else equal, and the rate of allowed price increase will be higher than the CPI. As noted above, the markup growth term could be set equal to zero under normal circumstances but if the target firm was making excessive returns, then this term could be set negative (leading to a higher X factor).

If all firms in the industry are operating at similar levels of efficiency initially then a common X factor can be applied to all firms either periodically or on a 'rolling average' basis. The latter has the advantage of mimicking market processes more closely and providing a higher degree of certainty. However, until incentive regulation has been operating consistently for a prolonged period, there is likely to be a wide spread of productivity levels for individual firms. Differential X factors are often used initially in this circumstance.

The differential X factor approach has usually been adopted where industry wide data are used to determine the productivity growth rate and input price growth rate in determining the X factor for a number of firms in the industry in the early stages of incentive regulation (see Meyrick and Associates 2003). The differential X factor is then used to tailor the regulatory regime to the circumstances of each particular firm. It distinguishes between productivity levels and productivity growth rates. Normally, firms that are at the forefront of industry performance have high productivity levels but low productivity growth rates. This is because they have removed almost all unnecessary slack from their operations and are only able to increase productivity at the rate of technological change for the industry.

Conversely, laggard firms normally have low productivity levels but are potentially capable of high productivity growth rates. This is because they can make some easy gains by removing the slack from their operations to mimic the operations of the industry's best performers. Consequently, they can achieve productivity growth far in excess of the rate of technological change for the industry for an interim period while they catch up to the productivity levels of the best performing firms. As a result of this catch up process, the best performing firms in the industry will, ironically, not be able to match the average productivity growth rates for the industry (although they have superior productivity levels) while laggard firms will be able to outperform the industry average productivity growth rate.

In a regulatory context, if a firm is a long way from best practice (after allowing for operating environment and service quality differences) then a higher X factor may be applied to allow for the fact that the firm should be able to make some easy 'catch up' gains and exceed the average industry productivity growth rate. This ensures the firm's consumers receive some of those initial catch up benefits. In subsequent regulatory periods we would expect the firm to move closer to the average industry productivity performance and so the size of the differential X factor would diminish. Conversely, for a firm that is already close to best practice, a negative stretch factor may be set to allow for the fact that this firm is unlikely to be able to match industry average productivity growth performance as it cannot make easy catch up gains and is instead only able to grow its productivity at the rate of technological change. In the long run, as competition and the regulatory framework drive all firms towards best practice, the industry average productivity growth rate will draw close to the rate of technological change in the industry.

In practice, two additional important parameters are the length of the regulatory review period and how performance by the utility in excess of that expected at the outset of the regulatory period is treated at the next regulatory review. The norm in Australia is for the regulatory period to be five years. Reviews more frequent than this run the risk of regulation effectively becoming cost of service based with longer review periods potentially exposing both the utility and the regulator to excessive risk if the initial X factor is set at the wrong level.

The way superior performance by the utility is treated at the next regulatory review can have a bearing on the incentives the firm faces to improve efficiency towards the end of the regulatory period. If gains from superior performance are going to be taken from the firm at the start of the next regulatory period then it has an incentive to delay efficiency improvements that it would otherwise have implemented until after the start of the next regulatory period. That way the firm gets to keep the benefits of the efficiency improvement for longer. Various schemes such as efficiency carry–over mechanisms and glide paths have been designed to reduce these adverse incentives but they involve an increase in transactions costs. In the long run when the regulator is confident that all firms are at a reasonably comparable starting point after allowing for operating environment differences and that it has sufficient information it may opt to lengthen the regulatory and/or move to a rolling average X factor based on industry productivity performance over, say, the last five to ten years. The latter approach has been used in the US rail industry for an extended period. Until then, however, the regulator will be faced with a dilemma that involves trading off the strength of the incentives the firm faces with the risks both the regulator and the firm face. These issues are explored further in the following section.

To implement incentive regulation in the form outlined above, we will require information on the TFP performance and input price changes of the firm, its peers and the economy as a whole and the firm's profitability. Operating environment differences play an important role in determining TFP levels and have to be allowed for in the analysis. Australia is characterised by a wide range of operating environment conditions but a relatively small number of network service providers. This limits the scope to segment Australian data on the basis of operating environment characteristics and increases the desirability of including overseas utilities to increase sample size. However, this makes adequate allowance for international differences in organisational structure and characteristics particularly important. Most performance measurement exercises start off with similar types of firms domestically before moving to wider comparisons of more diverse firms within the industry nationally and then to include overseas firms.

2.2 Information asymmetries

Laffont and Tirole (2000) have highlighted the role of information asymmetries in network regulation and this framework has been used by the ACCC (2003) in its review of the draft statement of regulatory principles for transmission services. In practice, regulators want to ensure that good quality network services are provided to customers at as low a price as possible. However, the regulator faces the problem of trying to set these prices in the absence of perfect information about the firm's costs. In exploring this problem in more detail, it is useful to classify two factors that affect the firm's costs:

- exogenous factors – these relate to the nature of the technologies that the firm might use to provide the services, the opportunity cost of capital for the firm and the difficulty in undertaking certain tasks given its situation (generally termed 'operating environment' factors); and
- endogenous factors – these relate to the discretionary actions of the firm that affect costs and service quality, generically termed effort.

The regulator, under information asymmetry, faces an adverse selection problem[1] with respect to exogenous factors. Stylistically, the regulator cannot tell whether the costs of service delivery are high or low for a particular firm. Since the regulator has to ensure provision of the service, a low cost firm has no incentives to reveal that it is low cost, because by doing so they would encourage the regulator to set low prices. Indeed, they have incentives to convince the regulator that they are high cost. The regulator, faced with the lack of information and the compulsion to secure supply, has no choice but to set a price that would compensate a high cost provider.

The regulator also faces a moral hazard problem[2] with respect to endogenous factors. Only if the firm is highly exposed to the consequences of its own actions, will it exercise discretion. Hence, a regulator could take one of two extreme positions:

[1] Adverse selection can occur when the characteristics of a particular firm cannot be distinguished from the characteristics of the average firm. Hence, in the insurance industry, for instance, if an insurer sets premiums based on the average risk and has no way of identifying the risk of a particular individual it will mainly receive applications from high risk individuals and few applications from low risk individuals.

[2] Moral hazard arises where the marginal private costs of a course of action are less than the marginal social costs of that action. For example, if an individual is insured and the insurer cannot observe the care that person takes then the person has less incentive to be careful as the costs of careless actions are reduced to the individual

- the regulator can establish a pricing scheme which ensures that the firm bears the cost consequences of its actions. The extreme example would be permanently fixed prices, in which case the firm that reduced costs by $1 would realise $1 of additional profit. This then addresses the moral hazard problem, but does little to address the adverse selection problem; or
- the regulator can set prices on the basis of the actual costs incurred, such that if the firm reduces costs by $1, then the firm realises no additional profit. This addresses the adverse selection problem but not the moral hazard problem.

These are examples of 'high' and 'low powered' incentive schemes, respectively (see ACCC 2003). In the latter, the regulator effectively fully insures the firm's profits. In the former, the regulator provides no insurance whatsoever. In practice, there are no regimes that adopt these extremes, although those regimes broadly described as 'CPI–X' are generally closer to the former type, and those described as rate of return or cost of service regulation are generally closer to the latter.

If the regulator were perfectly informed, then it would select the high powered incentive scheme in its most extreme form – a fixed price in perpetuity – giving incentives for socially optimal effort. Furthermore, since the regulator was perfectly informed, it would set a price that left no rent to the owners of the firm. However, as noted above, the regulator does not have perfect information and may, indeed, face significant information asymmetry. When this is the case, the regulator must trade off the risk of:

- conferring rents on the owners of the firm; versus
- high cost of production because the firm does not have incentives to reduce costs.

While the foregoing makes a clear distinction between the low and high powered incentive schemes, the distinction in practice is less precise. For example:

- in cost of service regulation, there is a regulatory lag between the time at which costs are incurred (or avoided) and the time at which the regulator adjusts prices to reflect this. Some commentators suggest that this regulatory lag allows the firm to profit from efficiency improvements, and is therefore desirable (in so far as it gives incentives to improve efficiency); and
- the process by which the X factor is redetermined can reduce incentives for productive efficiency in later years of a review cycle, such that the regime becomes more cost of service in nature.

(but not to society).

The challenge facing incentive regulation is to find the optimal compromise between the two extremes that recognises the extent of information asymmetry faced by the regulator, the avenues that the regulator has available for dealing with this, and the requirement to reduce rents. In this context, productivity measurement serves two potential purposes:

- it serves to reduce the extent of information asymmetry faced by the regulator, which allows the regulator to set a higher powered incentive contract at a price more closely matched to each firms' technology – that is, it reduces the adverse selection problem by better revealing to the regulator each firm's production technology and costs; and
- it can be formalised into yardstick competition which, in theory, can allow the regulator to set prices as if it had perfect information, but without specific knowledge of the firms' underlying technology.

The former use of benchmarking is widely practiced by regulators. However, regulators have been reluctant to formalise their benchmarking into specific price formulae. This largely reflects the perception that firms are sufficiently different to undermine the validity of such a direct formulaic approach or, alternatively, that sample sizes are too small to be able to validly quantify the impacts of firms' specific characteristics on technology.

Quality of service issues also present particular problems under high level incentive schemes. In the face of information asymmetry that prevents the regulator from observing quality and/or recognising the cost implications of quality of service, the firm may have incentives to sacrifice quality of service to reduce costs and raise profits under the price cap. As a consequence, regulators typically respond by imposing quality of service standards and sanctions in respect of failure to observe these standards. While this generally addresses the problem of measuring quality of service, it is less clear that it results in the optimum level of quality of service.

There is also scope for utilities to reduce costs on asset maintenance in the short term with little or no observable deterioration in short run quality of service. This is particularly problematic in emerging regulatory regimes that may be subject to relatively frequent change and where information asymmetry is greatest. Comparative performance analysis again has a potentially important role to play in redressing this information asymmetry.

2.3 Alternative methods for measuring productivity

In this section we briefly review the four principal methods that have been used to measure productivity – indexing methods, DEA, SFA and econometric cost functions – and assess their strengths and weaknesses.

TFP indexes

TFP indexes have been the most common technique used to derive estimates of past economy–wide and industry level productivity performance. A TFP index is generally defined as the ratio of an index of output growth divided by an index of input growth. Growth rates for individual outputs and inputs are weighted together using revenue and cost shares, respectively. In other words, the TFP index is essentially a weighted average of changes in output quantities relative to a weighted average of changes in input quantities.

The advantages of TFP indexes include:

- indexing procedures are simple and robust;
- they can be implemented when there are only a small number of observations;
- the results are readily reproducible;
- the procedure imposes good disciplines regarding data consistency; and
- they maximise transparency in the early stages of analysis by making data errors and inconsistencies easier to spot than using some of the alternative techniques.

'Multilateral' versions of the common time–series Tornqvist and Fisher indexes can also be used to compare TFP levels between firms as well as growth rates over time. Judicious choice of multiple outputs in this indexing framework can go a large part of the way to adjusting for customer and energy density differences (see Meyrick and Associates 2003).

Like any quantitative method, TFP indexes have limitations as well as advantages. These include the fact that they are a non–parametric technique and, hence, cannot produce confidence intervals and other statistical information, the need to aggregate heterogeneous outputs and inputs and the need to estimate the annual physical input and cost of capital goods. Normalising for operating environment differences other than density also requires the use of second stage econometric methods such as an input requirements function (see Lawrence, Zeitsch and Salerian 1994). Successful application of these second stage methods usually requires a reasonably long time series of observations for each firm.

Data envelopment analysis

DEA is a theoretically attractive approach to measuring efficiency levels using linear programming techniques. It has the capacity to produce a large amount of useful information. It can readily incorporate multiple outputs and inputs and can decompose inefficiency down into differences in allocative and technical efficiency and can further decompose differences in technical efficiency into differences in scale effects, input congestion effects and a residual 'pure' efficiency component. It can identify a group of 'peers' for each inefficient observation which are essentially similar organisations performing at superior efficiency. Furthermore, to calculate technical efficiency differences, only data on output and input quantities are required. There is no need to collect value information on items such as capital inputs or output quality where measurement is problematic.

However, these advantages of DEA are also often the source of the technique's practical disadvantages. By permitting researchers to 'delink' output and input values and quantities, there is a temptation to include whatever data comes to hand without adequately thinking about how this data fits into the firm's overall output and input framework. Also, the fact that DEA can produce a large amount of information leads to a temptation for users to focus on the results produced to the detriment of ensuring the integrity and consistency of the data used.

DEA is also more sensitive to measurement error and outliers than other efficiency measurement techniques. If one firm's outputs are overstated or its inputs understated then it can become an outlier that significantly distorts the shape of the efficient frontier and reduces the efficiency scores of part of the sample. This makes it particularly important to ensure that outputs and inputs are measured accurately and consistently for all observations.

Stochastic frontier analysis

TFP and DEA are both deterministic methods that provide no statistical information on confidence intervals. This has led to the development of SFA which is an econometric rather than deterministic approach to estimating the efficient frontier using an asymmetric error term. The essence of the SFA approach to efficiency measurement is to recognise that not all of the difference between a firm's actual costs and the frontier line of best fit is due to inefficiency. Some of it may be explained by purely random events. Consequently, the error component in the model is made up of two elements – genuine inefficiency and random fluctuations. The error term is a conflation of a normally, symmetrically distributed random error component with a mean of zero, and an inefficiency component which is truncated at zero, and which therefore has a one–sided distribution. However, to make SFA operational usually involves a residual degree of subjectivity in the specification of the error term and a large number of observations are needed to generate sufficient degrees of freedom and ensure robust results. Like all econometric methods, SFA does not score highly on reproducibility as each analyst will tend to choose different stochastic specifications and methods of estimation. SFA models are also less transparent and more difficult to explain to groups who are not specialist econometricians.

Econometric cost functions

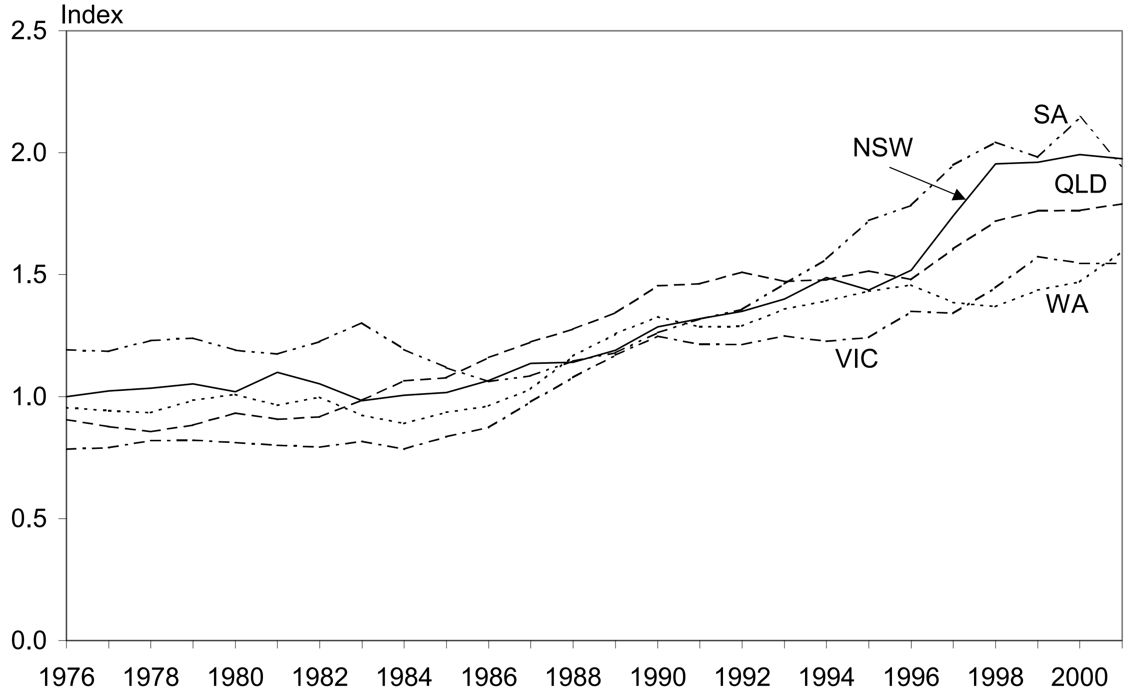
The estimation of cost functions using ordinary least squares econometric techniques has also been widely used in estimating efficiency for incentive regulation purposes. Most cost function applications have used the flexible translog functional form. The cost function approach has more robust statistical properties and readily allows for the inclusion of operating environment variables although, in practice, the ability to include multiple operating environment factors is limited by statistical difficulties, even in large samples. Despite their many advantages, cost functions do not score highly on reproducibility and require a relatively large data set for estimation. Different econometricians will choose different functional forms for the cost function; different break points for splines (differential time trend variables) and different stochastic specifications and methods of estimation. Cost functions can also be estimated for each firm individually or across the entire sample. These differences can lead to different productivity estimates.

2.4 Previous Australasian electricity industry productivity studies

The pioneering electricity industry productivity study in Australia was that of Lawrence, Swan and Zeitsch (1991). This was subsequently updated in Bureau of Industry Economics (1996) and, most recently, in Lawrence (2002). These studies looked at the TFP performance of each of the five mainland state electricity supply systems. They examined the combined performance of generation, transmission, distribution and retail within each state using consistent data that were collected and reported over a long period by the Electricity Supply Association of Australia (ESAA). The most recent study also drew on ABS data to supplement gaps in the ESAA data from 1993 onwards. The Bureau of Industry Economics (1996) study also included an aggregate of the US investor–owned utilities.

Lawrence (2002) covers the 26 year period from 1976 to 2001. The industry's total output is measured by the gigawatt hours of electricity consumed, which increased steadily over the entire period. Input use is measured as an aggregate of four broad input categories: labour, capital, fuel, and materials and services. TFP increased at a trend annual rate of 3 per cent for the entire period and at a trend rate of 3.3 per cent per annum since 1990. After remaining almost flat for the decade from 1976 as outputs and inputs moved in unison, TFP increased rapidly during the second half of the 1980s as reforms started to be implemented in the lead–up to corporatisation. The rate of TFP growth then slowed markedly during the first half of the 1990s before again growing strongly between 1995 and 1998 with the move to privatisation in some states and the introduction of a national electricity market. Multilateral TFP indexes for the individual state systems are presented in figure 1.

Figure 1: **Australian state electricity industry multilateral TFP indexes, 1976–2001**



Source: Lawrence (2002)

London Economics (1993) undertook a TFP study of the Australian state electricity supply systems using a similar approach and data to that used by Lawrence, Swan and Zeitsch (1991). They found that TFP had increased at a trend annual rate of 3.1 per cent for the system as a whole for the nine years up to 1991. Transmission and distribution TFP were found to have increased at 5.1 and 3.7 per cent per annum, respectively. This was more rapid than generation's trend annual increase of 2.9 per cent for the same period.

In 1999 the Independent Pricing and Regulatory Tribunal of New South Wales commissioned London Economics (1999) to assess the efficiency performance of the NSW distributors to inform its pricing determination. This study used a range of techniques including data envelopment analysis, stochastic frontier analysis and TFP indexes to compare the NSW distributors' efficiency with that of a sample of international distributors. The study found that the NSW distributors would have to reduce their input use by between 13 and 41 per cent to achieve best practice given comparable operating environments. Subsequent review of the study by the distributors found a number of data and measurement errors (Lawrence 1999).

Denis Lawrence has undertaken a series of TFP studies of Australian distributors since 1999. Some of the results are presented in Tasman Asia Pacific (2000a,b). The database has been assembled by direct survey of the participating distributors and includes multiple outputs. While this detailed database now contains 11 of the 16 Australian distributors, the focus to date has been on cross sectional rather than time series comparisons so no TFP growth rates have been derived. The Queensland Competition Authority (2001) used the results of the study and a companion cost function study by Pacific Economics Group (2000a,b) incorporating data for US investor owned distributors to derive achievable reductions in distribution operating and maintenance expenditure.

The most recent and detailed Australasian electricity industry productivity study is that of Meyrick and Associates (2003). This study was commissioned by the New Zealand Commerce Commission to measure the performance of New Zealand's 29 distribution businesses and its transmission company, Transpower. The data source used is the NZ lines business Disclosure Data covering the March years 1996 to 2002. Fisher TFP indexes are calculated for Transpower and the distribution industry as a whole. This information was used to form an estimate of the future X factors that could apply to transmission and distribution. Multilateral TFP indexes and cost functions were then used to assess the productivity levels of each of the 29 distributors as the basis for allocating the distributors to three groups each receiving a different stretch factor in addition to the underlying distribution X factor. The same database was also used to allocate the distributors to three groups each receiving a different stretch factor based on their profitability. The overall X factor suggested for a particular distributor was made up of the sum of the underlying distribution TFP growth rate, its productivity stretch factor and its profitability stretch factor.

2.5 Other uses of productivity information

Quite apart from its potential use in incentive regulation, information on electric utility and industry TFP performance can be used for a number of public policy and internal utility purposes. TFP performance is a critical indicator of the success or otherwise of ongoing infrastructure industry reform efforts. It is the key indicator of overall industry efficiency relative to comparable industries overseas and thus provides important information on the contribution of this important infrastructure industry to Australia's international competitiveness. It also provides the basis for analysing the contribution of operating environment differences to observed performance gaps.

The same database required for measuring TFP performance can be used to quantify the distribution of the benefits from productivity improvements among the key stakeholder groups of customers, employees and shareholders. A reasonable sharing of benefits is necessary if reforms are to be sustainable (see Lawrence, Diewert and Fox 2001 and Lawrence and Richards 2003).

Finally, TFP performance can be used as an important internal management tool to monitor both past and forecast future firm performance. It is relatively economical in its use of data and typically only draws on information that well run companies would readily have at hand.

3 DATA REQUIREMENTS

To measure productivity performance we require data on the price and quantity of each output and input and data on key operating environment conditions. We require quantity data because productivity is essentially a weighted average of the change in output quantities divided by a weighted average of the change in input quantities. Although the weights are complex and vary depending on the technique used, they are derived from the share of each output in total revenue and the share of each input in total costs. To derive the revenue and cost shares we require information on the value of each output and input, ie its price times its quantity. Hence, we require either the price and quantity of each output and input or, alternatively, their values and quantities, or their values and prices.

It is particularly important to ensure that the data used in the productivity study are consistent, ie that the sum of price times quantity for all outputs equals total revenue and the sum of price times quantity for all inputs equals total cost. As noted in the previous section, although there is a quantity–only version of the DEA technique that only produces information on technical efficiency, its use often leads to analysts sidestepping difficult data issues. By delinking price and quantity information and analysts are not forced to allocate total revenue and total costs across the range of outputs and inputs included. This removes a vital discipline on the analyst and there is a temptation to include whatever data comes to hand without adequately thinking about how this data fits into the firm's overall output and input framework. Hence, to produce credible productivity results and ensure data consistency, the same fully specified database is required for all the major quantitative techniques – TFP indexes, DEA, SFA and econometric cost functions.

In a sense the quantity data are the primary drivers of productivity results while the value or price data are secondary drivers in that they are used to determine the weights for aggregation. Quantity information can be obtained either directly or indirectly. Direct quantity data are physical measures of a particular output or input, eg gigawatt–hours of throughput or full–time equivalent employees. Indirect quantity data are obtained by deflating the revenue or cost of a particular output or input by an average price or a price index. There are arguments in favour of both methods. Some argue that the indirect method allows greater differences in the quality of outputs or inputs to be captured and for a greater range of items to be captured within the one measure (eg a greater extent of automation reflected in a higher capital value). However, the indirect method places more onus on having both the value and the price data completely accurate. Since price data are generally harder to match to the specific circumstances of a particular firm, there is more scope for error with the indirect method. Hence, it is a good policy to rely on direct quantity data wherever possible and to only use indirect quantity data in those cases where the category is too diverse to be accurately represented by a single quantity (eg materials and services inputs).

Since productivity levels and growth rates will vary significantly with differences in operating environment conditions such as energy density (throughput per customer), customer density (customers per kilometre of line), climatic conditions and terrain, we also require information on the most important of these factors to allow some type of ‘normalisation’ for these differences to ensure we are comparing like with like. It is also important to have information on service quality levels as it will generally be more costly to provide a more reliable service. Since firms have an incentive to achieve productivity targets by reducing service quality levels, we need to again ensure we are comparing like with like across comparators.

The information demands for productivity studies depend on the detail included in the output and input specification. There will generally be a trade–off between accuracy and data demands as the number of outputs and inputs is increased. As the level of disaggregation becomes finer, it is generally more feasible to represent each category by a direct quantity measure and there is less ‘averaging’ across heterogeneous components within a broad category. However, productivity studies are usually undertaken at a relatively aggregated level to make them more tractable. Most early electricity industry TFP studies included only one output and three inputs (labour, materials and services, and capital). Meyrick and Associates (2003) is one of the more detailed studies including three outputs and five inputs.

Productivity studies are usually subject to the ‘80/20’ rule which states that 80 per cent of the information is obtained with the first 20 per cent of effort. The remaining 80 per cent of effort is expended to refine the underlying story. This means that undertaking the productivity study at a relatively aggregated level is not likely to change the underlying story and using publicly available but audited sources of information is likely to accurately capture productivity trends. This is illustrated by work simultaneously undertaken at the Industry Commission and the then Pacific Power in 1992. Pacific Power had initiated a detailed ‘bottoms up’ TFP study of its operations using detailed internal information. The author of the current report initiated a parallel ‘tops down’ study using only relatively aggregated publicly available data and taking much less time than the Pacific Power study. When the results of the two exercises were compared they were found to be almost indistinguishable. The Pacific Power study was subsequently published in SCNPMGTE (1992). For regulatory purposes, however, it is important that data sources be verifiable, even if only relatively aggregated data are used.

Measuring the performance of electricity networks presents a number of data challenges, not the least of which is defining exactly what the outputs of transmission and distribution are. This is a non–trivial exercise given the network nature of the industry and the peculiar characteristics of electricity as a product including its non–storability. In the following sections we examine a number of difficult measurement issues including how to define transmission and distribution outputs, inputs and operating environment variables.

3.1 Measuring transmission and distribution outputs

The main challenge in calculating TFP for an electricity lines business is the specification of exactly what a lines business's outputs are and how to measure the quantity and value of each of them. Transmission and distribution output can be measured from either a 'supply side' or a 'demand side' perspective. At the simplest level, the output would be the amount of energy 'throughput' and its value would be the transmitter's or distributor's total revenue. This approach essentially treats the transmission and distribution systems in an analogous fashion to a pipeline and was a common approach of early studies of electricity transmission and distribution using TFP or other comprehensive indicators. It simply concentrates on the demand for the final product delivered by the transmission and distribution networks. However, there are other important dimensions to a transmitter's and distributor's outputs that need to be taken into account. These include the reliability and quality as well as the quantity of the electricity supply and the coverage and capacity of the systems (ie the fact that the system is there to meet the highest potential peak as well as actual day to day demand).

A number of distributor representatives in Australia have drawn the analogy between an electricity distribution system and a road network. The distributor has the responsibility of providing the 'road' and keeping it in good condition but it has little, if any, control over the amount of 'traffic' that goes down the road. Consequently, they argue it is inappropriate to measure the output of the distributor by a volume of sales or 'traffic' type measure. Rather, the distributor's output should be measured by the availability of the infrastructure it has provided and the condition in which it has maintained it – essentially a supply side measure.

This way of viewing the output of a network industry can be extended to a number of public utilities. For instance, a number of analysts have measured the output of public transport providers using both a 'supply side' and a 'demand side' measure of output. The supply side measure of a passenger train system, for instance, would be measured by the number of seat kilometres the system provides while the demand side output would be measured by the number of passenger kilometres. In the case of public transport this distinction is often drawn because suppliers are required to provide transport for community service obligation and other non–commercial reasons. Using the supply side measure looks at how efficient the supplier has been in providing the service required of it without disadvantaging the supplier as happens with the demand side measure because of low levels of patronage beyond its control.

In previous work on distribution efficiency we have estimated both supply side and demand side output models. Demand side models tend to favour urban distributors with dense networks while the supply side models tend to favour rural distributors with sparse networks (but long line lengths). In Meyrick and Associates (2003) we have further advanced the distribution output specification by combining the key elements of the demand and supply models to form a comprehensive output measure which contains three components – throughput, network line capacity and the number of connections. The connection component recognises that some distribution outputs are related to the very existence of customers rather than either throughput or system line capacity. This will include customer service functions such as call centres and, more importantly, connection related capacity (eg having more residential customers requires more small transformers and poles). This three output specification has the advantage of incorporating key features of the main density variables (customers per kilometre and sales per customer).

Future work may move in the direction of linking capacity to a measure related to the efficient design capacity of the network such as the 10 per cent probability of exceedence demand as there is a risk that in the long term the network owner could build a network with a capacity far in excess of that required. If it did so efficiently, it could still appear to have a high TFP unless capacity is ultimately linked back to that reasonably required.

There is also a fourth dimension to a lines business's output. This is the quality of supply which encompasses reliability (the number and duration of interruptions), technical aspects such as voltage dips and surges and customer service (eg the time to answer calls and to connect or reconnect supply). Reliability is likely to be the most important of these service quality attributes and the one for which the most data are available. However, previous attempts to include reliability measures as a fourth output have proven unsuccessful due to the way output is measured and the complex relationship between reliability and current input usage. As both the frequency and duration of interruptions are measured by indexes where a decrease in the value of the index represents an improvement in service quality, it would be necessary to either include the indexes as 'negative' outputs (ie a decrease in the measure represents an increase in output) or else to convert them to measures where an increase in the converted measure represents an increase in output. Most indexing methods cannot readily incorporate negative outputs and inverting the measures to produce an increase in the measure equating to an increase in output leads to non–linear results. Measuring reliability by the time on supply each year rather than the time off supply effectively produces a constant as the time off supply is such a small proportion of the total time each year. As a result of these difficulties, most transmission and distribution productivity studies do not include service quality as an explicit output. This is a priority area for future research.

Of the three distribution outputs that can readily be included, energy throughput can be measured by the number of gigawatt–hours of energy delivered. The line capacity of the system can be measured by the number of MVA–kilometres formed by summing the product of line length for each voltage capacity and a conversion factor based on the voltage of the line. This measures not only the length of line but also its overall effective capacity. Finally, the connections variable can be measured by the number of connections or customers. Some studies introduce additional differentiation by breaking throughput and/or customer numbers down by customer type (eg residential, commercial, industrial and other). Transmission outputs usually cover system line capacity and throughput but not customer numbers.

To aggregate the three outputs into a total output index using indexing procedures, we have to allocate a weight to each output. For most industries which produce multiple outputs these output weights are taken to be the revenue shares. However, in this case we cannot observe separate amounts being paid for the different output components. In this case we can either make some arbitrary judgements about the relative importance of the output components or we can draw on econometric evidence. One way of doing this using econometrics is to use the relative shares of cost elasticities derived from an econometric cost function. The latter approach is often used in industries not subject to high levels of competition because the cost elasticity shares reflect the marginal costs of providing the outputs. This was the approach followed in Meyrick and Associates (2003) for aggregating distribution outputs. Transmission outputs were then aggregated using the relative split between throughput and system line capacity derived from the distribution data.

Overseas experience of measuring transmission and distribution outputs

Many regulatory studies of overseas transmission and distribution utilities have also used both demand and supply side variables in their specifications. Jamasb and Politt (2000) outline some of the recent European studies. In the Netherlands, a recent price review of distribution businesses (DTe 1999) used six output variables: units supplied, peak demand – high voltage, peak demand – low voltage, network length, small customers and large customers. The corresponding transmission pricing review used four variables: units transmitted, maximum simultaneous demand, 220 kV circuit lines and number of transformers. A recent pricing study of Norway's distribution businesses also had a variety of output measures including number of customers, electricity delivered and length of lines and cables. Table 1 summarises the inputs and outputs used in 20 benchmarking studies reviewed by Jamasb and Pollitt (2000). Several key variables have been used as either outputs or inputs depending on the specification of the individual study.

Table 1: **Inputs And Outputs Used in 20 Distribution Benchmarking Studies**

Input	*Output*
• units sold	• units sold
	• residential sales
	• non-residential sales
• no. of customers	• no. of customers
	• no. residential customers
	• no. non–residential customers
• network size	• network size
• LV lines	
• MV lines	
• HV lines	
• transformer capacity	• transformer capacity
• MV transformer capacity	• no. of transformers
• HV transformer capacity	
• service area	• service area
• maximum demand	• maximum demand
• purchased power	• power sold to other utilities
• transmission/distribution losses	
• labour/wages	
• administrative labour	
• technical labour	
Cost measures:	
• OPEX	
• OPEX + annualised standard capital costs	
• administrative/accounting costs	
• maintenance costs	
• capital	
• CAPEX user cost + labour costs	
• materials	
Miscellaneous:	*Miscellaneous:*
• industrial demand	• service reliability
• customer dispersion	• load factor
• share of industrial energy	• net margin
• network size/customers	• revenues
• % system unload	• distance index
• residential/total sales	• network density
• outages	• categorical variable for urban areas
• no. residential customers/network size	
• inventories	
• line length*voltage	

Source: Jamasb and Pollitt (2000)

3.2 Measuring transmission and distribution inputs

Most studies of transmission and distribution productivity include three broad input categories – labour, materials and services, and capital. Labour quantity is usually measured by the number of full–time equivalent staff while labour cost is measured by wages and salaries including on–costs. However, extreme caution has to be exercised in comparing labour inputs across firms with the increased but varying use of contracting out. Some studies such as Tasman Asia Pacific (2000a,b) have attempted to overcome the impact of differing levels of contracting out by requesting information on the labour content of contracted services. This information is by nature somewhat speculative but provides a starting point for attempting to make like–with–like comparisons of labour productivity. In Meyrick and Associates (2003) there was effectively no reliable labour data available and the labour input had to be rolled in with overall operating and maintenance costs.

Materials and services costs are usually calculated by subtracting labour costs from total operations and maintenance costs (which exclude all capital–related costs). The quantity of materials and services inputs has to be derived indirectly given its diverse composition by deflating its cost by a relevant price index. In those studies that separate out the labour component of contracted services, only the non–labour component is included in this category.

Capital inputs always present one of the major measurement difficulties in productivity studies. Being durable inputs that are not fully consumed in one time period, their cost has to be allocated over their lifetime and changes in their service potential allowed for as they physically deteriorate over time.

There are a number of different approaches to measuring both the quantity and cost of capital inputs. The quantity of capital inputs can be measured either directly in quantity terms (eg using a measure of line length) or indirectly using a constant dollar measure of the value of assets. Some analysts have argued that measuring the quantity of capital by the deflated asset value method provides a better estimate of total input as it better reflects the quality of capital and can include all capital items, not just lines and transformers. There are two potential problems with this approach. Firstly, it requires the asset valuations to be completely consistent across organisations and over time. This will be unlikely to be the case across jurisdictions within Australia, let alone between Australia and other countries. Secondly, approaches using the capital stock to reflect the quantity of inputs usually incorporate some variant of either the declining balance or straight line approaches to measuring depreciation. Electricity line business assets tend to be long lived and to produce a relatively constant flow of services over their lifetime. Consequently, their true depreciation profile is more likely to reflect the 'one hoss shay' or 'light bulb' assumption than that of a declining balance. That is, they produce the same service each year of their life until the end of their specified life rather than producing a given percentage less service every year. In these circumstances it is better to measure the quantity of capital input by the physical quantity of the principal assets.

It is desirable to include at least four capital input categories including overhead lines, underground cables, transformers and other capital. The quantity of overhead and underground lines can be measured directly by their capacity (eg in MVA kilometres) while transformers can be measured by their MVA rating. The quantity of the other capital input category usually has to be measured indirectly given its diverse composition and its cost will be deflated by a relevant capital price index.

The annual cost of using capital inputs can also be measured either directly by applying a formula which includes an estimated depreciation rate, a rate reflecting the opportunity cost of capital and other factors such as taxation effects to the value of assets or indirectly as the residual of revenue less operating costs.

The sophistication of the direct annual user cost formula used in transmission and distribution productivity studies varies widely depending on the quantity and quality of relevant data available. An example of a basic before–tax annual user cost formula is given by:

(1) $$u = \underbrace{rP}_{\text{interest cost}} + \underbrace{\delta(1+\rho)P}_{\text{depreciation cost}} - \underbrace{\rho P}_{\text{capital gains}}$$

where: r is the nominal interest rate;

δ is the economic depreciation rate;

ρ is the inflation rate of capital items; and

P is the purchase price of capital.

Including tax effects (where allowable deductions for tax purposes include depreciation and interest rate deductions) the annual user cost formula becomes:

(2) $$UCC = (r-\rho)P + \delta(1+\rho)P + t[(r-\rho)P + \delta(1+\rho)P - dP - rfP]/(1-t).$$

where: d is the rate of depreciation allowable for tax purposes;

r is the nominal interest rate; and

f is the debt ratio (debt over (debt plus equity)).

Many electricity industry productivity studies use a simpler direct approach of multiplying the asset value by a constant proportion representing depreciation and the real opportunity cost rate (ie the nominal opportunity cost rate less capital gains). Others annuitise the total cost of using the asset over its lifetime (eg Lawrence, Swan and Zeitsch 1991).

The indirect approach of allocating a residual or ex post cost to capital of the difference between revenue and operating costs has been favoured by some regulatory agencies such as the US Federal Communications Commission (1997). However, estimating productivity using a direct estimate of the cost of capital is more consistent with the underlying producer theory where an ex ante measure is required.

Recent European studies take a variety of approaches to their specification of inputs (see table 1). As outlined in Jamasb and Politt (2000) the Netherlands had operating expenditure and total costs as their sole input into their pricing reviews for distribution and transmission, respectively. Meanwhile, Norway's study of distribution utilities used capital (book value and replacement cost), goods/services, losses and labour.

3.3 Allowing for operating environment conditions

Operating environment conditions can have a significant impact on transmission and distribution costs and productivity and in many cases are beyond the control of managers. Consequently, to ensure reasonably like–with–like comparisons it is desirable to 'normalise' for at least the most important operating environment differences. Likely candidates for normalisation include energy density (energy delivered per customer), customer density (customers per kilometre of line), customer mix, the degree of undergrounding, and climatic and geographic conditions.

Energy density and customer density are generally found to be the two most important operating environment variables in distribution normalisation studies (see Meyrick and Associates 2003). Being able to deliver more energy to each customer means that a distributor will usually require less inputs to deliver a given volume of electricity as it will require less poles and wires than a less energy dense distributor would require to reach more customers to deliver the same total volume. Offsetting this to some degree may be the requirement for the higher density distributor to have larger transformers to service its higher consumption customers but again it will require a smaller number of transformers than its less dense counterpart.

A distributor with lower customer density will require more poles and wires to reach its customers than will a distributor with higher customer density but the same consumption per customer making the lower density distributor appear less efficient unless the differing densities are allowed for. Most studies incorporate density variables by ensuring that the three main output components – throughput, system capacity and customers (or connections) – are all explicitly included. This means that distributors who have low customer density, for instance, receive credit for their longer line lengths whereas this would not be the case if output was measured by only one output such as throughput.

There has been some debate over whether reliability should be included as a form of operating environment condition. Ideally, reliability should be included as a fourth type of output as noted in the previous section as it is something that is ultimately under the distributor's control. Attempts to include reliability as an operating environment variable often result in the reliability indicator acting as a proxy for unmeasured geographic and climatic conditions. Distributors operating in mountainous terrain, areas where there is rapid vegetation growth and more storm–prone areas will have to expend higher amounts of operating expenditure and possibly capital expenditure to achieve a given reliability level than their peers operating in flat, drier areas.

There is also some uncertainty about the direction of causation and associated lags between input use and changes in reliability. On the one hand, it may take some time for reliability problems to be recognised and solutions to be approved and implemented. This would point to a relationship between current productivity performance and the reliability performance of, say, two years previously. On the other hand, distributors in remote locations with large service areas have argued that it takes around three years for them to complete a suite of projects addressing the performance of their worst performing feeders. This would point to a relationship between current input use and reliability performance three years into the future.

Climatic and topographic/geographic factors are likely to be the most important operating environment factors for transmission and distribution. The temperature and wind conditions in the area traversed by the transmission or distribution line will influence the effective capacity rating of the line without causing overheating or excessive sagging. The hotter and stiller the ambient conditions, the lower will be the rating associated with a given line construction so that a line of greater apparent capacity might be required to achieve the required actual rating. Conversely, the weight of snow or ice loading may result in excessive sagging in alpine regions and again limit the actual line capacity. Terrain will also be an important driver of transmission and distribution costs with more rugged terrain increasing the costs of construction and requiring more inputs for maintenance. For instance, in steep, inaccessible terrain maintenance crews may have to be flown in by helicopter or snow-cats may be required in alpine regions. Similarly, transmission and distribution lines through bushfire prone areas may require higher construction standards and/or be subject to more outages when fires occur than lines through more benign environments.

Obtaining useable data on climatic and geographic factors is usually problematic as they differ markedly across most transmitters' and distributors' territories. This is particularly the case for rural networks where these factors are likely to be more important. The Northern Territory is a classic example where the service territory ranges from the tropical north to the desert regions in the south.

In practice the ability to include a wide range of operating environment variables in econometric studies is usually limited by multicollinearity between these variables and the main output variables and/or a lack of variation in the variables over time. Including the main density variables is, however, feasible and captures the main operating environment characteristics likely to affect costs for the large majority of networks.

3.4 Data sources used in previous studies

The primary data source used by the system level TFP studies of the five mainland state electricity systems started by Lawrence, Swan and Zeitsch (1991) was the Electricity Supply Association of Australia's (ESAA) annual statistical summary. These data were published by the ESAA in a very constant format from 1947–48 through until around 1993 and provided a consistent source of information over many decades. In some cases the ESAA data were supplemented by information from state authorities and a number of earlier reporting errors were corrected. From 1993 onwards some states stopped reporting their capital data in historic costs. While these data were not of direct use for TFP studies, it provided a consistent source of input to more sophisticated capital stock estimates. From around 1995 onwards some of the newly disaggregated generation and distribution entities stopped supplying complete data returns to the ESAA which broke the series' continuity and usefulness.

In the early studies, the value of output was measured by total revenue from sales of electricity while the quantity of output was the corresponding gigawatt hours of electricity sold, both obtained from the ESAA source. The value of fuel inputs was also available from the ESAA (for all states except Victoria) as was the total energy content of all fuels used. The energy content expressed in terajoules was used as the quantity of fuel inputs. The value of fuel inputs for Victoria was supplied by the former State Electricity Commission of Victoria.

The total number of operating and maintenance personnel was available for each state from the ESAA data and was used as the quantity of labour input. Additional data on the value of wages and salaries paid for New South Wales was obtained from the Engineering and Financial Statistics published by the then Energy Authority of NSW. This enabled an implicit average wage rate to be calculated for NSW operating and maintenance personnel. In the absence of separate wages and salaries data for the other states, the NSW average wage rate was applied to each state's number of operating and maintenance personnel to obtain an estimated value of wages and salaries paid.

User costs for capital assets were calculated using the method of Swan (1990) which takes into account investment streams, asset lives, interest during construction and capacity commissioned each year. Investment expenditure made in past years was converted to current dollars using a general price index to reflect changes in purchasing power. An annual user charge was calculated as the constant real annuity consisting of interest and depreciation charges associated with a given real rate of return which the investment must earn over its expected economic lifetime to equal its direct capital outlays and interest costs during construction. The real annual user cost was used as the quantity of capital input. The value of capital inputs was obtained by multiplying the real annual user costs by the Private Final Consumption deflator. In all cases an asset life of 33 years and a real rate of return of 8 per cent were assumed. The data required to construct these series comprised annual net additions to capacity, net investment and work in progress, all of which were obtained from the ESAA source.

Finally, the value of the other inputs component was obtained by subtracting the value of fuel inputs and the estimated value of wages and salaries from total operating and maintenance expenditure. The latter was also obtained from the ESAA although a number of corrections had to be made to undo past reporting errors by the electricity authorities. Its value was deflated by the Australian Bureau of Statistics' equipment prices paid index to form an implicit quantity.

For the studies which included the US investor owned utilities (Swan Consultants 1991 and Bureau of Industry Economics 1996), broadly similar data for the US was obtained from the Edison Electric Institute and the United States Energy Information Administration.

When the Australian results were updated to 2000–01 in Lawrence (2002) the absence of consistent data, or in some cases any data at all, from the ESAA created major problems. These gaps were filled using much more aggregate level ABS data. For instance, the ESAA has not presented consistent fuel cost estimates since 1994 so the 1994 state fuel prices were indexed forward using an ABS fuel price index. Similarly, the ABS price index for average weekly earnings in the electricity, gas and water industries was used to update the labour price series previously obtained from the Energy Authority of NSW. For the capital data, since 1993 the ESAA has stopped reporting asset additions and works in service for some states while data for others was then presented on an inconsistent basis. The ESAA data were supplemented with net capital expenditure data from the ABS and assumptions about the proportion of works in service.

The ESAA has only reported operating and maintenance expenditure on a consistent basis up to 1997. For subsequent years purchases were updated for NSW, Victoria and WA using changes in the ABS (Catalogue No 8226) series for purchases and selected expenses. For Queensland and SA the ABS series appeared unreasonably volatile so the quantity of materials and services for these states has been updated in line with changes in industry output.

While the Lawrence (2002) study makes the best estimates of productivity it can based on available information, the data that has had to be used in the study from 1994 onwards would not be sufficiently robust for regulatory purposes. This is in contrast to the data prior to 1994 which was largely sourced from the ESAA on a consistent basis for many years. One of the problems with the infrastructure reform process in Australia has been the failure to build in reporting requirements for newly privatised and corporatised entities. Other countries such as the US which are characterised by high levels of private ownership of infrastructure have quite detailed public reporting requirements. While we need to be conscious of not imposing unnecessary burdens and transactions costs on firms, it is clear that the current level of reporting in Australia is inadequate to enable robust and objective assessment of infrastructure performance.

The other lesson to be learnt from previous Australian studies is that there are risks in relying on large 'off–the–shelf' databases when making international comparisons. The best results in benchmarking are obtained from international comparisons using data specifically collected for the purpose from a relatively small group of overseas utilities (see, for example, Zeitsch and Lawrence 1996). This is the only way that you can be confident that data has been collected for exactly comparable activities and similar costs have been treated similarly. The latter is particularly important for the allocation of overheads where more vertically integrated overseas firms are included. The use of large 'off–the–shelf' databases is fraught with difficulty in both these regards. There are often too many utilities included for the analyst to be able to verify the data for all the overseas utilities. For instance, in London Economics (1999) some of the data were found to be incorrect when checked against primary sources (Lawrence 1999).

The most recent Australian distribution productivity study (Tasman Asia Pacific 2000a,b) collected the necessary data directly from participating distributors by survey. A survey form was initially given to the distributors and this was followed up by interviews to ensure the data were being supplied on as consistent a basis as possible. The interview component was particularly important in collecting estimates of the labour content of contracted services. This study provides a snapshot based on one year's data for each distributor. Although the original intention was to collect three years' data for each distributor, most were not able to supply more than one year due to the extent of restructuring occurring within the industry at the time. Sufficient time should now have passed for the businesses of most distributors to have stabilised and for them to have consistent information reporting mechanisms in place enabling multiple years' data to be supplied in future exercises.

Because the distribution benchmarking study was originally undertaken for a consortium of distributors, it was set up using the so–called 'honest broker' model. Each distributor supplied their data to the consultant who held the data in confidence and provided each participant with a report that compared their performance to other distributors on a range of indicators where only the distributor receiving the report was explicitly identified. Other participants were identified by A, B, C, etc with the labels changing for each indicator. This protected the commercial sensitivity of the data and was a condition required by the distributors to participate in the exercise. Permission had to be obtained from all participants for the data to be used for any other purpose or for new distributors to enter the study. The study was subsequently extended under the auspices of a regulator after permission was obtained from the original eight participants.

While the 'honest broker' model is probably best suited to normal commercial benchmarking rather than benchmarking as input to the regulatory process, it does provide a useful model where participation is purely voluntary. However, without ongoing sponsorship from interested regulators exercises of this nature are likely to be either once off or to only attract interest at each five yearly regulatory review. To provide a robust resource for regulatory decision making data collection needs to be ongoing every year rather than just once every several years.

Meyrick and Associates (2003) uses official Disclosure Data the New Zealand distributors and Transpower are required to supply every year and which is then published. The Disclosure Data concept was initially viewed as a means of facilitating public scrutiny of the lines businesses as a substitute for more formal regulation. However, New Zealand is now moving to more explicit regulation and the Disclosure Data are forming the basis of performance assessment. The current Disclosure Data provisions require businesses to provide large amounts of data but the focus of this is largely on financial information and until recently there has been little scrutiny of the data to ensure its consistency. From the perspective of comparative performance studies, most of this data are either unused or unusable.

Some analysts have observed that there is usually an inverse correlation between the quantity of data required to be presented and its quality. This does appear to be the case for the current Disclosure Data. Meyrick and Associates (2003) notes that unless there is a compelling use for the bulk of the current Disclosure Data, there would be significant benefits from reducing the overall quantity of Disclosure Data required but refocusing it to information that is more useful for comparative performance analyses, including disaggregation across output types and geographic characteristics. Consequently, in setting up data collection mechanisms it is important to concentrate on ensuring the quality of a small number of key variables rather than simply collecting large amounts of information.

3.5 Variables required

In this section we list the key variables required to undertake transmission and distribution productivity studies. The list is intended to be indicative rather than definitive and there may be a case for adding additional items to the list or deleting unused ones as thinking evolves. The list has been designed as a 'wish list' covering all the variables that might be required in all of the currently anticipated output and input specifications. The number of variables that would be used in any one study would be only a subset of this list. The list has been compiled with a view to keeping options open for alternative likely output and input specifications.

Outputs

Transmission and distribution

- Total throughput leaving network
- Peak demand
- Energy entering the network
- Route kilometres of overhead line and underground cable
- Circuit kilometres of overhead line and underground cable
- Line and cable length by type, voltage and capacity
- MVA conversion factors for various line/cable types or voltages
- MVA kilometres of line
- 10 per cent probability of exceedence demand
- SAIDI and SAIFI attributable to generation
- SAIDI and SAIFI attributable to transmission
- SAIDI and SAIFI attributable to distribution
- Planned SAIDI and SAIFI attributable to transmission/distribution
- Unplanned SAIDI and SAIFI attributable to transmission/distribution
- MAIFI
- Total operating revenue from regulated activities
- Line losses (per cent)

Transmission only

- GWh sold to directly connected industrial customers
- Revenue from directly connected customers
- Capital contributions, recoverable work etc accounted as revenue

Distribution only

- Throughput by customer class (residential, commercial, industrial, other)
- Throughput by geographic class (CBD, urban, rural, remote)
- Revenue by customer class (residential, commercial, industrial, other)
- Revenue by geographic class (CBD, urban, rural, remote)
- Capital contributions, recoverable work etc accounted as revenue
- Overall SAIDI and SAIFI attributable to distribution
- Planned SAIDI and SAIFI attributable to distribution by geographic class (CBD, urban, rural, remote)
- Unplanned SAIDI and SAIFI attributable to distribution by geographic class (CBD, urban, rural, remote)
- MAIFI by geographic class (CBD, urban, rural, remote)
- Number of voltage excursion events by geographic class (CBD, urban, rural, remote)
- Number of complaints concerning unreliability of supplies and the quality of supply by geographic class (CBD, urban, rural, remote)

Inputs

Labour

- Number of full–time equivalent employees in regulated transmission/distribution function
- Shared allocation of full–time equivalent employees to regulated transmission/distribution activities (eg head office)
- Estimate of full–time equivalent contract labour and consultants involved in pure regulated distribution activities (optional)
- Labour cost of employees in regulated transmission/distribution functions (including on–costs)
- Labour cost of shared allocation of employees to regulated transmission/distribution activities (eg head office)
- Labour component of hired and contracted services for regulated activities (optional)

Operating and maintenance costs

- Total O&M costs attributable to regulated transmission/distribution (excluding all capital costs)
- Materials and consumables expenditure in regulated transmission/distribution functions
- Shared allocation of materials and consumables expenditure to regulated transmission/distribution activities (eg head office)
- Index of prices paid for O&M

Capital

- Total overhead network circuit km
- Overhead network circuit km by voltage class and rating
- Overhead network circuit km by geographic class and rating
- Total overhead route km
- Overhead route km by voltage class
- Overhead route km by geographic class
- Total underground network circuit km
- Underground network circuit km by voltage class and rating
- Underground network circuit km by geographic class
- Total all substations installed transformer capacity (MVA)
- Zone substation installed transformer capacity (MVA)
- Zone substation effective firm transformer capacity (MVA)
- Distribution substation installed transformer capacity (MVA)
- Distribution substation effective firm transformer capacity (MVA)
- Transformer capacity owned by high voltage or other customers
- Total number of poles and towers
- Number of transmission poles and towers
- Number of sub–transmission poles and towers
- Number of HV poles and towers (including those also carrying lower voltages)
- Number of LV poles and towers

- Optimised replacement cost by type of asset (eg plant, equipment, buildings, computers, etc)
- Optimised replacement cost by nature of asset (eg overhead wires, underground cables, transformers, other)
- Depreciated optimised replacement cost by type of asset (eg plant, equipment, buildings, computers, etc)
- Depreciated optimised replacement cost by nature of asset (eg overhead wires, underground cables, transformers, other)
- Book value of plant
- Gross additions to plant
- Retirements of plant
- Average age of assets by nature of asset
- Expected overall and residual life of assets by nature of asset
- Rate of depreciation allowable for tax purposes
- Debt ratio (debt over (debt plus equity))
- Index of purchase prices by major asset categories

Operating environment variables

- Average rainfall in region pa
- Average number of lightening strikes per square km pa
- Average number of gale force wind days pa
- Percentage of lines on terrain with grade in excess of 20 per cent
- Percentage of lines in high risk bushfire areas

Distribution only

- Energy density (throughput per customer)
- Energy density by customer type / class / consumption
- Details of 'major / dominant' customer
- Customer density (customer per km of line)
- Customer density by customer type / class

4 DATA AVAILABILITY

In this section we initially review the likely availability of the data necessary for productivity analyses in Australia. We then proceed to examine the availability of similar data overseas in anticipation of an eventual move to international comparisons of productivity levels and growth rates and operating environment conditions.

4.1 Australia

The data items listed in section 3.5 will have varying degrees of availability depending on whether they are likely to be:

- already publicly disclosed in reporting;
- included in (possibly confidential) specific reporting to regulators;
- collected, collated and used by the utility for its own management purposes (and hence disclosable relatively readily); or,
- characteristics, classifications or collations which may be of direct interest only to the regulator for productivity measurement purposes.

Using this broad classification of likely availability, in table 2 we attempt to classify the data items as follows:

- Public domain – through annual reports, industry statistics, submissions to regulators, etc;
- In regulatory data – regulatory accounts and other specific regulatory reporting (though possibly provided to the jurisdictional regulator on a confidential basis);
- Directly available from the utility, having been collated within the utility for its own purposes but not reported externally; and,
- Possibly available with effort by the utility collecting specific data and/or collating data held disparately within the organisation.

The entries represent a preliminary assessment rather than a definitive listing, so that judgements such as ‘possibly’ and ‘probably’ are used to indicate likely availability more frequently than a more definitive ‘yes’ or ‘no’. Table 2 indicates that much of the higher level data are likely to already be accessible by regulators but that much of the more detailed data are unlikely to be available without assistance from the utility. However, a cooperative utility ought, with proper briefing and definitions, be able to provide nearly all of the necessary data.

Table 2: **Availability of identified data items**

Variable	*In public domain*	*Regulatory data*	*Directly available*	*Possible with effort*
<u>Outputs</u>				
Transmission and distribution				
Total throughput leaving network	Yes			
Peak demand	Yes			
Energy entering the network	Probably	Yes		
Route kilometres of overhead line and underground cable	Possible overall figure only	Probably	Yes	
Circuit kilometres of overhead line and underground cable	Possible overall figure only	Probably	Yes	
Line and cable length by type, voltage and capacity		Possibly by voltage, not by capacity	Yes	
MVA conversion factors for various line /cable types or voltages				Yes
MVA kilometres of line				By derivation from above
10 per cent probability of exceedence demand			Possibly	Yes
SAIDI and SAIFI attributable to generation		Probably	Yes	
SAIDI and SAIFI attributable to transmission		Probably	Yes	
SAIDI and SAIFI attributable to distribution		Probably	Yes	
Planned SAIDI and SAIFI attributable to transmission/distribution		Possibly	Should be	Yes

Table 2: **Availability of identified data items**

Variable	*In public domain*	*Regulatory data*	*Directly available*	*Possible with effort*
Unplanned SAIDI and SAIFI attributable to transmission/distribution		Possibly	Should be	Yes
MAIFI (momentary interruptions)				Possibly
Total operating revenue from regulated activities	Yes	Yes		
Line losses (per cent)			Yes	
Transmission only				
GWh sold to directly connected industrial customers		Probably	Yes	
Revenue from directly connected customers	No	Probably not	Yes	
Capital contributions, recoverable work etc accounted as revenue			Yes	
Distribution only				
Throughput by customer class (residential, commercial, industrial, other)		Possibly	Yes	
Throughput by geographic class (CBD, urban, rural, remote)		Probably not	Possibly	Needs definitions
Capital contributions, recoverable work etc accounted as revenue			Yes	
Revenue by customer class (residential, commercial, industrial, other)		Possibly	Yes	
Revenue by geographic class (CBD, urban, rural, remote)		Probably not	Possibly	
Overall SAIDI and SAIFI attributable to distribution	Probably	Yes		

Table 2: **Availability of identified data items**

Variable	*In public domain*	*Regulatory data*	*Directly available*	*Possible with effort*
Ditto by geographic class (CBD, urban, rural, remote)	Probably not	Probably not		Probably
Planned SAIDI and SAIFI attributable to distribution by geographic class (CBD, urban, rural, remote)		Probably not		Probably
Unplanned SAIDI and SAIFI attributable to distribution by geographic class (CBD, urban, rural, remote)		Probably not		Probably
MAIFI by geographic class (CBD, urban, rural, remote)			Probably not	Possibly
Number of voltage excursion events by geographic class (CBD, urban, rural, remote)			Probably not	Unlikely to be complete
Number of complaints concerning unreliability of supplies and the quality of supply by geographic class (CBD, urban, rural, remote)		Possibly, but probably not by geography		Probably
<u>Inputs</u>				
Labour				
Number of full–time equivalent employees in regulated transmission/distribution function	Unlikely	Possibly		Should be – but contracting difficulty
Shared allocation of full–time equivalent employees to regulated transmission/distribution activities (eg head office)		Unlikely	Probably	Should be
Estimate of full–time equivalent contract labour and consultants involved in pure regulated distribution activities (optional)		Unlikely	Probably	Should be

Table 2: **Availability of identified data items**

Variable	*In public domain*	*Regulatory data*	*Directly available*	*Possible with effort*
Labour cost of employees in regulated transmission/distribution functions (including on–costs)		Unlikely	Should be	
Labour cost of Shared allocation of employees to regulated transmission/distribution activities (eg head office)		Unlikely	Should be	
Labour component of hired and contracted services for regulated activities (optional)		Unlikely		Possibly
Operating and maintenance costs				
Total O&M costs attributable to regulated transmission/distribution (excluding all capital costs)	Probably	Yes		
Materials and consumables expenditure in regulated transmission/distribution functions		Probably not	Should be	
Shared allocation of materials and consumables expenditure to regulated transmission/distribution activities (eg head office)		Probably not	Should be	
Index of prices paid for O&M				Probably sourced other than from utility
Capital				
Total overhead network circuit km	Possibly	Probably	Yes	
Overhead network circuit km by voltage class and rating		Possibly	Km & voltage- Yes	Rating - Probably
Overhead network circuit km by geographic class and rating		Probably not	Km & voltage- Possibly	Voltage & Rating – Probably

Table 2: **Availability of identified data items**

Variable	*In public domain*	*Regulatory data*	*Directly available*	*Possible with effort*
Total overhead route km	Possibly	Probably		
Overhead route km by voltage class		Possibly	Yes	
Overhead route km by geographic class		Probably not	Possibly	
Total underground network circuit km	Possibly	Probably	Yes	
Underground network circuit km by voltage class and rating		Possibly	Km & voltage - Yes	Rating – probably
Underground network circuit km by geographic class and rating		Probably not	Km & voltage- Possibly	Voltage & Rating – Probably
Total all substations installed transformer capacity (MVA)		Probably	Yes	
Zone substation installed transformer capacity (MVA)		Probably	Yes	
Zone substation effective firm transformer capacity (MVA)			Possibly	Yes
Distribution substation installed transformer capacity (MVA)		Probably	Yes	
Distribution substation effective firm transformer capacity (MVA)			Possibly	Yes
Transformer capacity owned by high voltage or other customers			Possibly	Yes
Total number of poles and towers		Possibly	Yes	
Number of transmission poles and towers		Probably not	Yes	
Number of sub–transmission poles and towers		Probably not	Yes	

Table 2: **Availability of identified data items**

Variable	*In public domain*	*Regulatory data*	*Directly available*	*Possible with effort*
Number of HV poles and towers		Probably not	Yes	
Number of LV poles and towers		Probably not	Yes	
Optimised replacement cost by type of asset (eg plant, equipment, buildings, computers, etc)		Yes, but may not be segregated	Yes	
Optimised replacement cost by nature of asset (eg overhead wires, underground cables, transformers, other)		Yes, but may not be segregated	Yes	
Depreciated optimised replacement cost by type of asset (eg plant, equipment, buildings, computers, etc)		Yes, but may not be segregated	Yes	
Depreciated optimised replacement cost by nature of asset (eg overhead wires, underground cables, transformers, other)		Yes, but may not be segregated	Yes	
Book value of plant		Probably	Yes	
Gross additions to plant		Possibly	Yes	
Retirements of plant		Possibly	Yes	
Average age of assets by nature of asset		Probably	Detail available	Average calculable
Expected overall / residual life of assets by nature of asset		Probably	Detail available	Average calculable
Rate of depreciation allowable for tax purposes		Possibly	Yes	
Debt ratio (debt over (debt plus equity))		Probably	Yes	
Index of purchase prices by major asset categories				Probably sourced from outside utility

Table 2: **Availability of identified data items**

Variable	*In public domain*	*Regulatory data*	*Directly available*	*Possible with effort*
Operating environment variables				
Average rainfall in region pa			Probably from other source	May need separate locations
Average number of lightening strikes per square km pa			Probably from other source	May need separate locations
Average number of gale force wind days pa			Probably from other source	May need separate locations
Percentage of lines on terrain with grade in excess of 20 per cent				Probably
Percentage of lines in high risk bushfire areas				Probably from other source
Distribution only				
Energy density (throughput per customer) (distribution)		Probably	Yes	
Energy density by customer type / class / consumption			Yes	May need analysis
Detail of "major / dominant" customer			Yes	
Customer density (customer per km of line) (distribution)		Probably not explicitly	Yes	
Customer density by customer type / class			Probably not directly	May need analysis

Provision of future data (ie data collected and provided after the data set is known) is likely to be more reliable than 'reconstruction' of historic data to suit new definitions or classifications.

In the remainder of this section we review the four categories of data availability summarised in table 2 before briefly looking at some of the pitfalls to be aware of in reconstructing consistent series from historic data.

Public domain

Items which are likely to be already in the public domain include those appearing, for example, in industry data collections by organisations other than the utility itself, annual reports and other public releases from the utility including public submissions to regulators. They are likely to present high level data and are unlikely to disclose competitive or comparative information of strategic value to other organisations.

Such public information is likely to include energy throughput, possibly with information on losses within the utility, as well as observed maximum (half-hourly) demand and its time of occurrence. Segregation of customers is less likely to be publicly available. Overall network revenue and the number of network customers are likely to be disclosed but their segregation according to classes or size of customer, locations and load profiles may not be public information. In particular, directly connected or large contract customers would be represented only in energy and revenue aggregates, rather than being individually identified by name, location or characteristics.

System reliability performance in terms of SAIDI and SAIFI is likely to be represented only at high level, without segregation according to the location or nature of the area and customers served or according to specific external influences such as exposure to seaside spray, lightning, snow or dust laden plains winds.

System assets used are likely to also be available at a high level, possibly segregated according to being overhead or underground, but probably not according to voltage, construction type or delivery capacity.

While overall operation and maintenance costs are likely to be disclosed for the regulated activity, the direct labour input in full–time equivalent employees is probably not disclosed, and most unlikely to be segregated according to provision by inhouse labour and the labour content of contracted tasks, and not according to the various locations, voltages or customer classes served. For example, vegetation control may be listed as an overall contracted item, but the labour content is unlikely to be identified, nor the segregation of tasks according to urban or rural, commercial or domestic, high or low voltage. Allocation of overheads to various activities is likely to be clouded.

Regulatory Reporting

Regulatory reporting of financial, operational and physical information is likely to contain a further level of detail, but is unlikely to be uniformly available in quantity and quality across all jurisdictions.

With regard to physical data, segregation by line or cable type and voltage are likely to be available but there is unlikely to be segregation by capacity or by urban or rural location or by the characteristics of the customers supplied.

Asset valuations are likely to be a little more segregated by being overhead or underground, for transformers or other items, and by voltage, but probably not by location or customer characteristics. The details of the segregation may appear in the valuation submissions according to the methodology required to be employed. Unit rates may represent those in a ‘rates list’ or those appropriate in the opinion of the valuer. Details of optimisation should be available in specific locations, but may be related more to values optimisation than to an associated capacity adjustment. Details of previous book or other valuation items, adjustment for augmentations and extensions as well as retirements should be available, but may not readily be segregated according to location and customer characteristics. Overall capacity of transformers is likely to be disclosed, but may not well represent the ‘firm capacity’ of the various locations according to an *n–1* rating assessment. The number of poles or towers may be listed, but segregation according to voltage carried, location or capacity is unlikely. Rating questions can relate also to design reliability standards and provision of system redundancy for emergency supply. The criteria will likely differ according to location and customer characteristics, but will probably not be explicit.

Life expectancy and residual life are probably explicit, but may appear as averaged values rather than as data for specific asset classes and locations. The lives and depreciation rates may not match those used for taxation purposes. Although this is not a problem for productivity studies this information would be useful for calculating more detailed capital user costs.

Customer details of consumption and revenue by location, customer type and profile are unlikely to be disclosed in detail. Class details (residential versus other, possibly versus contract, commercial, and industrial classes) may be disclosed, but geographical details are less likely. System performance data (SAIDI and SAIFI) will be more detailed than in public disclosure, but are again unlikely to be segregated according to customer location or by being a planned or unplanned interruption. The detail of ‘black spot/feeder’ identification and proposed alleviation strategies and plans are likely to vary across jurisdictions. For transmission systems, appropriate performance measures are still under development.

Possible conflicts between transmission operator opex minimisation imperatives and the impact of system constraints on energy markets are still to be properly resolved.

The recording and classification of other quality of supply determinants (eg voltage drops and spikes) will also vary across utilities and jurisdictions.

While overall operation and maintenance reporting should include more details than publicly available, it is unlikely that regulatory reporting will provide much further information on the labour content of contracted services nor will the materials and consumables elements be well identified. There may be definitional clarification required as far as costs incurred for ‘renewal of assets’ as distinct from ‘maintenance of assets’ and their treatment as opex or capex are concerned. Treatment of capital contributions may need to be considered carefully. This is often recorded as part of annual revenue for accounting purposes, rather than being considered as creating an enduring asset (albeit at zero value for return on utility investment) which will need associated opex, lifetime maintenance and possible eventual replacement at the end of its life.

Customer environment densities, energy per customer and customers per kilometre are likely to be only stated (or derivable) at an aggregated level, rather than by customer type or location.

Available from the utility

In principle, almost all the information required ought be available from a cooperative and informed utility. The ease of provision, particularly for retrospective data, depends on whether the data are likely to have been collected and collated for the utility’s own management purposes, or whether the information, segregation or collation is only required for regulatory purposes.

Information which is ‘direct’ and well specified in advance will also be more reliable than information which is the result of ‘allocations’ after the event. Thus, for example, system and customer details which are based on clear characteristics of relevance to the utility such as segregation of lines, cables and transformers by voltage and of customer energy consumption by tariff class ought to be readily available while segregation of similar data into CBD, urban, rural and remote locations may be less readily to hand. Separation of assets and costs associated with, for example, a subtransmission voltage system (say at 132 kV) into those parts which are classified as ‘transmission’ for Code/regulatory purposes because of their parallel and supporting role from those which perform a distribution purpose are less likely to be of immediate relevance to the operating utility, and hence less readily or precisely available.

Similarly, changes in classification and data requirements as well as utility ownership and management changes over time will make the collation of a consistent data series more difficult. For example, provision and treatment of metering services, originally within an integrated utility, may have variously been regarded as a network, retail or contestable function with associated asset and operating cost allocations. Recoverable works, such as streetlighting, and the alteration of mains from overhead to underground in conjunction with local government authorities may also present asset and operational classification difficulties.

Transformer and substation capacity and rating will be known, but regarded as of more interest in relation to the observed actual loads required or forecast than as a measure of potential supply. Interruption frequency and duration, particularly the relatively recent recognition of "momentary" interruptions are likely to have been observed but the degree of causal segregation may depend on previous management and regulatory interest. Response time to customer telephone contact, particularly in the event of a supply interruption which is already known to the utility may be of more interest in a regulatory regime than as an operational measure.

Segregation of operating costs as labour, materials or other items for contracted work may be of less interest to the utility than the effective and economical performance of the required task so that any regulatory data analysis may still require assessment and allocation rather than measurement. Allocation of overhead costs, particularly in a utility with multiple functions in different service and regulatory environments may remain subject to uncertainty.

Some operating environment factors such as storm frequency and severity, terrain characteristics, vegetation growth rates may not have been subject to careful recording within the utility unless or until of specific regulatory interest and may make cross comparison less reliable.

Potential pitfalls in reconstructing historic data

As indicated earlier, consolidated and consistent data collection by the ESAA has become less complete following the various reforms in the industry and the style of individual reporting has tended towards high level data, rather than the more specific data likely to be necessary for detailed productivity analysis. Differing and changing ownership and structures as well as changing associated business activities are likely to cloud the issue, rather than facilitating a data stream that is uniform in classification and breadth. Even the timing of these alterations can make 'financial year' reporting data inconsistent.

For example, system annual energy, peak demand and revenue will be readily available, but segregation according to customer class, size or location is unlikely to have been separately stated. Reliability will be available as overall figures, with various segregations according to regulatory requirements, but possibly not uniformly according to system location and environment.

Some of the data will be recoverable through regulatory data and other reporting requirements to jurisdictional regulators (often confidentially), or in various submissions to those regulators. System asset details will be included as part of the ODV calculations and submissions, but the level of detail will vary according to the valuation methodology. Valuation dates are unlikely to coincide across organisations or jurisdictions, so that adjustment towards annual values between valuations through inflation, depreciation, new construction and retirements will be necessary. Even different methods of valuation (eg full periodic revaluation versus roll forward with adjustments) will require care in interpretation. Correlation of system elements and their individual capacity is unlikely to be submitted. Detail of operating costs will be available, but probably not segregated according to customer characteristics. Identification of equivalent labour inputs through activities contracted out is unlikely to be available.

Other data will have been assembled for use by the organisations for their own management purposes, while some potentially useful data will probably exist only in raw form, rather than collected and collated as might be required. Customer/tariff class, consumption and location data will be available but possibly not collated as required for analysis.

Uniformity of definition may also present problems in comparing like with like. For example, transformer capacity can be quoted by the summation of each unit's nominal rating, or the station's cyclic emergency rating on an *n–1* basis in each location. Capacity of lines and transformers will differ depending whether the system peak load occurs during a series of hot summer afternoons, or during a cooler winter evening. Reporting and treatment of 'unusual events', such as bushfires, vehicle impact interruptions and dust induced insulator flash-over may vary according to the jurisdiction. Accounting treatment of capital contributions (in cash or kind) and the allocation of various overhead charges may distort revenues or valuations. The segregation of a network to CBD, urban, rural or remote is also likely to be subjective.

Changes in recording and reporting as well as the area served and customers connected will have occurred and will occur as organisations separate or combine so that consistency and continuity of data over time may present some difficulties.

Summary

Although the availability of the data required for robust productivity studies is currently patchy and a number of consistency issues exist, sufficient data appears to be available in the public domain and in regulatory sources to make a good start on historic productivity measurement for both transmission and distribution, with appropriate caveats. Securing the cooperation of utilities would certainly provide much additional data and allow more detailed studies. Going forward, specifying clear data requirements and explicit data collection mechanisms will enable most of the existing data deficiencies to be overcome at relatively low cost.

4.2 Availability and accessibility of international data

In this section we discuss the availability and accessibility of international data that could be used to enable the performance of Australian transmission and distribution to be compared with that of other countries. Internet searches were undertaken to identify potential data sources, and the availability (types of data, years for which data are noted as available) and accessibility (open access, proprietary) of data. Data sources investigated were the United States, Canada, United Kingdom, and the European Union. With the exception of the United States, datasets at other than a highly aggregated level are not open access. Some aggregated data are accessible, such as average prices, but data at a more detailed level are not easily identifiable or accessible.

4.2.1 United States

The main public sources of data on the electricity industry in the United States are the Energy Information Administration (EIA) and the Federal Energy Regulatory Commission (FERC).

Energy Information Administration (EIA)

EIA is part of the Department of Energy (DOE). It was created by Congress in 1977 as a statistical agency and provides ‘policy–independent data, forecasts, and analyses to promote sound policy making, efficient markets, and public understanding regarding energy and its interaction with the economy and the environment.’

EIA is required by law to publish, and otherwise make available to the public, high quality statistical data that reflect national electric supply and demand activity as accurately as possible. To meet this obligation, as well as internal DOE requirements for accurate data, the Electric Power Division of the EIA has developed statistical surveys that encompass each significant electric supply and demand activity in the United States.

Statistical surveys conducted by the EIA include Form EIA-412, the Annual Electric Industry Financial Report, which is used to collect data on municipal, federally owned and unregulated entities. Data from Form 412 are compiled into a database, the Public Electricity Utility Database that is accessible free of charge from www.eia.doe.gov/cneaf/electricity/ page/eia412.html. Data can be downloaded in Excel format for the years 2001 and 2002 (incomplete), and in database format for historical data for the years 1990 to 2000. Excel files comprise:

- Electric balance sheet;
- Electric income statement;
- Electric plant;
- Taxes, tax equivalents, contributions and services;
- Sales of electricity for resale;
- Electric operation and maintenance expenses;
- Purchased power and power exchanges;
- Electric generating plant statistics;
- Existing transmission lines; and
- Transmission lines added within the last year.

Form EIA-861, Annual Electric Power Industry Data, is used to collect information on peak load, generation, electric purchases, sales and revenues. Database files can be downloaded free for the years 1990 to 2002 (preliminary data) from: http://www.eia.doe.gov/cneaf/electricity/page/eia861.html. Data that can be accessed from the downloaded files include:

- File1 contains aggregate operational data such as control area operators, energy balance, and revenue information from each electric utility in the country, including power marketers, and federal power marketing administrations.
- File2 contains information on retail revenue, sales, and customer counts, by state and class of service, for each electric distribution utility, for all consumers provided fully bundled electric service (both energy and delivery service) by a single electric utility in all 50 states, the District of Columbia, the Dominion of Puerto Rico, and the Territories of American Samoa, Guam, and the Virgin Islands.
- File3 contains information on retail revenue, sales, and customer counts, by state and class of service, for customers who selected alternate energy service providers in states that have deregulated their retail electricity markets, either fully or partially. The revenue reported is the revenue received only for the energy portion of the customer's bill, (revenue for delivery services is not included).
- File3d contains information on the delivery of power to customers who selected alternate power suppliers in state-level, 'retail wheeling' programs. The revenue, megawatthours,

and consumer count information in this file was reported by distribution utilities delivering power sold by other energy suppliers. The revenue is the revenue received by the distribution utility for the delivery services provided to customers who were sold power by others, usually competitive retail energy service providers (ESPs). The megawatthours shown are the delivered megawatthours sold by the ESPs (and reported by ESPs as shown in File3.dbf) to customers who switched energy suppliers in the distribution utility's service area. The revenue is not duplicative of the energy revenue shown in File3.dbf. The megawatthours and customer counts are duplicative of the megawatthours and customers counts shown in File3.dbf, and should not be used to derive national, census division, or state-level sales and revenue totals.

- File4 contains information on electric utility demand-side management programs, including energy efficiency and load management effects and expenditures.
- File5 contains the names of the counties, by State, in which the respondent has equipment for the distribution of electricity to ultimate consumers.

Data obtained from Form 861 are used to compile the Electric Power Annual, the latest issue being for 2001: http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html. A related publication, Electric Sales and Revenue, has been discontinued with summary data now included in the Electric Power Annual. Electric Sales and Revenue data are downloadable in Excel format from: http://www.eia.doe.gov/cneaf/electricity/esr/esr_tabs.html. These data include aggregated data by state and utility on numbers of customers, sales and revenue.

Federal Energy Regulatory Commission

The status and responsibilities of the Federal Energy Regulatory Commission (FERC) are described on the website (http://www.ferc.gov/about/ferc-does.asp) as 'an independent agency that regulates the interstate transmission of natural gas, oil, and electricity. FERC also regulates natural gas and hydropower projects.' As part of that responsibility, FERC:

- Regulates the transmission and sale of natural gas for resale in interstate commerce;
- Regulates the transmission and wholesale sales of electricity in interstate commerce;
- Licenses and inspects private, municipal, and state hydroelectric projects;
- Oversees environmental matters related to natural gas and hydroelectricity projects and major electricity policy initiatives; and
- Administers accounting and financial reporting regulations and conduct of regulated companies.

Detailed data on electricity supply in the United States is compiled by the FERC using the Form 1 survey instrument, Annual Report of Major Electric Utilities, Licensees, and Others. The FERC Form 1 is a comprehensive financial and operating report submitted for electric rate regulation and financial audits. Major is defined as having (1) one million Megawatt hours or more; (2) 100 megawatt hours of annual sales for resale; (3) 500 megawatt hours of annual power exchange delivered; or (4) 500 megawatt hours of annual wheeling for others (deliveries plus losses). The FERC Form 1 can be downloaded from: http://www.ferc.gov/docs-filing/eforms/form-1/viewer-instruct.asp. Data compiled from the FERC Form 1 for 1994 to 2002 can be accessed from: ftp://rimsweb2.ferc.gov/f1allyears/, and data from 1990 to 1996 are downloadable from the EIA at www.eia.doe.gov/cneaf/ electricity/page/ferc1.html.

FERC Form 1 comprises 61 schedules and these are listed in appendix 1. The FERC Form 1 does not include information on customers served or system reliability. Some data on the number of customers served by type (residential, commercial, industrial) are collected on Form EIA-861, referred to above. Data on system reliability are collected on Form EIA-417, but are not accessible from the EIA site. It appears that these data are confidential.

Edison Electric Institute

Edison Electric Institute (EEI) is a private membership-based organisation. The membership includes US shareholder owned electric companies, international affiliates, and associates. Information and data are available for purchase either through hard copy publications or electronic subscription. EEI produce a Statistical Yearbook of the Electric Utility Industry that can be purchased as can each of the tables published in the Yearbook. The Yearbook table of contents can be downloaded from the website. Data comprise generating capacity, electric power supply, generation, fuel, energy supply and disposition, energy sales, customers, revenues, financial, and economics and other (http://www.eei.org/ products_and_services/descriptions_and_access/stat_yearbook.htm). The data appear to be at a relatively aggregated level.

Utility Data Institute

The Utility Data Institute (UDI) is referenced as a source of data in several reviews of international electricity industry comparative performance. UDI is now part of Platts UDI Products Group (http://www.platts.com/udidata/) and Platts is the energy information group of the McGraw–Hill Companies, Inc. Products listed under the product catalogue on Platts UDI website related to electricity include:

- 2003 Directory of Electric Power Producers and Distributors (Nov 2002);
- 2003 Who's Who at Electric Power Plants (Jan 2003);

- 2003 International Directory of Electric Power Producers and Distributors (May 2003);
- UDI Energy Business Directories online;
- World Electric Power Plants Data Base (Sep 2003);
- Electric Power Sector Country Profiles (Apr 2003); and,
- 2000 Production Cost Data Bases (Jan 2002).

The UDI site also lists topics of interest by subject matter. Many of the databases relate specifically to electricity market performance and generation plants. One of the more relevant ones for this exercise appears to be POWERdat. This database enables analysis of cost competitiveness and power trends and includes company level information on:

- Operations and costs;
- Prices;
- Financial profiles;
- Production costs; and,
- Ownership and capacity profiles.

The Platts Opri Electric Utility Database is also of particular interest and contains financial, operating and O&M data in a single database. This database contains every electric utility company filing the FERC Form 1 for the years 1988–2000 and includes 1,865 statistical line items from the Form 1. Also included are 20 financial benchmark statistics and 7 operations statistics created by Opri's analysts. Overall, the database is said to contain data for 217 electric companies on physical outputs and inputs, revenue, O&M expenses, assets and other key financial variables. The Opri Electric Utility Database is said to allow analysts to:

- Conduct comparative analysis & benchmarking;
- Evaluate mergers and acquisition opportunities;
- Track system costs; and,
- Profile companies.

The Opri database is available for purchase on CD–Rom at a cost of $US 2,150.

Pacific Economics Group

Pacific Economics Group (PEG) has undertaken a number of benchmarking studies using a proprietary data set they have developed and maintained. This data set is focused on US energy utilities and uses a number of sources including the FERC Form 1 returns and information from the US Energy Administration, the US Department of Commerce and an engineering consultancy, Whitman, Requardt, and Associates. PEG has spent considerable time 'cleansing' their US electricity utility database to ensure the accuracy of data and consistency of treatment of different activities. While narrower in geographic coverage than the large commercial databases, the quality control in the PEG database is much higher. An important part of the added value from using this database is a higher level of confidence that the activities of vertically integrated US utilities have been separated along lines consistent with overseas comparator organisations.

Summary

Large data holdings on electricity companies are available and accessible from the EIA and FERC. Although these data are accessible, use of the data for comparative benchmarking would require a substantial collation exercise, careful selection of the utilities to be included in the benchmarking analysis, and careful consideration of the level of aggregation of data that is acceptable for the purposes of comparisons. Data available for purchase from UDI are also potentially useful. The proprietary database maintained by Pacific Economics Group is a useful source although the contents of the database are not available for review and scrutiny for commercial reasons.

4.2.2 Canada

Several data sources on electricity are available for Canada, none of which appear to be as comprehensive as those for the United States. The Canadian Electricity Association (CEA) (http://www.canelect.ca/english/aboutcea) provides the most extensive and detailed coverage of the industry with a number of relevant benchmarking publications available for purchase (http://www.canelect.ca/english/aboutcea_documents_reports_benchmarking.html):

- Forced Outage Performance of Transmission Equipment - This report covers 9 major components of transmission equipment in Canada with an operating voltage of 110 kV and above, but also includes compensators, reactors and capacitors with a voltage below 110 kV. Clause 1 contains information on data contributors. Clause 2 contains a list of the transmission inventory dealt with in the report as well as a summary of the performance of the equipment. Clause 3 contains the definitions used in calculating the figures in this report. Computer printouts containing the performance statistics are contained in the appendices of the report. These statistics are classified by voltage classes, by subcomponents, by primary causes and by interrupting mediums.
- Service Continuity Report on Distribution System Performance in Canadian Electrical Utilities - This annual report contains the performance indicators SAIDI, SAIFI, CAIDI

and the Index of Reliability for Canada (over 9.6 million customers) and for individual utilities. Also included are the major causes of interruption to the system and to customers. This report is a useful benchmarking tool that can be used to determine the quality and performance of utilities' service to their customers. The distribution system performance for the current year is given along with comparisons to the previous year and to the five-year average.

Demand, supply and capacity overview information can be viewed in html format on the CEA website (http://www.canelect.ca/english/electricity_in_canada_snapshot_Demand.html). The information comprises:

- Canada Electric Power Generation: % of Total: 2002
- Generation By Province/Region: 2001, TWh
- Canadian Thermal Generation by Fuel Type: % of Total
- Canadian Electricity Demand By Sector: 2001, As % of Total
- Canadian Installed Generation Capacity: 2000, As % of Total MCR
- Canadian Installed Generating Capacity by Province/Region and Type: 2000, GW
- Canada: Reserve Margins For Electric Power Generation: 1980-2002, %
- CEA/CSGI: Bird's Eye View of Canadian Electricity Demand to 2020: TWh
- NEB 2003 Mid-line Projection of Canadian Electricity Demand to 2020: TWh

The publication by CEA, Annual Industry Review, can be downloaded from: http://www.canelect.ca/english/aboutcea_documents_annual.html. It is conjectured that some disaggregated data for comparative benchmarking would be available for purchase from the CEA.

The National Energy Board of Canada (NEB) (http://www.neb.gc.ca/) and Statistics Canada (http://www.statcan.ca/english/Pgdb/) are other sources of information and data on the Canadian electricity industry. The NEB is an independent federal agency that regulates several aspects of Canada's energy industry. Its purpose is to 'promote safety, environmental protection and economic efficiency in the Canadian public interest within the mandate set by Parliament in the regulation of pipelines, energy development and trade.'

NEB publications are listed at: http://www.neb.gc.ca/Publications/index_e.htm. Electricity publications can be downloaded at: http://www.neb.gc.ca/energy/EnergyReports/index_e.htm#Electricity. The NEB's publication, Canadian Electricity Trends and Issues

(2001), can be downloaded and provides a broad assessment of the electricity market nationally and for each of the Canadian provinces. Some statistical data are available from: http://www.neb.gc.ca/stats/index_e.htm. Examination of the data indicates that the focus is on exports and imports of energy rather than an emphasis on the domestic market.

Statistics Canada publishes aggregate data (http://www.statcan.ca/english/Pgdb/) similar to that published by the Australian Bureau of Statistics.

To summarise, disaggregated data for comparative benchmarking is likely to be available from the CEA but would only be accessible if purchased. Some information and limited aggregate data are accessible from CEA, NEB and Statistics Canada.

4.2.3 United Kingdom

Data sources examined for the United Kingdom were the Office of Gas and Electricity Markets (Ofgem), the representative bodies for the electricity industry, and the Energy Group, Department of Trade and Industry (http://www.dti.gov.uk/energy/gas_and_electricity/). The Electricity Association has ceased operations and there are now three representative bodies, the Association of Electricity Producers (http://www.aepuk.com/), the Energy Networks Association (http://www.energynetworks.org/), and the Energy Retail Association (no website). Information and data are not accessible free from these organisations. A limited number of publications are available for purchase.

Ofgem is the regulator for Britain's gas and electricity industries. Its role is to 'promote choice and value for all customers' (http://www.ofgem.gov.uk/ofgem/index.jsp). A search of the site for 'statistics' yielded no useful information on data that might be held by Ofgem. Ofgem would need to be contacted in order to establish whether they hold any accessible datasets that would be useful for comparative benchmarking.

The Energy Group, Department of Trade and Industry (DTI), is responsible for developing and implementing government policy towards the electricity and gas utilities in Great Britain. Information and statistics available are listed by subject matter at: http://www.dti.gov.uk/energy/inform/index.shtml. The Digest of United Kingdom Energy Statistics 2003 can be downloaded from: http://www.dti.gov.uk/energy/inform/dukes/dukes2003/index.shtml. The Digest includes predominantly aggregate data, although some regional data are provided.

With respect to regional energy consumption statistics the website notes that the Energy White Paper, issued in February 2003, emphasised the importance of local and regional decision making for energy policy in delivering a number of national energy policy objectives. It confirmed the DTI's commitment to 'collect and make available data on the pattern of energy use in local areas, to enable local authorities and regional bodies to target activity more effectively'.

The Department of Trade and Industry consulted last year on the need for sub-national information on energy consumption. Having established the need for such information from a wide range of users, the Department is now consulting about how to compile such estimates including, in particular, how to collect information on electricity use (http://www.dti.gov.uk/energy/inform/regional_energy/index.shtml). No other potential sources of disaggregated data have been identified.

4.2.4 European Union

The Directorate-General for Energy and Transport (http://europa.eu.int/comm/dgs/energy_transport/index_en.html) and Eurostat (the EC's statistical agency) (http://europa.eu.int/comm/dgs/eurostat/index_en.htm) collect and collate data on energy supply within the European Union. Data collected is at the country level rather than the regional or utility level. The publication, EU Energy and Transport in Figures 2002 can be downloaded from: http://europa.eu.int/comm/energy_transport/etif/. Included in the publication is average electricity price information for industry and households for each of the member states. Reports related to the opening of internal electricity and gas markets are available from: http://europa.eu.int/comm/energy/electricity/benchmarking/index_en.htm.

5 MODELS FOR DATA COLLECTION

From the previous section we have seen that much of the data required for Australian transmission and distribution productivity studies is currently available although it is typically not all in the public domain and the quantity and quality of data varies between jurisdictions. Going forward, it would be desirable to have a common set of data available for as many transmission and distribution firms as possible. Ideally this data should:

- use a common set of definitions;
- be audited or otherwise confirmed so that regulators can have confidence in the analysis produced from it;
- be provided in as timely a fashion as possible; and,
- be in the public domain as much as possible so that all interested parties can undertake analysis using a common starting point.

Given the current structure of the industry, there are a number of options for collecting and holding data. These range from a centralised model where one organisation is responsible for collecting and holding data to decentralised models where each jurisdiction looks after data collection and holding for its own transmission and distribution firms. There is also a range of options for handling differing confidentiality requirements for different data items.

In this section we proceed by assuming that data collection and storage decision–making remains decentralised. We examine the strengths and weaknesses of three broad models within the continuum of possible frameworks which can be described as the disclosure data model, the 'honest broker' model and the URF service quality model.

5.1 Disclosure data model

New Zealand initiated a disclosure data regime for its transmission and distribution lines businesses in 1995. This required data covering financial, physical and service quality information to be provided by the regulated electricity distribution and transmission companies within five months of the end of the financial year directly to the government under the Electricity (Information Disclosure) Regulations 1994 and 1999. This Disclosure Data are gazetted each year and audited by the Ministry of Economic Development.

The original objective of this regime was to provide a basis for public scrutiny of lines businesses' operations and performance as a substitute for more explicit regulation. Over time the Disclosure Data has come to form the basis of performance measurement which will be explicitly linked to the setting of CPI–X price 'thresholds' (Commerce Commission 2003, Meyrick and Associates 2003). Breach of a price threshold may trigger a more detailed investigation by the regulator.

This disclosure data model maximises public availability of the data and sets explicit timelines for data provision and auditing. However, the New Zealand model has a number of major flaws. Despite the wide range of items now reported in the Disclosure Data, the consistency and quality of the data are variable. At the outset of the scheme, insufficient consistent definitions were stipulated and distributors appear to have interpreted what was required differently leading to apparent inconsistencies across distributors and, in many cases, considerable variability from year to year for the one distributor. Some firms took advantage of the loose definitions by shifting costs from some retail and other activities into their lines businesses. This led to a further tightening of data definitions and requirements in 1999 and the separation of distribution and retail activities in the same year.

Some data collection gaps remain such as the requirement that information only has to be supplied for entities existing at the end of the financial year. Where distributors have merged, data for the entity which has been absorbed does not have to be disclosed from the beginning of the financial year up to the date of the merger.

A further limitation of the New Zealand regime is that the data are now being used for performance measurement purposes which ideally requires a different mix of data to that originally specified. A number of the key variables that would normally be required for productivity analyses are missing while much of the detailed data provided are not used. For instance, there is effectively no useful labour data and much of the financial and accounting cost detail provided is unnecessary for productivity measurement. A refocussing of the regime is likely to occur in the next few years to concentrate on more relevant data and a culling of much of the detailed information currently required but which does not appear to be used.

Despite these limitations, the New Zealand disclosure data model in many ways represents an ideal. There is an explicit requirement to supply audited data by a set date and all the data are publicly available. Given the nature of the data required for productivity studies, the case for keeping some of the data confidential is not strong. The lesson from the New Zealand experience is that it is important to have a clear idea at the outset what the data are going to be used for and to ensure that all relevant data are included and comprehensively defined. This type of model may be harder to implement in Australia where there are nine jurisdictions rather than a single jurisdiction country such as New Zealand.

5.2 Honest broker model

Another option used in data collection and holding is what we have termed the 'honest broker' model. This model has at its core a third party – the honest broker – that is neither the regulated business nor a regulatory authority. This model is often used in business initiated studies where data confidentiality issues are of paramount concern.

In this model, regulated businesses provide a defined data set to a third party whose role is to hold the data and audit its accuracy. The third party may supply either an agreed summary of that data for regulatory and benchmarking purposes or, more likely, simply the results of the final productivity analysis which may only identify one firm while protecting the identity of the other firms by labelling them A, B, C, etc. In this model the roles of the different parties can include those outlined in table 3.

Table 3: **Potential roles in the honest broker model**

Party	*Role*
Regulator	• Develop standards, definitions, minimum data requirements and protocols for the businesses and honest broker to follow • Approve an independent third party to act as data holder and auditor • Conduct regular, periodic audits of data provided by third party • Penalise businesses who do not provide data to the third party
Third party/ honest broker	• Make available to the regulator all data in a timely manner for regulatory purposes • Ensure that all competitive information is treated in a confidential manner • Audit data for accuracy • Use the data provided only for comparative work to ensure accuracy and not for any other purpose for commercial benefit
Data provider	• Provide complete, accurate and timely information to the data collector • Report in a standardised electronic format • Inform the third party of any errors in a timely manner

This model has the advantage of freeing regulatory bodies from the role of data collection and management. The inclusion of an independent third party can work to ensure that confidentiality of data is maintained although, as noted in the preceding section, the justification for keeping some of the data required for productivity studies confidential is not strong. However, having another party involved in data collection is likely to increase the complexity and lack of transparency of data monitoring. It can also lead to the third party developing an inappropriate degree of control over the process and, ultimately, extracting rents from their 'monopoly' position. In many ways this model is at the opposite end of the spectrum to the disclosure data model. Most data remains confidential and interested parties cannot replicate the results of the productivity analyses or undertake sensitivity analyses.

This model is generally more appropriate to a process where participation is voluntary and the mechanism can be used to give a degree of comfort to participants who might be concerned about incurring a commercial disadvantage by releasing data. This model has been used in a distribution regulation study in Australia (see Tasman Asia Pacific 2000a,b) but this was a line of work initiated originally by a group of distributors where participation was voluntary. Going forward, this model would be less preferred than the disclosure data model where data provision is compulsory and all data are made publicly available.

5.3 URF service quality model

The Utility Regulators Forum (2002) has guided the development of a model for a national framework of collection, holding and disclosure of service quality information. Through a process of consultation and discussion among the regulators, the major stakeholders in the URF developed standard definitions behind the agreed data fields. Each jurisdiction represented in the URF agreed that the data fields determined by the URF would represent the minimum reporting requirement and also agreed to publish data on these fields in a nationally consistent reporting format. The individual regulators can also require regulated businesses in their jurisdiction to provide greater information than that required for the minimum reporting requirements. Access to these reports is to be available to all interested parties through each jurisdiction's regulator's website. Jurisdictions are, in the main, complying with the URF definitions although there have been some deviations to suit the special circumstances of some jurisdictions (such as in the definition of exclusion events).

In this model the responsibility for data collection and maintenance is decentralised – it remains with the state and territory regulatory authorities rather than controlled by a single national body and transparency is maximised. A major advantage of this framework is that the definitions are precisely specified and there is little room for misinterpretation by data providers. This model appears to be a practical version of the disclosure data concept which has been implemented for the Australian situation of multiple jurisdictions. It represents the best role model for developing productivity data collection, publication and holding in Australia. It would use existing mechanisms without dramatically increasing the resources required to achieve a sound outcome.

If data confidentiality concerns prove to be a barrier to developing publicly available productivity data, information technology now provides a potential solution through the use of internet 'portals'. One option is have a system of common, tiered access to information available on regulators' websites. If some information (probably the majority of information required for productivity studies) is not sensitive then this can be included on a section of the website accessible by all users. If some portion of the data required for productivity studies is commercially sensitive but regulators can reach agreement on protocols to share that information while protecting its confidentiality, then that data can be placed on each regulator's website in an area only accessible by other regulators' staff who have the relevant clearance codes. Each regulator may also collect additional commercially sensitive or confidential information for its own purposes that it does not necessarily wish to share with other regulators. This third tier of information can be protected by access codes that limit access to the regulator's staff and possibly other relevant organisations within that jurisdiction only.

Wherever possible it is important to not only have accurate and comprehensive data but to ensure that the data are publicly available. This will provide greater incentives to achieve accuracy in information disclosure, provide greater amounts of information for business comparisons, as well as ensuring more informed regulation of businesses. Common access to data by all interested parties also ensures that the benefits of data collection are shared amongst all – the regulator (in terms of improved data on which to make well informed regulatory decisions), the businesses (by providing greater understanding of what has driven regulatory decisions and making available important comparative data for benchmarking purposes) and the public (by enabling higher levels of scrutiny for important public policy decisions).

6 CONCLUSIONS

This report has reviewed the main data requirements for productivity studies of electricity transmission and distribution. The main data items required for these studies are the prices and quantities of the major outputs and inputs and information on the key operating environment characteristics of each firm likely to be beyond management control. We have specified a long list of desirable data series designed to keep future options open regarding the exact specification of the key output and input variables. The actual data that would be used in any one productivity study would be, hence, a subset of the overall variable list presented at the end of section 3.

A review of the availability of the identified data series has indicated that some of the higher level data is likely to be currently available to regulators, either in the public domain or in their own regulatory data holdings. Most of the remaining information should be available with the cooperation of utilities and only a small number of variables are likely to be currently unavailable although extensive definitional and comparability issues currently exist.

The best model for future collection, holding and dissemination of data appears to be a process similar to that followed by the URF on service quality statistics. This would involve setting up a consultation process among key stakeholders to reach a consensus on the range of variables included and the definition of each variable. Each regulator would then collect and publish the agreed data set for utilities under its coverage. If some data are considered commercially sensitive then options that allow tiered access to data may be a second best solution.

While a number of consistency issues arise with historic data and care would need to be exercised in the interpretation of results, there appears to be enough data available to make a worthwhile start on transmission and distribution productivity studies. These studies would start off at a higher level using currently available data and give regulators experience with the construction and use of productivity information and its strengths and weaknesses. At the same time these studies could inform the parallel process of consultation on the coverage of required data and the definition of each variable. The highest payoff initially will come from studies looking at transmission and distribution within Australia. Once data and measurement issues have been advanced within Australia, there will be a return from extending comparisons to overseas utilities. At this stage the US and New Zealand appear to offer the best prospects for comparison due to better availability of the necessary data at the firm level.

Regardless of whether productivity information is ultimately used in a move to greater use of incentive regulation or not, it is critical to start the process of data collection and dissemination now. It takes time to develop agreed definitions and to get the necessary collection mechanisms in place but they are an important investment in keeping future regulatory options open. They are also a vehicle for increasing understanding of industry performance. If the process is started now, by the time the next round of regulatory reviews start for the regulatory periods commencing around 2010, several years of reliable data will be available for productivity analysis should regulators wish to consider the use of incentive regulation at that time. If a start is not made now, insufficient data of an agreed and consistent quality will be available at that time to support such a move. The marginal cost of developing the necessary data collection mechanisms is low compared to the option value it provides for future regulatory decision making, quite apart from the other public policy advantages of having such data available.

This report has highlighted the demise of the erstwhile ESAA data series that formed the basis of early Australian electricity industry productivity studies. A major flaw in the Australian infrastructure reform process to date has been the lack of requirements built in to require the supply of key data to independent agencies. This contrasts markedly with practice in the US which actually has a much higher level of private ownership but a much higher level of public data disclosure. The current process offers a chance to redress this situation. The highest payoffs will result from ensuring as much of the data collected as possible – and preferably all of it – is in the public domain.

In moving forward, the following checklist for productivity studies and data collection may prove useful:

- Are all major outputs and inputs included?
- Are all outputs and inputs adequately specified?
- Have the key stakeholders been consulted on model specification and data accuracy?
- Have operating environment differences been allowed for?
- Are the data accurate, consistent and comparable?
- Is the modelling transparent and the data accessible?

Finally, it is important to recognise that productivity measurement in network industries is an evolutionary process. The specification of outputs and inputs is progressively being refined as is the consistency and accuracy of available data. Every productivity study will have some limitations and leave scope for improvement in output and input specification and the data used. However, it is only by making the best use of what is currently available that progress will be made. Waiting for either the perfect data set or the perfect specification of outputs and inputs is nothing more than a recipe for indefinite inaction. The current exercise offers scope for significant advances in this area – but it is imperative to make a start now.

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