Benchmarking Western Power's Electricity Distribution Operations and Maintenance and Capital Expenditure

Prepared for
Western Power Corporation

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AUSTRALIAN CAPITAL TERRITORY NEW SOUTH WALES VICTORIA

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EXECUTIVE SUMMARY

This report discusses the performance of Western Power's distribution operations over the period 1999–2003 compared to 12 other Australian electricity distribution businesses (DBs). The overall project was sponsored by the two Queensland DBs, Energex and Ergon Energy. Participation in the study is conditional on maintenance of data confidentiality. The report for each of the participating DBs compares performance for that DB with the rest of the sample without disclosing the identity of other participants.

We present performance measures covering the following aspects:

- Operating environment features (figures 1 and 2)
- Financial performance (figures 3 and 4)
- Network charges (figures 5 to 7)
- Reliability performance (figures 8 to 13)
- Complaints (figures 14 and 15)
- Total and partial productivity indexes (figures 16 to 19)
- Labour productivity (figures 20 and 21)
- Operating expenditure efficiency (figures 22 to 25)
- Capital stock efficiency (figures 26 to 31)
- Capital expenditure efficiency (figures 32 to 35)

Western Power is a distributor of larger than average size for the sample in terms of throughput, customer numbers and network length. Its mixture of urban and rural coverage gives it an average customer density of 9.8 customers per kilometre of line, 57 per cent below the sample mean of 23 customers per kilometre of line.

Western Power had good financial performance with the highest profit margin and the fourth highest return on assets. The Victorian DBs generally do well on financial measures reflecting the more commercial nature of their ownership structure. Western Power had the fourth lowest average prices in 2003. This was in spite of Western Power's operating conditions which impact strongly on costs and could be expected to increase prices, all else equal.

Western Power had around average reliability performance up to 2002 but a mixed performance in 2003 due to widespread summer storms and bushfires in southwest Western Australia. It had the ninth lowest SAIFI of the included distribution businesses in 2003. In

2001 and 2002 Western Power had the seventh lowest SAIFI for the group and in 2000 it had the sixth lowest SAIFI for the group. Western Power's SAIDI more than doubled from 131 minutes in 2002 to 288 minutes in 2003 to give it a rank of eleventh on this measure. In 2002 Western Power ranked fifth on SAIDI. Its 2003 CAIDI figure was the highest for the group at around 60 per cent above the overall average of 77 minutes off supply. However, in 2002 Western Power ranked sixth and its CAIDI was around 18 per cent above the group average for that year.

The comprehensive efficiency indicator we report in this study is total factor productivity (TFP), which is an index of the ratio of all output quantities (weighted by revenue shares) to all input quantities (weighted by cost shares). Western Power's TFP performance ranks fifth and is around 6 per cent lower than the group average. The Victorian DBs generally tend to do well on this measure. As well as differences in efficiency, this may also in part reflect the fact that they take their power at 66 kV and do not have any 132 kV subtransmission system as found in some of the other states.

On operating and maintenance expenditure (opex) partial productivity (the total output index from the TFP analysis divided by the quantity of opex) Western Power ranks second best out of the 13 included DBs. It had a steady increase in its opex partial productivity over the 5 year period, with an overall increase of 20 per cent which is equivalent to an average annual growth rate of 4.6 per cent. Western Power had the ninth highest capital partial productivity of the 13 included DBs.

Looking at other measures of opex efficiency, Western Power ranked fifth out of 13 on opex per MWh in 2003. The urban based distributors generally perform well on this measure while the predominantly rural based systems incur higher opex per MWh. Western Power had the third lowest opex per network kilometre. The rural based distributors generally perform well on this measure. Western Power ranked third on opex per customer in 2003 reflecting its relatively large customer base.

Just as there are a number of ways of looking at opex efficiency, then the efficiency of the use of the capital stock can also be examined in analogous ways. In this case we use asset replacement cost as the most appropriate measure of the capital stock. This abstracts from differences in average asset age, which will influence DORC based comparisons. Looking at asset replacement cost per kWh generally favours urban based DBs with relatively dense networks. Western Power ranks seventh out of 12. The rural based DBs dominate the replacement cost per network kilometre series and Western Power ranks fourth on this measure. Western Power ranks sixth on the measure of asset replacement costs per customer which generally tends to favour urban based DBs.

1 INTRODUCTION

Benchmarking studies provide an important source of information on the performance of an electricity distribution business (DB) relative to its peers and the associated potential for further efficiency improvements. In this report, Meyrick and Associates ('Meyrick') benchmarks the performance of Western Power Corporation's distribution operations ('Western Power') against 12 other Australian DBs. A comprehensive range of performance indicators has been used to compare the performance of these businesses with one another. The two Queensland DBs, Energex Ltd and Ergon Energy, have sponsored the current study.

Performance benchmarking provides DBs and regulators with a means of assessing whether the DBs are operating as efficiently as possible, whether the DBs are meeting (and will continue to meet) satisfactory reliability and service quality standards and whether cost savings are being passed on to users of the service. At a more detailed level, performance benchmarking can provide answers to the following types of questions:

- Do prices charged appear reasonable?
- Have satisfactory reliability standards been achieved?
- Are response times to service difficulties satisfactory?
- Are customers satisfied with the distributors' service?
- What productivity improvements have distributors achieved?
- Has distributors' return on capital been appropriate or inadequate?
- Are 'X' factors proposed by regulators sensible given past and expected future productivity gains?
- How close are the distributors to best practice?
- What performance improvements would it be reasonable to expect the distributors to achieve based on the observed performance of similar utilities?
- How should we adjust the distributors' measured performance to allow for factors beyond management control?

The following section of the report outlines in broad terms the scope of the study and the performance measurement framework we believe to be appropriate for benchmarking electricity distributors. Section 3 then reports the findings of the performance indicator analysis.

2 PERFORMANCE MEASUREMENT FRAMEWORK

Meyrick have updated and expanded for this report the studies of Australian distributors its staff undertook in 1999, 2000 and 2002. The original 1999 study was sponsored by four of the Victorian DBs and covered 8 DBs in total. In 2000 the Queensland Competition Authority sponsored expansion of the original study to include the two Queensland DBs. In 2002 Power and Water Corporation and the Utilities Commission jointly sponsored a further extension to include the Northern Territory DB. At that time the study covered 11 of the then 18 Australian distributors. The current study has been sponsored by the two Queensland DBs, Energex Ltd and Ergon Energy. It covers 13 of Australia's now 16 electricity distributors. Those included are listed in table 1. Only ACTEW–AGL, Australian Inland Energy and ETSA Utilities are not included in the study.

Table 1: **Australian distribution businesses included in the benchmarking study**

Distribution Business	*Location*
Full survey participants:	
AGLE	Victoria
Aurora Energy	Tasmania
Citipower	Victoria
Energex	Queensland
Ergon Energy	Queensland
Powercor	Victoria
PowerWater	Northern Territory
TXU Networks	Victoria
United Energy	Victoria
Western Power	Western Australia
Included using public information:	
EnergyAustralia	New South Wales
Integral Energy	New South Wales
Country Energy	New South Wales

Ten distributors participated on the same basis as the earlier study by filling in detailed questionnaires for Meyrick. As the data are commercially sensitive, Meyrick has held it in the strictest confidence and we report in a format that does not allow individual distributors to be identified. For this reason, in this report we outline Western Power's results compared to the other DBs, none of which are named. Instead, these DBs are given an alphabetic code in each graph or table, depending on their relative order. Thus, the code changes between graphs so that, for example, DB "A" does not always refer to the same distributor.

The four NSW distributors either did not respond to invitations to participate or declined to participate in the survey. However, sufficient information was available in the public domain as a result of the recent IPART price review to include the three major NSW DBs – EnergyAustralia, Integral Energy and Country Energy – in most graphs.

The results reported generally cover the five years ending 1999–2003. Not all information was available for all distributors so some graphs report results for less than the full sample of 13 and, in some cases, for less than the full five year period for some distributors.

Most of the indicators in this report refer specifically to the pure distribution components of the businesses. It is sometimes difficult to unambiguously identify the distribution network and the boundaries between transmission and distribution systems differ between states. For the purposes of this report, we requested data on sub-transmission (50 to 150kV) and distribution (<50kV) lines and cables and all transformers other than those at the end of transmission lines (ie to include all transformers with primary winding less than 150kV). As a further guide, we noted that distribution systems generally are operated radially, connecting transmission bulk supply points to individual customers. Thus, we asked distribution businesses to include all inputs, outputs and other specified data associated with owning, operating, maintaining, planning and designing but not constructing the network. However, differences in boundaries between transmission and distribution entities between states mean that the responding DB has not always had either responsibility for or access to data for the full range of operations requested. Consequently, data for some DBs may reflect a different historical boundary relative to transmission.

Western Power has endeavoured to supply data for its distribution operations based on the National Electricity Market definitions.

In implementing CPI–X regulation, state regulators allow the DBs to raise sufficient revenue to cover operating costs, finance necessary new investment and provide an adequate return on past investment efficiently undertaken, all subject to an estimate of reasonable future productivity improvements expected of an efficiently run business. At the same time, revised and updated reliability and service quality standards are generally specified to protect consumers. To address these issues, we provide a performance measurement framework covering the following aspects:

- Operating environment features (figures 1 and 2)
- Financial performance (figures 3 and 4)
- Network charges (figures 5 to 7)
- Reliability performance (figures 8 to 13)
- Complaints (figures 14 and 15)
- Total and partial productivity indexes (figures 16 to 19)

- Labour productivity (figures 20 and 21)
- Operating expenditure efficiency (figures 22 to 25)
- Capital stock efficiency (figures 26 to 31)
- Capital expenditure efficiency (figures 32 to 35)

Such a suite of performance indicators establishes the relative performance of the distribution businesses across major facets of their businesses. It also provides an opportunity to examine the priorities and trade-offs of the various distributors, for example comparing different indicators such as price with reliability and productivity with cost.

Most regulators place great emphasis on reliability and this is likely to increase in the future. For this reason, we have collected data on the major reliability measures used by electricity distributors. Given that a major source of complaints about electricity suppliers' performance comes from the public's direct dealings with DBs, regulators are keen to ensure that good customer service standards are achieved to minimise criticisms of industry performance.

Another key aspect of implementing CPI–X regulation relates to productivity levels. Costs will be allowed or reimbursed on the basis of efficient practice. Estimates of likely future achievable productivity gains will be the key determinant of 'X'. Judgements about 'efficient' costs are often made on the basis of direct comparison with comparable best practice utilities. In the short term, judgements about achievable productivity gains in future years will be heavily influenced by recent changes in productivity performance.

Consequently, our performance measurement framework must capture productivity performance across the main drivers of costs: directly employed and contract labour, materials and services, fixed assets and capital expenditure. This is done by incorporating a range of partial productivity indicators where operating and maintenance expenditure (opex), capital replacement costs and capital expenditure are normalised on a number of different bases including throughput, network kilometres, customer numbers and peak demand.

As well as the various partial productivity and financial measures outlined above, it is also important to incorporate 'comprehensive' or summary performance indicators. These indicators keep the focus on the operation of the distribution business as a whole and help to keep the interpretation of the individual partial measures in context.

Total factor productivity (TFP) is the preferred comprehensive efficiency indicator. It combines labour, capital and materials and services partial productivities into an overall productivity measure which tracks changes in the quantity of total output relative to the quantity of total inputs. TFP mainly tracks changes in quantities, or 'real' changes which are more likely to be under managers' control. By measuring productivity relative to all inputs, TFP avoids the problems of partial indicators such as labour productivity which can give a misleading picture due to changes in the mix of inputs (eg we can observe very high increases in labour productivity when capital is substituted for labour but to assess whether productivity has improved overall we need to look at the productivity of labour, materials and services and capital combined). TFP has been used overseas to determine the 'X' factor in CPI – X price cap regimes, including in the New Zealand Commerce Commission's (2003) recent decision.

We include three outputs in the TFP analysis – energy throughput in gigawatt–hours, the capacity of the system in MVA–kilometres and the number of customers. The MVA–kilometres output is 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 capacity. This three output specification has the advantage of incorporating key features of the main density variables (customers per kilometre and sales per customer) which drive distributors' costs and, thus, goes a large way towards adjusting for differences in operating environments. There are five inputs included in the TFP study – operating and maintenance expenditure, overhead lines, underground lines, transformers, and other capital.

Taken together, the areas covered by the framework enable effective benchmarking of the many facets of electricity distributor performance.

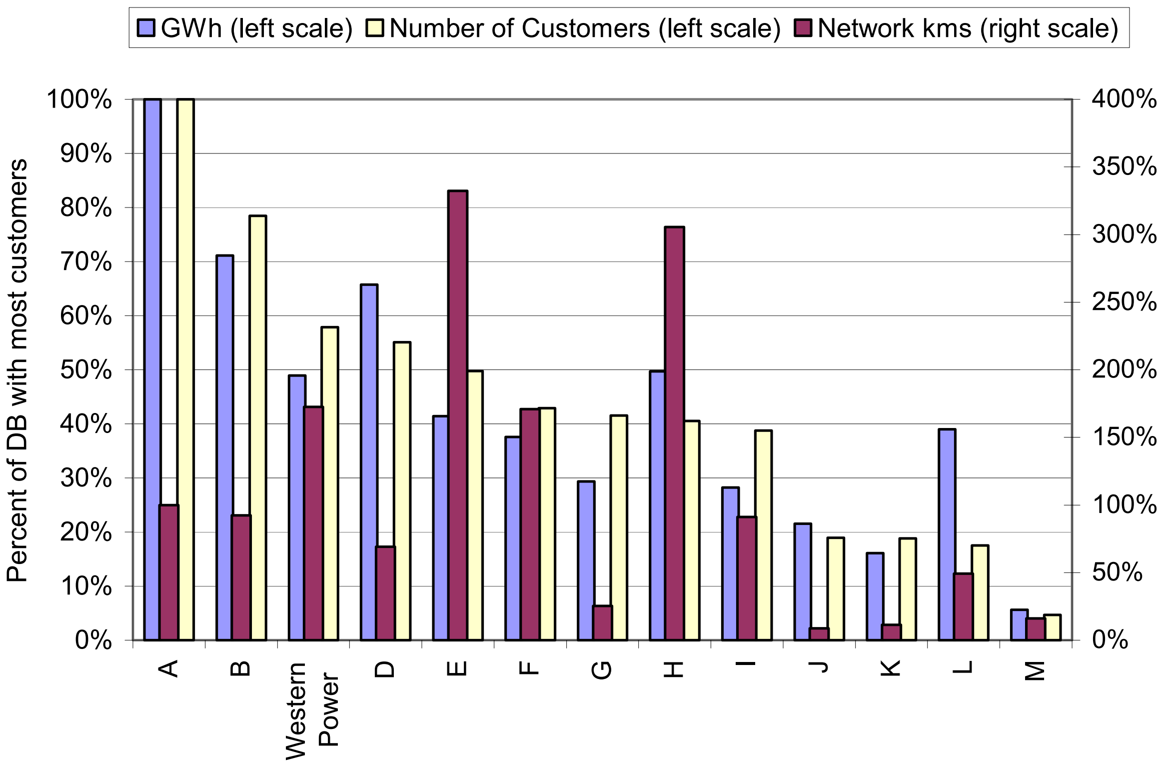
3 PERFORMANCE INDICATORS

3.1 Operating environment features

The 13 included Australian distribution businesses operate in varying environments, with often substantial differences in the size of the network, the amount of throughput, number of customers, split between rural, urban and CBD customers and between residential and business customers as well as growth in demand.

Western Power is a larger than average size distributor in terms of throughput (GWh) compared to the other 12 included distribution businesses. It supplied the fifth highest amount of power in 2003 at around 12,300 GWh, which was 15 per cent above the group average of 10,700 GWh. Figure 1 shows Western Power's relative throughput, number of customers and network kilometres compared to the other 12 included distributors, indexed so that Distribution Business A (which has the highest number of customers) equals 100 in each case.

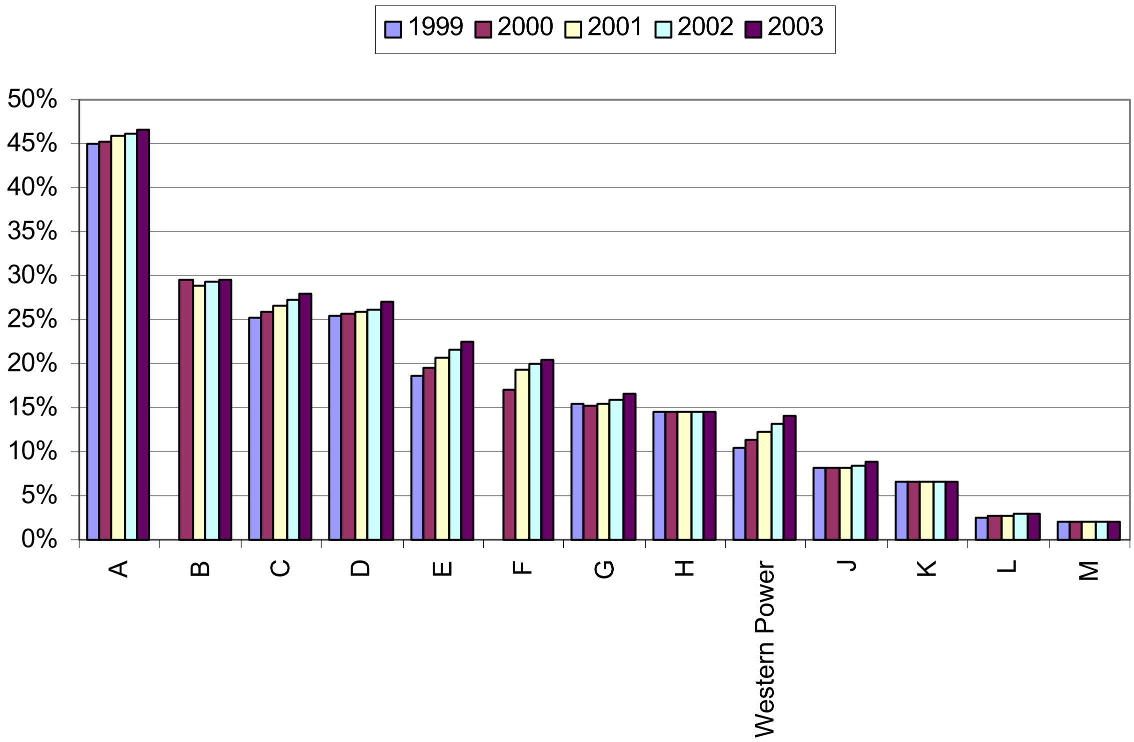
Figure 1: **Key features of the operating environment, 2003**



Western Power had the third largest customer base, with almost 825,000 customers compared to an average of 635,000. Western Power had the fourth lowest throughput per customer or energy density of the 13 DBs.

Western Power provided around 84,000 circuit kilometres of line giving it the third highest network length. This resulted in Western Power having the fifth lowest customer density (customers per kilometre of line) of the 13 DBs. Its customer density of 9.8 customers per kilometre of line was 57 per cent below the sample average of 23 customers per kilometre of line. This relatively sparse nature of the Western Power system provides particular challenges for achieving reliability and service quality targets.

Figure 2: **Share of underground by circuit length, 1999–2003**



As it has a large rural and metropolitan network as well as servicing the Perth CBD, Western Power has a below average proportion of underground cable as a proportion of total network kilometres (ie of underground plus overhead circuit kilometres). Figure 2 shows that 14 per cent of Western Power's circuit kilometres comprised underground cables, the fifth lowest of the 13 included distributors. Generally speaking, a higher share of underground cable will improve reliability and maintenance cost but add to capital cost per kilometre of line.

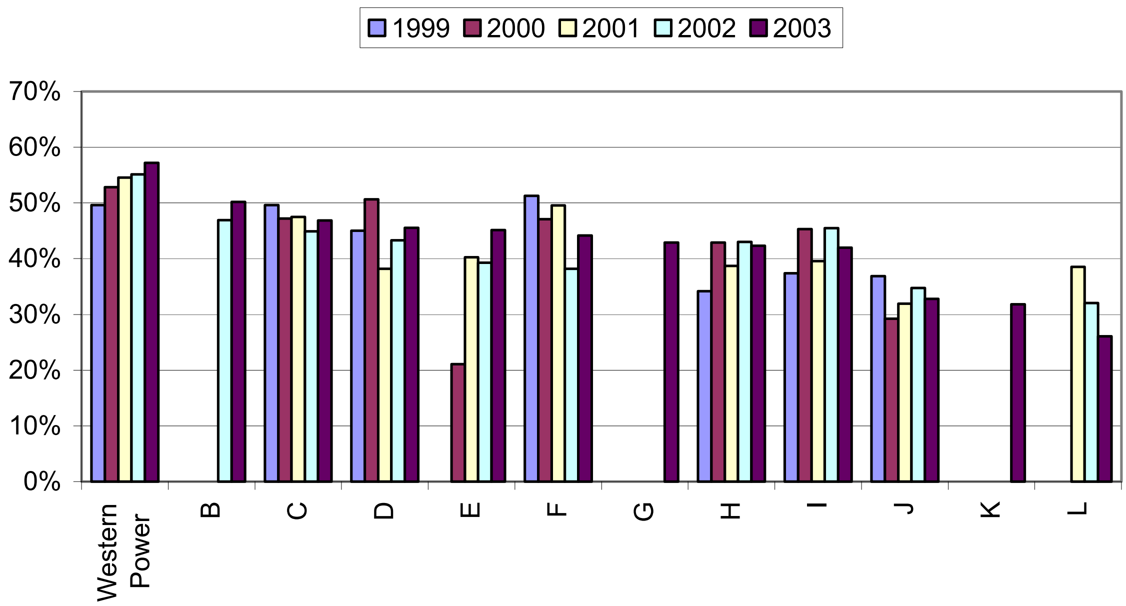
3.2 Financial performance

We begin the performance comparisons by examining the relative financial performance of Western Power's distribution operations. While data to support a range of financial indicators were requested in the survey, the data actually supplied by distributors varied considerably reflecting different ownership structures. To maximise the extent of comparability across the distribution businesses, we report indicators of net profit margins and return on assets.

Net profit margin is defined as earnings before interest and tax (EBIT) divided by total revenue (figure 3). It is a commonly used measure of profitability and one that is relatively easy to calculate. Earnings include those revenues and costs associated with core electricity distribution (eg Distribution Use of Service (DUOS) charges).

Most Australian DBs face reasonably similar price determination structures, with prices initially set to obtain a reasonable rate of return and then subject to CPI–X provisions thereafter. However, in moving to these types of systems elements of cross–subsidy have remained between various divisions within organisations often involving different allocations of costs to distribution and other functions. Mainly for these reasons, the 13 included systems have recorded quite a wide variation in net profit margin over the last 5 years.

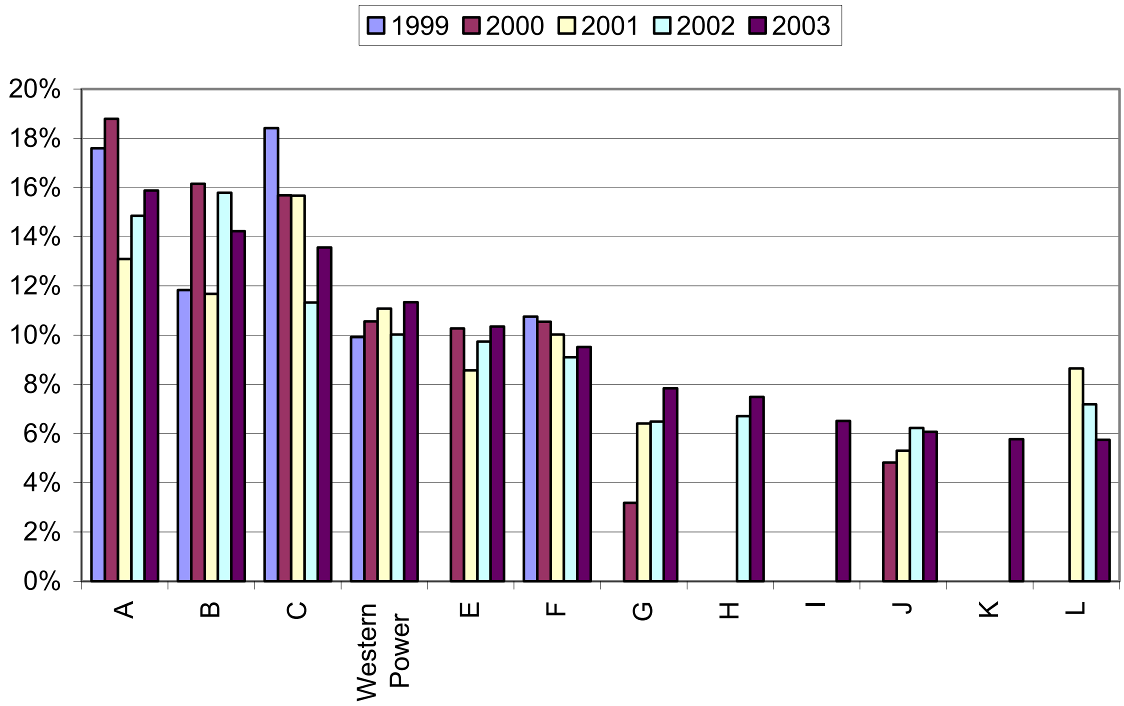
Figure 3: **Net profit margin (EBIT / total revenue), 1999–2003**



At 57 per cent in 2003, Western Power's net profit margin was the highest of the included distributors and over one third above the group average.

Return on assets is defined as EBIT divided by average total assets (figure 4). In this instance we take the depreciated optimised replacement cost (DORC) as the measure of asset value to maximise consistency across the DBs. This is one of the most important measures of profitability and provides a basis for comparing profitability across industries – although allowance has to be made for different levels of risk faced.

Figure 4: **Return on assets (EBIT / total assets at DORC valuation), 1999–2003**



Western Power's return on distribution assets was the fourth highest of the 13 included distribution businesses at 11.4 per cent in 2003. This was an improvement on its rate of just under 10 per cent in 1999. It should be noted, however, that differing importance of and differing treatment of customer contributions across jurisdictions makes comparisons of rates of return on assets on a completely like–with–like basis difficult.

We also asked for data to calculate return on equity, defined as operating profit before tax and after abnormals divided by total equity. However, many of the 13 included businesses were not able to easily calculate this measure for their pure distribution activities. This problem was exacerbated by the varying types of ownership, with some businesses government owned, some publicly listed and others part of larger vertically integrated utilities. Given the problems in obtaining consistent data on the value of equity in the pure distribution businesses, we have not reported return on equity.

3.3 Distribution network charges

The price charged for distribution services is defined as the DUOS revenue from the provision of distribution services to key customer groups (eg residential, industrial, commercial and rural) divided by the total energy delivered to that group.

Figure 5: **Network DUOS charges (cents per kWh), 1999–2003**

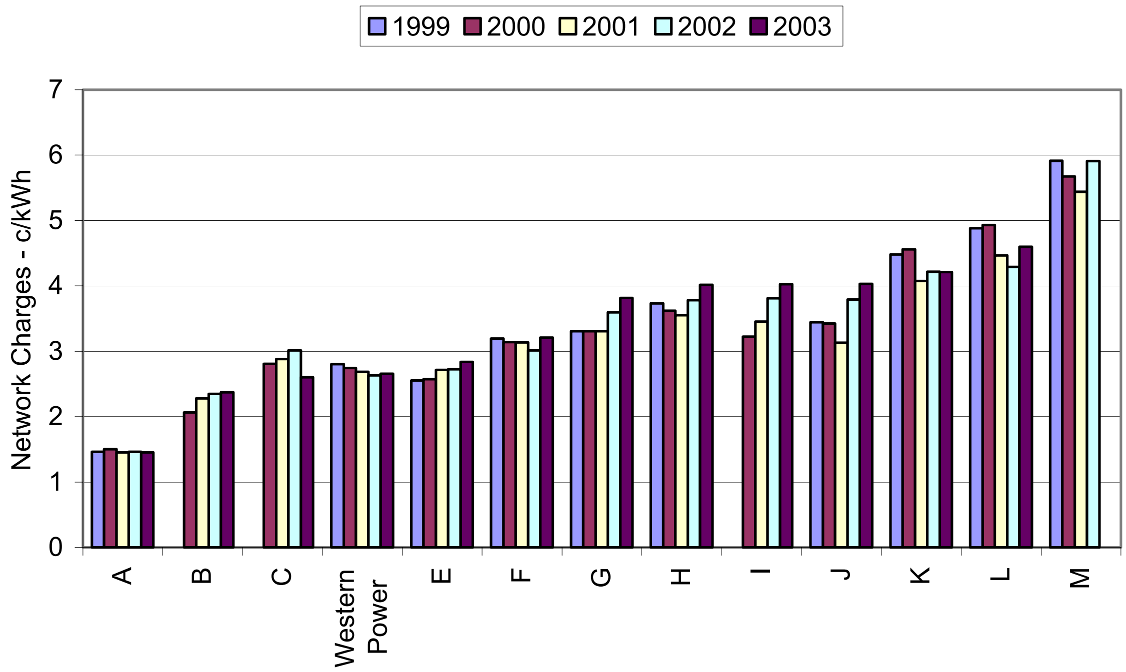


Figure 6: **DUOS charges for domestic/commercial/small Industrial (c/kWh), 1999–2003**

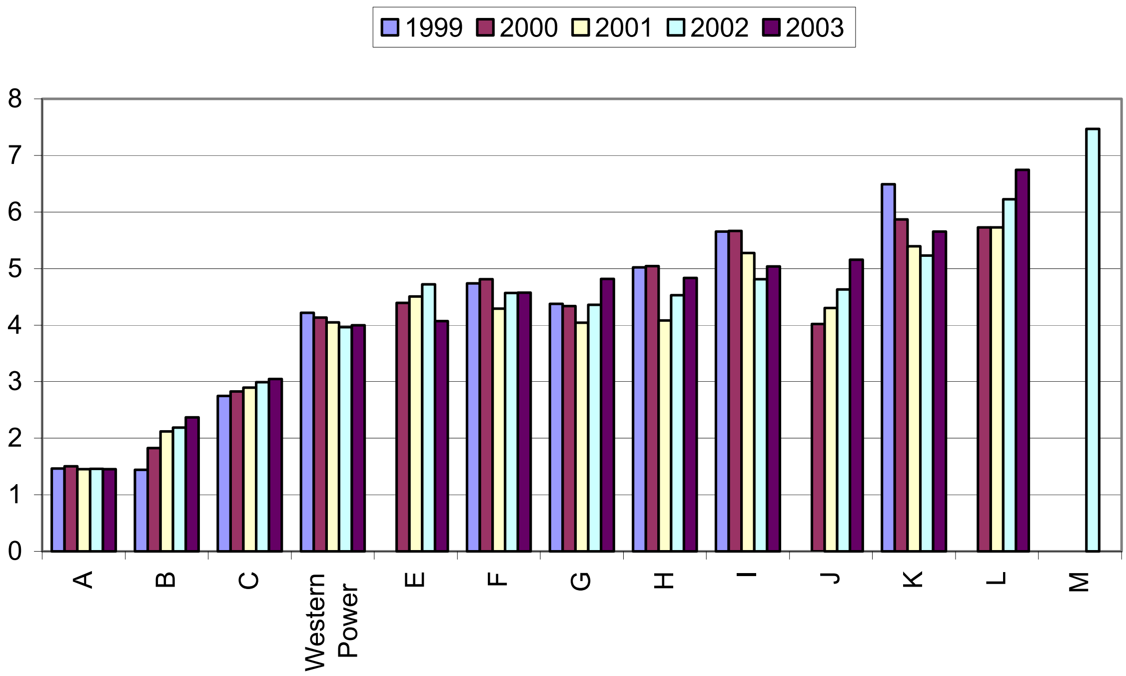
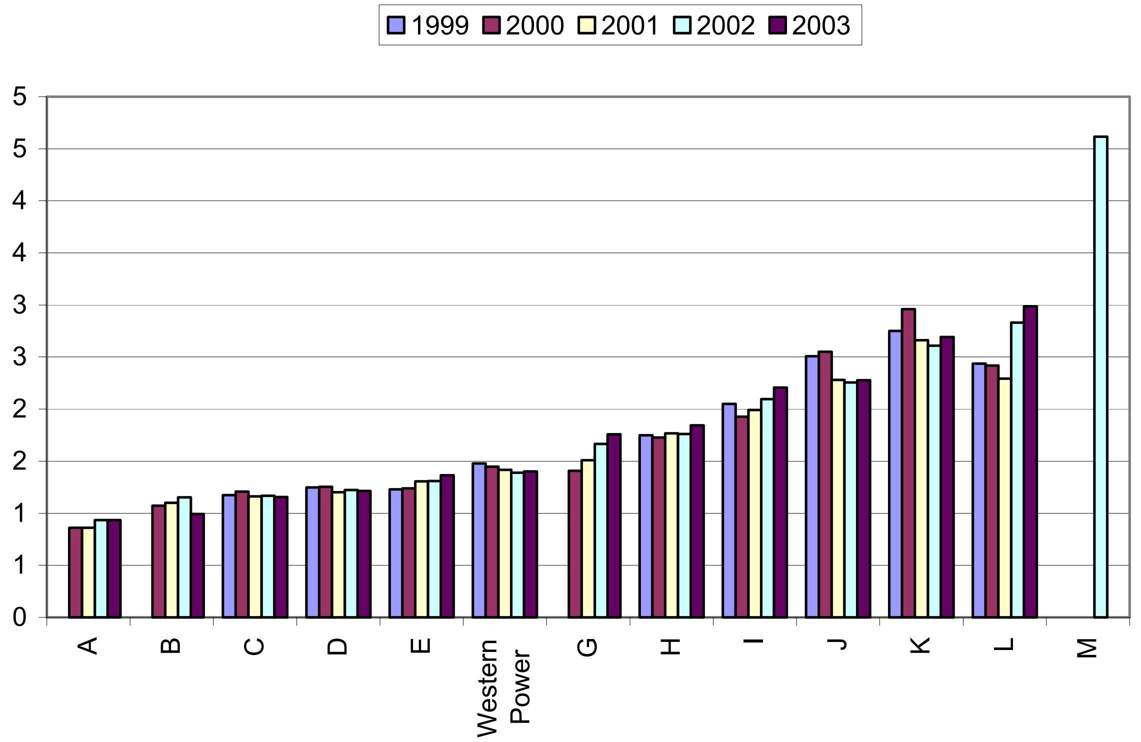


Figure 5 shows that, across all customers, Western Power's prices were below average for the included distribution businesses with Western Power ranking fourth out of 13. This was in spite of Western Power's operating conditions which impact strongly on costs and could be expected to increase prices, all else equal.

Figure 7: **DUOS charges for large industrial and other customers (c/kWh), 1999–2003**



As different DBs have a different mix of customers, with industrial and commercial customers typically charged less per kilowatt hour than domestic (or residential) customers, we asked for data by this disaggregation. However, with the separation of distribution and retail functions, most distributors now have limited information on the type of customers supplied other than their demand and consumption and are unable to readily distinguish between, say, large commercial and small industrial customers. In the end, many distributors could not provide a full break–up of sales to different customer classes but were able to provide reliable data on prices for a combination of domestic, commercial and small industrial customers (Figure 6) and a combination of large industrial and other customers (Figure 7).

Western Power also charged the fourth lowest average price to its combined domestic, commercial and small industrial customers among the included distribution businesses. As expected, the more rural based distributors generally charged more than their urban–based counterparts. Western Power charged the sixth lowest average price to its combined large industrial and other customers within the sample.

3.4 Reliability

Distributors typically collect many indicators of reliability for internal use and consideration by regulators. We report four of the most common measures:

- SAIFI;
- SAIDI;
- CAIDI; and
- customer interruptions not fixed within two hours.

We also collected data on momentary interruptions and on customer interruptions not fixed within twelve hours. However, we do not report these due to a lack of consistent data.

3.4.1 Sustained interruptions per customer (SAIFI)

SAIFI is defined as the total number of sustained customer interruptions divided by the average of the total number of connected customers at the beginning and end of the period. The index excludes momentary interruptions, such as interruptions restored by autoreclosures. Many of these incidents are still not captured in reporting systems and their inclusion would invalidate wider comparisons.

SAIFI, as defined above, is an internationally recognised index and thus permits comparisons with utilities worldwide (subject to using similar definitions and measurement systems). The index reported includes interruptions from distribution causes only and excludes those arising from the generation and transmission systems. Most DBs have supplied information on a post–exclusions basis so that the effects of exceptional natural or third party events which the DB could not have been expected to mitigate through prudent asset management are excluded.

Western Power had around average reliability performance up to 2002 but a mixed performance in 2003 due to widespread summer storms and bushfires in southwest Western Australia. It had the ninth lowest SAIFI of the included distribution businesses in 2003, with a value around 11 per cent higher than the average for the group (figure 8). In 2001 and 2002 Western Power had the seventh lowest SAIFI for the group and in 2000 it had the sixth lowest SAIFI for the group.

With only one exception, the distributors with an above average SAIFI in 2003 were all rural based. In figure 9 we present an alternative measure of interruption frequency where customer interruptions are normalised by the total circuit kilometres of overhead line and underground cable. This normalisation recognises that those DBs with longer line lengths face a higher exposure to risks that can cause outages. On this measure the rural based distributors perform better than their urban counterparts. Western Power ranked fifth best on this measure in 2003, with a value around 40 per cent lower than the average for the group.

Figure 8: **SAIFI (planned & unplanned) due to distributor only, 1999–2003**

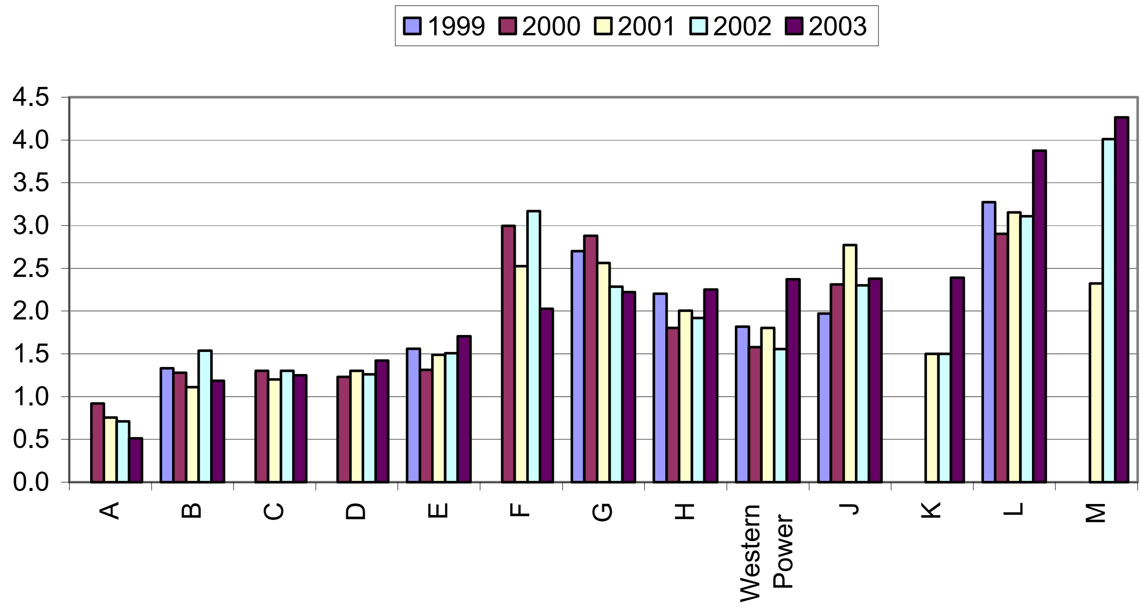
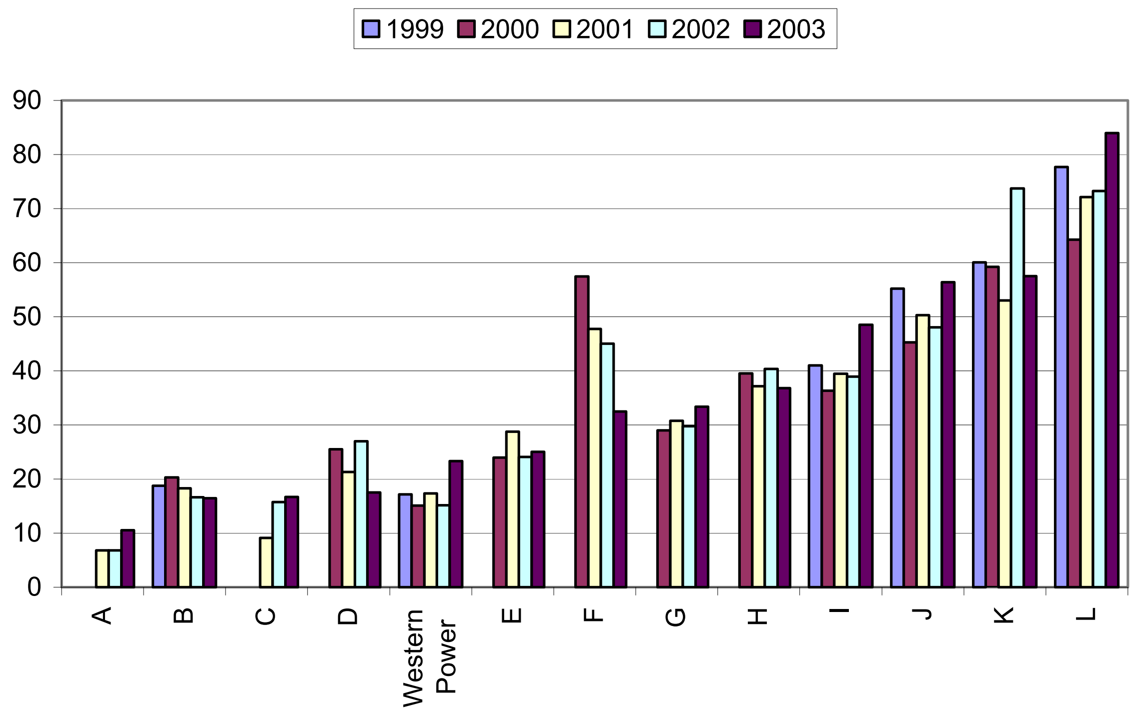


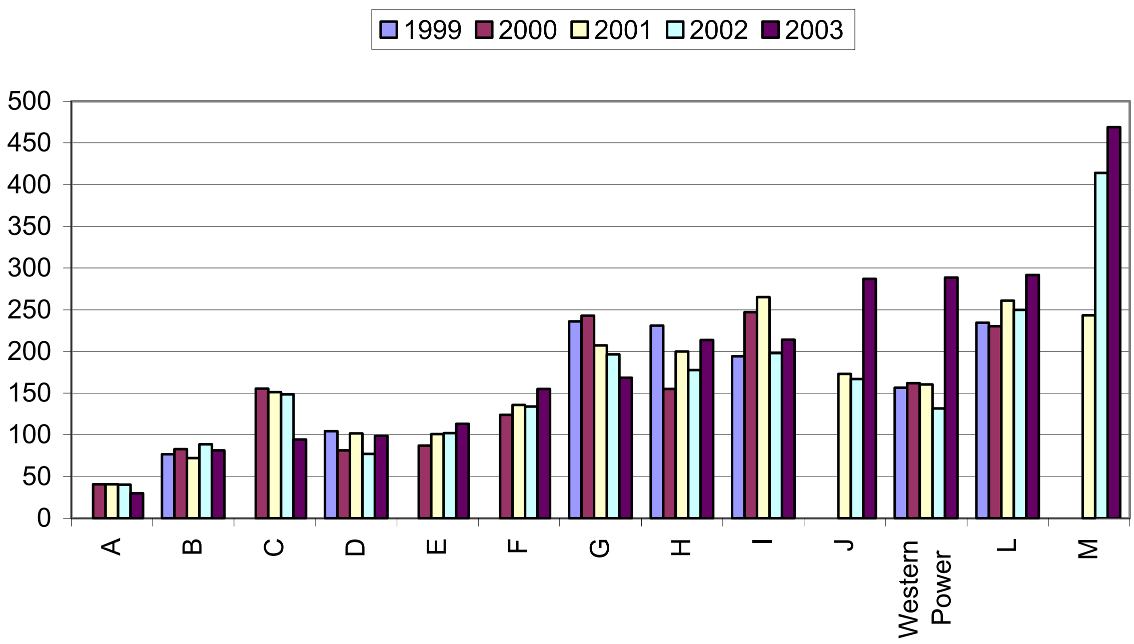
Figure 9: **Number of Interruptions per kilometre of total overhead and underground system length due to distributor only, 1999–2003**



3.4.2 Customer minutes off supply (SAIDI)

Western Power had around the average number of minutes off supply per customer compared to the other included distribution businesses up to 2002, but ranked eleventh in 2003 (figure 10). We measure this by SAIDI, the system average interruption duration index. This is sum of the duration of each sustained customer interruption (in minutes) attributable solely to distribution (post exclusions) divided by the average of the total number of connected customers at the beginning and end of the period. Again, this is an internationally recognised index and is the sum of planned and unplanned interruptions.

Figure 10: **SAIDI (planned & unplanned) due to distributor only, 1999–2003**



Western Power's SAIDI more than doubled from 131 minutes in 2002 to 288 minutes in 2003 due to the impact of the severe summer storms and bushfires. In 2002 Western Power ranked fifth on SAIDI.

3.4.3 Average duration off supply (CAIDI)

CAIDI is the sum of the duration of each sustained customer interruption duration (in minutes) divided by the total number of sustained customer interruptions. It is, thus, the length of the average interruption faced by the average customer. It is the ratio of SAIDI to SAIFI. CAIDI is less widely used internationally than SAIFI and SAIDI but it does form a useful index of restoration times.

Figure 11: **CAIDI (planned & unplanned) due to distributor only, 1999–2003**

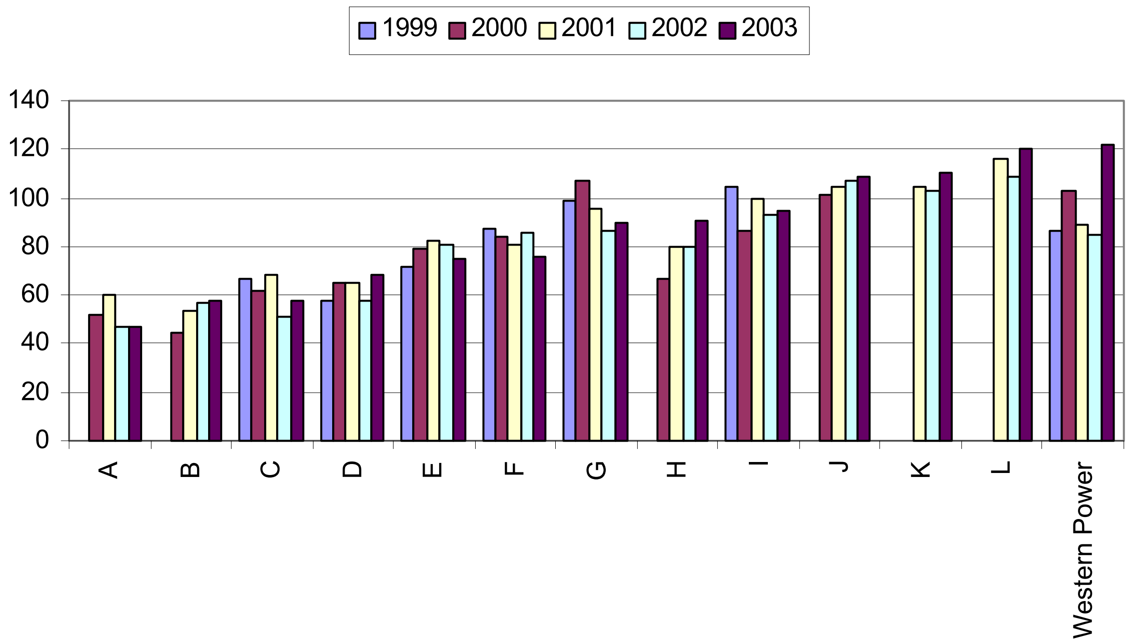
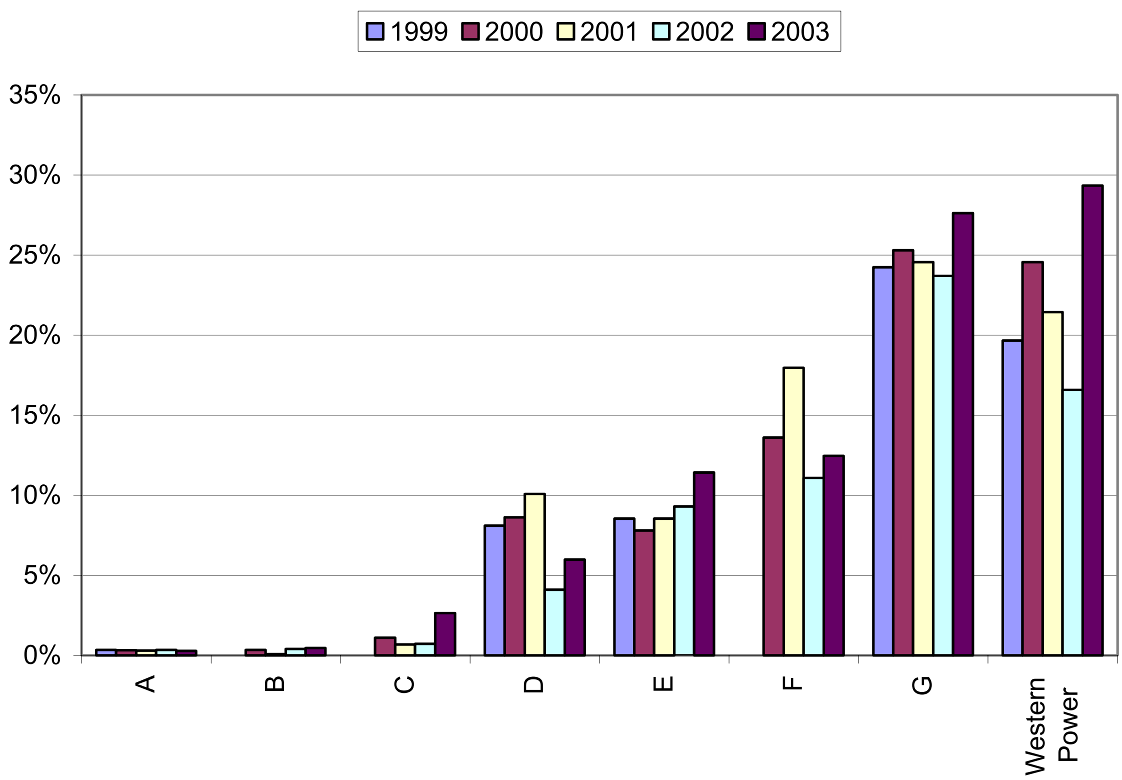


Figure 12: **Proportion of interruptions not restored within 2 hours, 1999–2003**



Western Power had marginally the worst performance on this measure out of the 13 distributors in 2003 (figure 11) due to the adverse impact of the severe summer storms and bushfires that year. Western Power's 2003 CAIDI figure was around 60 per cent above the overall average for the group of 77 minutes off supply. However, in 2002 Western Power ranked sixth and its CAIDI was around 18 per cent above the group average for that year. Unlike SAIDI and SAIFI, there was a mixture of rural and urban based distributors in the longer average interruption half of the sample.

3.4.4 Supplies not restored within 2 hours

The proportion of interruptions not restored within 2 hours is presented in figure 12 for the limited sample of 8 distributors who supplied this information. Western Power had the highest proportion of supplies not restored within 2 hours in 2003 among the limited sample. However, its proportion of supplies not restored within 2 hours increased by around three quarters between 2002 and 2003 due to the fires and storms experienced in 2003.

3.5 Service quality

The service quality measures we examine are the number of voltage excursion events per thousand kilometres of line, the number of complaints per thousand customers and the number of complaints per thousand system kilometres. Information on service quality was the least complete across most DBs and a general area for improvement in future reporting.

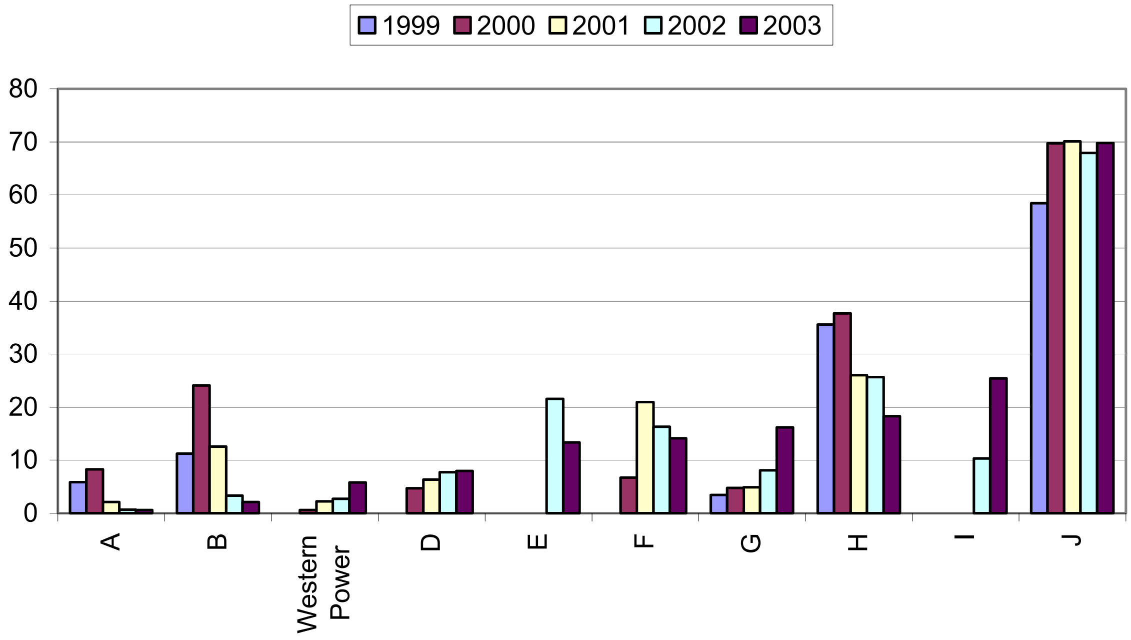
3.5.1 Voltage excursion events per thousand kilometres of line

This indicator measures the number of voltage excursion events due to problems with the distribution system only. A voltage excursion event occurs where the voltage falls outside the limits specified in the Distribution Code and results in at least one customer complaint. As such, this includes both over–voltage and under–voltage events. Line refers to wires and cables comprising the distribution network.

We should stress that this data is taken from the complaints recording databases of the various distribution businesses and, ideally, should refer to verified events. However, there is considerable variation in the coverage and accuracy of these systems between DBs and due to the inherent difficulty in actually verifying each complaint, we use all relevant complaints instead as the nearest available proxy.

Bearing these caveats in mind as well as its longer line length, Western Power ranked third on the number of complaints about variable power supply per thousand kilometres of line of the 10 distributors who reported figures (figure 13).

Figure 13: **Voltage excursion events per 1000 km of system length, 1999–2003**



3.5.2 Number of complaints

As with reliability indicators, DBs have many alternative measures of complaints. We have chosen those most commonly recorded by Australian distribution businesses, measuring total complaints as the sum of those relating to:

- connection and augmentation;
- quality and reliability of supply; and
- others concerning distribution.

The first element measures the number of complaints about the quality and timeliness of new connections and about the cost, timeliness, and quality of augmentation works. The second measures the number of complaints concerning unreliability of supplies and the quality of supply, including perceived voltage excursion events. The last measure captures the number of all other complaints received concerning the distribution business. These are summed and expressed relative to the total number of customers, measured in thousands, in figure 14 and relative to line length, measured in thousands of system kilometres, in figure 15.

Figure 14 indicates that Western Power had the sixth lowest number of complaints per thousand customers of the 13 included distributors in 2003. Recognising Western Power's relatively long line length and associated exposure to potential sources of outages by normalising by line length in figure 15 leads to it having the third best ranking in 2003.

Figure 14: **Total complaints per thousand customers, 1999–2003**

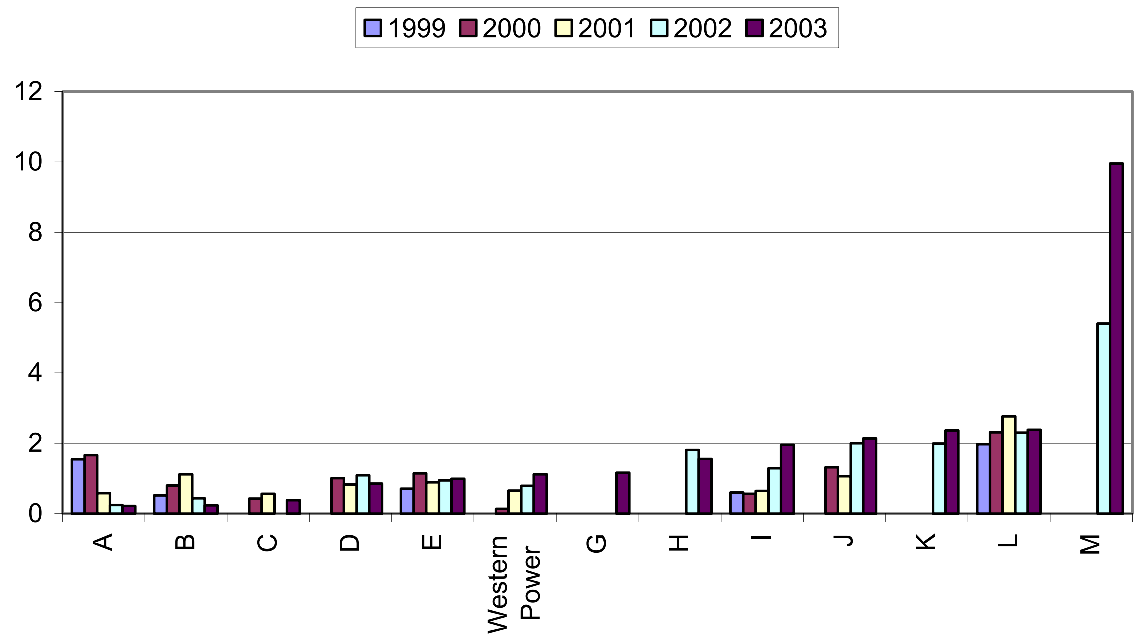
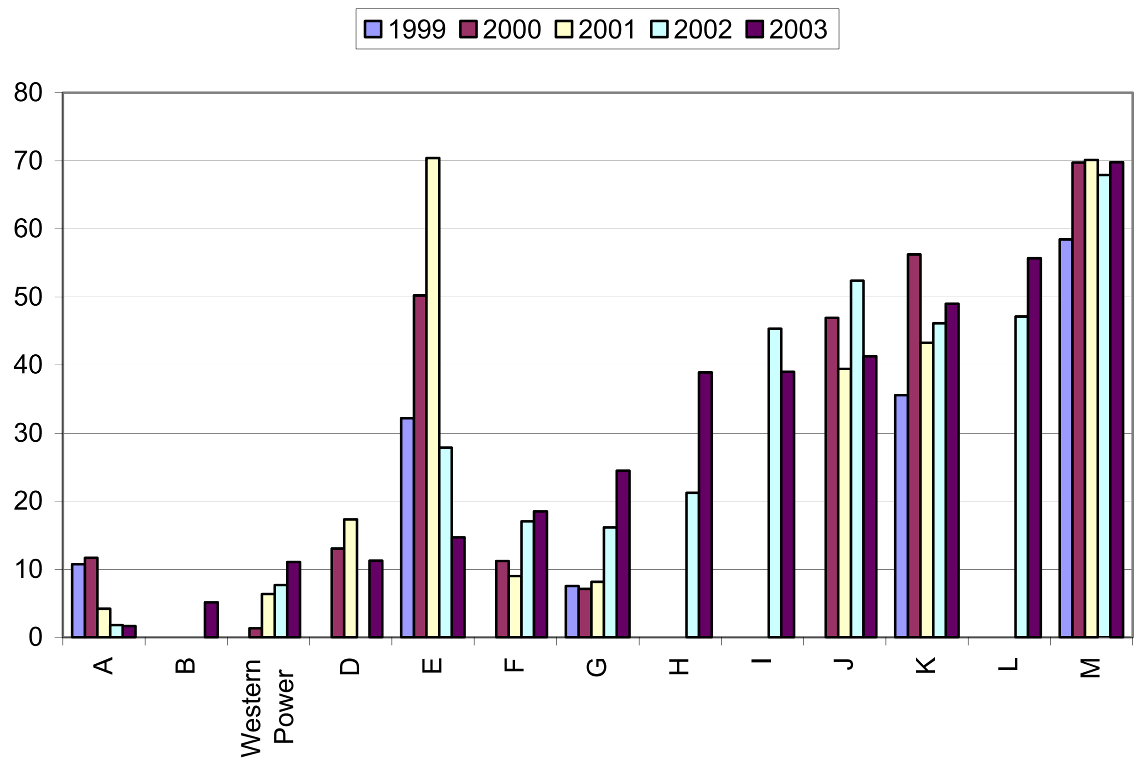


Figure 15: **Total complaints per thousand system kilometres, 1999–2003**



3.6 Multilateral total factor productivity

There are a number of important comprehensive efficiency indicators which look at the operations of the DB as a whole. The comprehensive indicator we report in this study is total factor productivity (TFP), which is an index of the ratio of all output quantities (weighted by revenue shares) to all input quantities (weighted by cost shares).

The main challenge in calculating TFP for a 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. 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 distributor's total revenue. This approach essentially treats the distribution system in an analogous fashion to a pipeline and was a common approach of early studies of electricity distribution using TFP or other comprehensive indicators. It simply concentrates on the demand for the final product delivered by the distribution network. However, there are other important dimensions to a distributor's output 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 system (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 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.

In previous work on distribution efficiency we have estimated both supply side and demand side output models. In the Australian context, the 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 (2003a,b) we have further advanced the 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 – the equivalent of local access roads in the roads analogy). This three output specification has the advantage of incorporating key features of the main density variables (customers per kilometre and sales per customer).

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 is available. However, previous attempts to include reliability measures as a fourth output have proven unsuccessful due to the way output is measured. 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. Given these difficulties we omit service quality as an explicit output in this study.

The distribution productivity analyses reported contain the following three outputs and five inputs.

Output quantities

Throughput: The quantity of the distributor's throughput is measured by the number of gigawatt hours of electricity supplied. This is similar to the output measures used in most early TFP studies of distribution.

System line capacity: The quantity of the distributor's system capacity is measured by its total MVA kilometres. The MVA kilometres measure seeks to provide a more representative measure of system capacity than either line length alone or the simpler kilovolt kilometres measure. The conversion factors used are the same as those used by Meyrick and Associates (2003b) which are based on an engineering assessment by Parsons Brinckerhoff Associates (2003). They reflect the fact that the effective capacity of an individual line depends not only on the voltage of the line but also on a range of other factors, including the number, material and size of conductors used, the allowable temperature rise as well as limits through stability or voltage drop.

Connections: Connection dependent and customer service activities are proxied by the distributor's number of connections.

Output weights

To aggregate a diverse range of outputs into an aggregate 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. Instead we use the estimated output cost shares derived from an econometric cost function. The most relevant Australasian study available is that of Meyrick and Associates (2003a,b) which estimates a cost function for a relatively large database of New Zealand distributors. This produces an output cost share for throughput of 22 per cent, for system line capacity of 32 per cent and for connections of 46 per cent.

Total distributor revenue is taken to be DUOS charges – transmission fees are excluded.

Input quantities

Operating expenditure: The opex cost covers distribution activities only and excludes all capital costs and transmission fees. It includes all directly employed labour costs, contracted services and materials and consumables costs associated with operating and maintaining the distribution service. The quantity of the distributor's opex is derived by deflating the opex series by the consumer price index.

Overhead network: The quantity of poles and wires input in the overhead network is proxied by the distributor's overhead MVA kilometres. At this point in time there is inadequate information available to use the alternative indirect measure of a constant price asset value for poles and wires.

Underground network: The quantity of underground cables input is proxied by the distributor's underground MVA kilometres. Again, at this point in time there is inadequate information available to use the alternative indirect measure of a constant price asset value for underground cables.

Transformers: The quantity of transformer inputs is proxied by the MVA of the distributor's installed transformers.

Other assets: The quantity of other capital inputs such as computers and control systems, etc is proxied by their real depreciated optimised replacement cost (DORC). The price of other assets is assumed to be the consumer price index.

Input weights

The value of total costs is formed by summing the estimated value of opex and 12.5 per cent of total DORC (or the nearest available asset value measure). We assume a common depreciation rate of 4.5 per cent and an opportunity cost rate of 8 per cent for capital assets. Input weights were then formed from the share of the cost of each of the five inputs in total cost.

Indexing method

For benchmarking purposes we need to use a TFP indexing method that allows us to compare productivity levels as well as growth rates. In this study we use the multilateral total factor productivity (MTFP) index originally developed by Caves, Christensen and Diewert (1982). The technical features of this index are briefly described in the appendix. The MTFP index has some important advantages. It is a robust technique which is relatively insensitive to data anomalies, does not require a large number of observations, provides information on productivity levels as well as growth rates and its basic operation can be readily communicated.

With the index number MTFP approach there is scope to partly capture density related operating environment conditions by the specification of multiple outputs. Incorporating both the energy delivered and network capacity measures of distribution output leads to a more even–handed treatment of urban and rural distributors. By choosing multiple outputs such as energy delivered, MVA–kilometres and connection numbers, it is possible to incorporate aspects of density such as customers per kilometre and energy delivered per customer into the MTFP measure directly in an analogous fashion to how this is captured in multiple output econometric cost functions.

3.6.1 MTFP results

In making MTFP comparisons (and, indeed, all efficiency comparisons) it is important to ensure that a like range of operations are being compared. This continues to be a challenge in electricity distribution where different historical developments between jurisdictions have led to different boundaries between distribution and transmission and different power transformation structures within distribution. Consequently, distributors who take their power from transmission service providers at lower voltages and, hence, have less subtransmission network and who are able to transform power to distribution voltages in one step rather than multiple steps will be advantaged in efficiency comparisons. This is because their distribution network will appear to be using fewer inputs to deliver the same output. However, this may in part reflect the fact that some inputs being classed as belonging to distribution in other jurisdictions are classed as being outside the distribution network for this distributor.

Similarly, the ability to have a single rather than multiple transformation steps may reflect the historical development of the system and be largely outside the control of current managers.

Another area of ambiguity is assets owned by the customer. Some large customers may own their distribution transformers while the DB owns those supplying other customers. Ideally we need to have all the distribution transformers included regardless of who owns them to allow like–with–like comparisons. While we have attempted to get common treatment in this study, this has not always been possible due to data limitations.

Figure 16: **Multilateral total factor productivity indexes, 1999–2003**

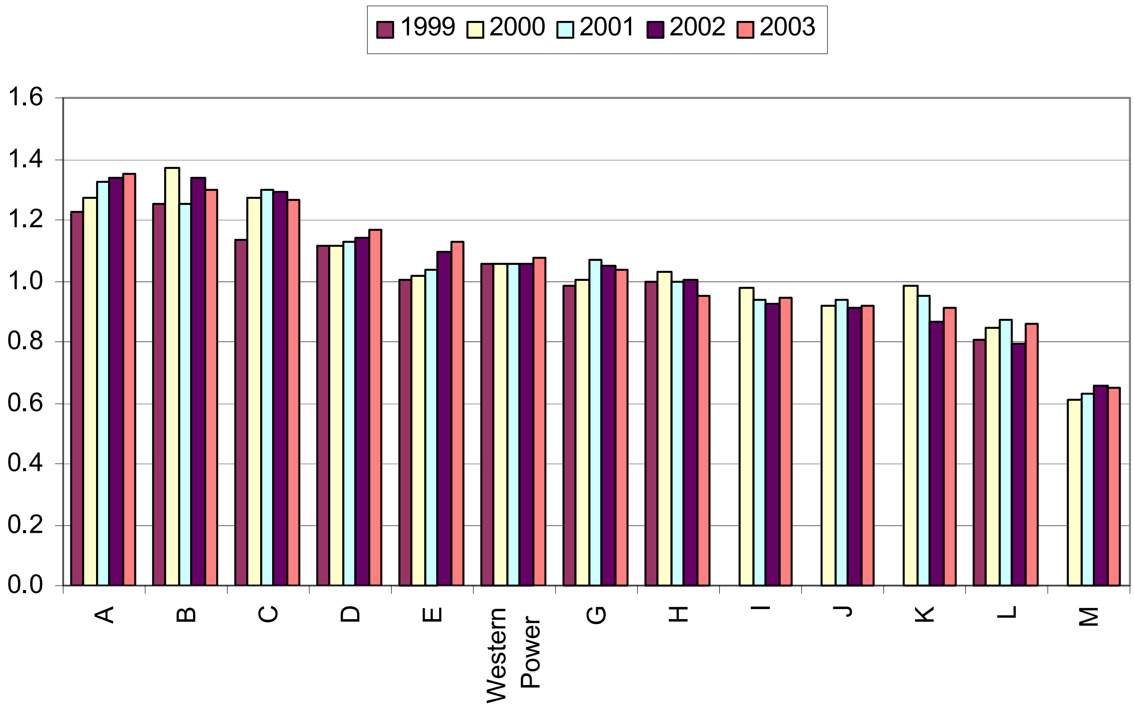


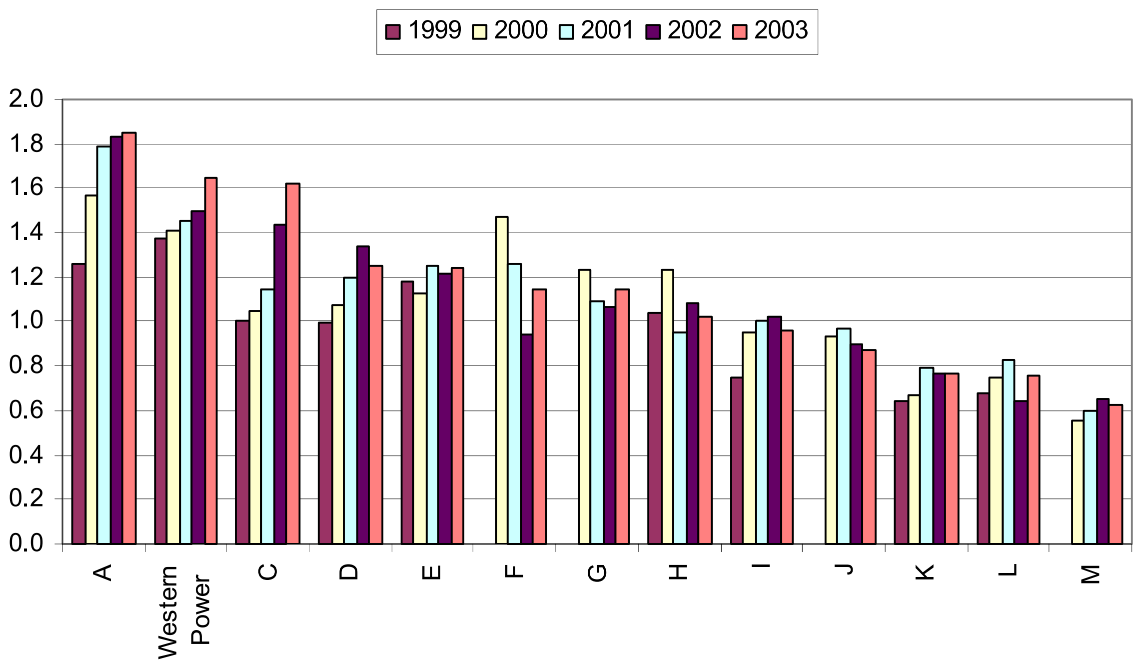
Figure 16 presents the results of the MTFP analysis. The distributor which appears to perform best on this measure has considerably narrower distribution boundaries than its peers, taking its power at lower voltage and owning fewer zone substation assets. While we have attempted to include a comparable amount of zone substation transformer capacity, it will still have an advantage due to its narrower voltage coverage. Consequently, it is not a good comparator for the other DBs but has been included in figure 16 for completeness. Its exclusion leaves Western Power as the fifth best performer on this measure.

Western Power's MTFP performance is around 6 per cent lower than the group average excluding DB 'A'. The Victorian DBs generally tend to do well on this measure. As well as differences in efficiency, this may also in part reflect the fact that they take their power at 66 kV and do not have any 132 kV subtransmission system as found in some of the other states.

3.6.2 Opex partial productivity

As well as comparing total outputs with the use of total inputs, we can also compare total outputs with the use of particular input components. In figure 17 we present the partial productivity of opex inputs which is the multilateral total output index divided by an index of opex quantities.

Figure 17: **Operating and maintenance partial productivity indexes, 1999–2003**



On this measure Western Power has above average performance ranking second out of the 13 included DBs. Western Power had a steady increase in its opex partial productivity over the 5 year period, with an overall increase of 20 per cent which is equivalent to an average annual growth rate of 4.6 per cent.

3.6.3 Capital partial productivity

In figure 18 we present analogous capital partial productivity indexes. These are multilateral output indexes divided by a multilateral index of capital quantity built up from the four capital components – overhead lines, underground cables, transformers and other capital.

Western Power has the ninth highest capital partial productivity of the 13 included DBs. Since MTFP performance is effectively a weighted average of the opex and capital partial productivities, its well above average performance on opex partial productivity and somewhat lower than average performance on capital partial productivity lead to its above average MTFP performance.

Figure 18: **Capital partial productivity indexes, 1999–2003**

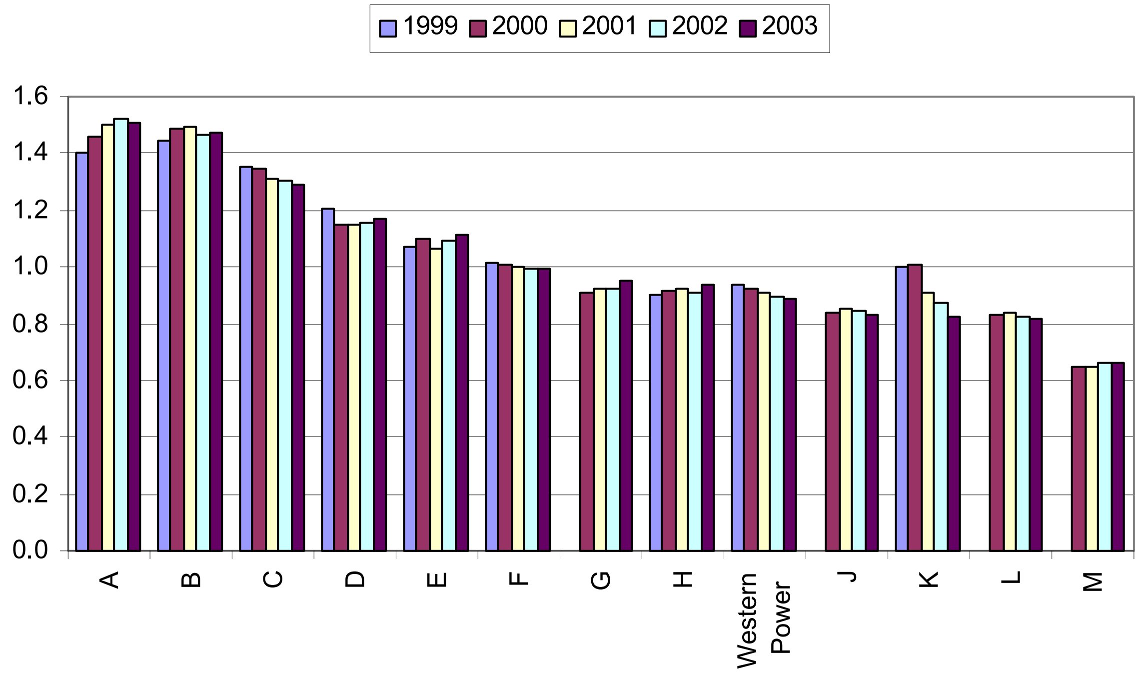
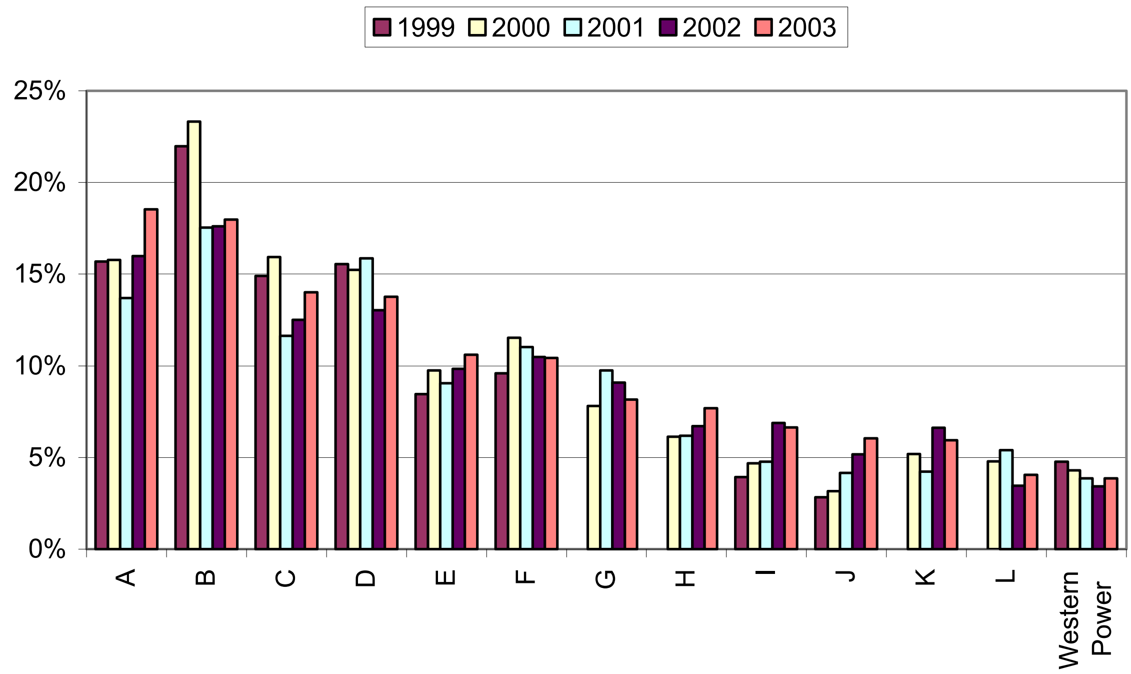


Figure 19: **Residual pre–tax rates of return, 1999–2003**



3.6.4 Residual rate of return

A by–product of constructing the MTFP database is the derivation of information on residual rates of return. The residual rate of return is derived by subtracting operating expenses and estimated depreciation (calculated as 4.5 per cent of DORC or the nearest available asset value measure) from DUOS revenue and dividing this by DORC. It is a relatively crude pre–tax measure but gives an indication of relative rates of return.

Using this measure, Western Power had the lowest residual rate of return in 2003. At 3.9 per cent this was well below the group average of just under 10 per cent. However, the discrepancy between this result and the financial rate of return reported in section 3.2 means that this result should be interpreted with extreme caution. An important explanation for this divergence is likely to be the relatively high level of customer contributions in Western Australia. Since Western Power's revenue requirement excludes a rate of return on those assets that customers have paid for upfront, the revenue included in the residual rate of return calculation will only provide a return on part of the asset base while all assets are included in the DORC valuation. Hence, this is likely to bias Western Power's observed residual rate of return downwards compared to the other included DBs. The Victorian DBs generally do well on this measure reflecting the more commercial nature of their ownership structure.

3.7 Labour Productivity

Labour constitutes an important component of a DB's opex. Labour productivity measures have traditionally been reported for electricity utilities and used as a basis for comparison due to their ease of construction. However, they have always had severe limitations and recent moves to greater use of contracting out have rendered them even less useful. We include two measures for completeness but caution against their use. These measures are:

- throughput per employee; and
- customers per employee.

Throughput per employee is simply the total number of gigawatt hours delivered from the distribution network divided by the average number of employees in the distribution business. This is a traditional productivity measure likely to be used in inter–utility comparisons. Similarly, customers per employee is calculated as the total number of customers divided by the average number of employees in the distribution business.

In the 2000 study conducted by Meyrick staff, we attempted to define 'employees' as full–time equivalents including contract labour and shared allocations from head office as well as direct employees in distribution operations and maintenance. While we attempted to collect similar information in the current study, most DBs found it difficult to estimate the labour content of their contracted services which are becoming increasingly important for all DBs. Consequently, we have reverted in this study to defining 'employees' in the narrow, traditional sense to include only the DB's employees directly on its own payroll performing distribution operations and maintenance functions and including an allocation of shared staff.

Figure 20: **Labour productivity: GWh per direct employee, 1999–2003**

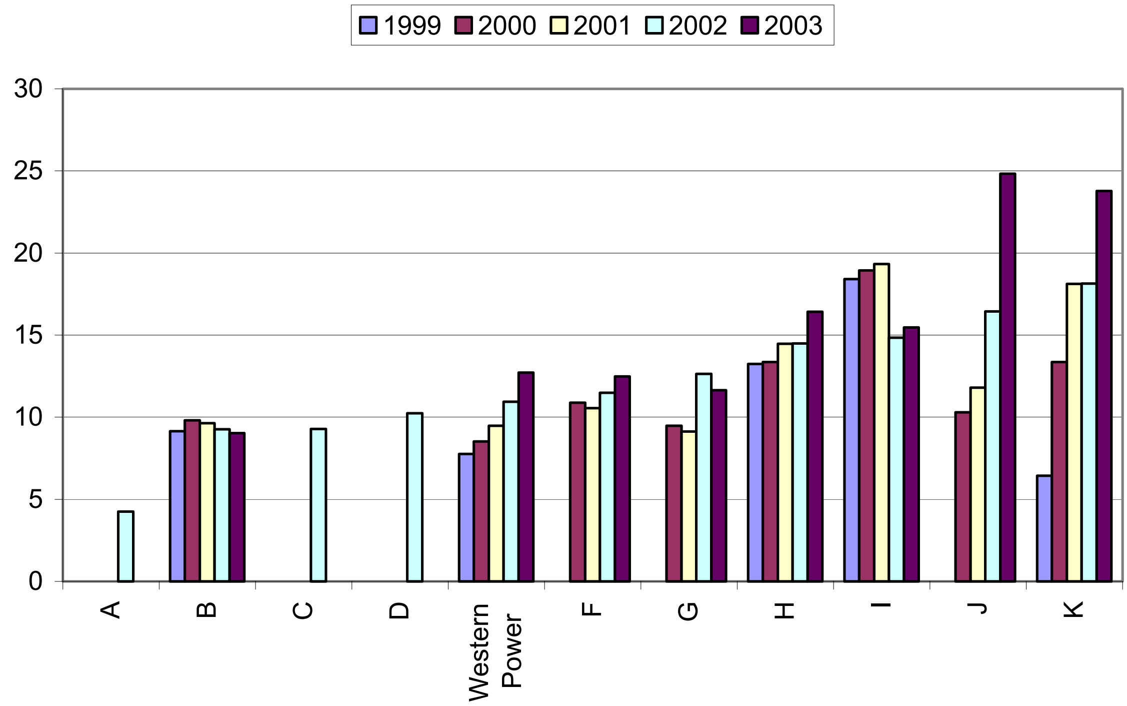
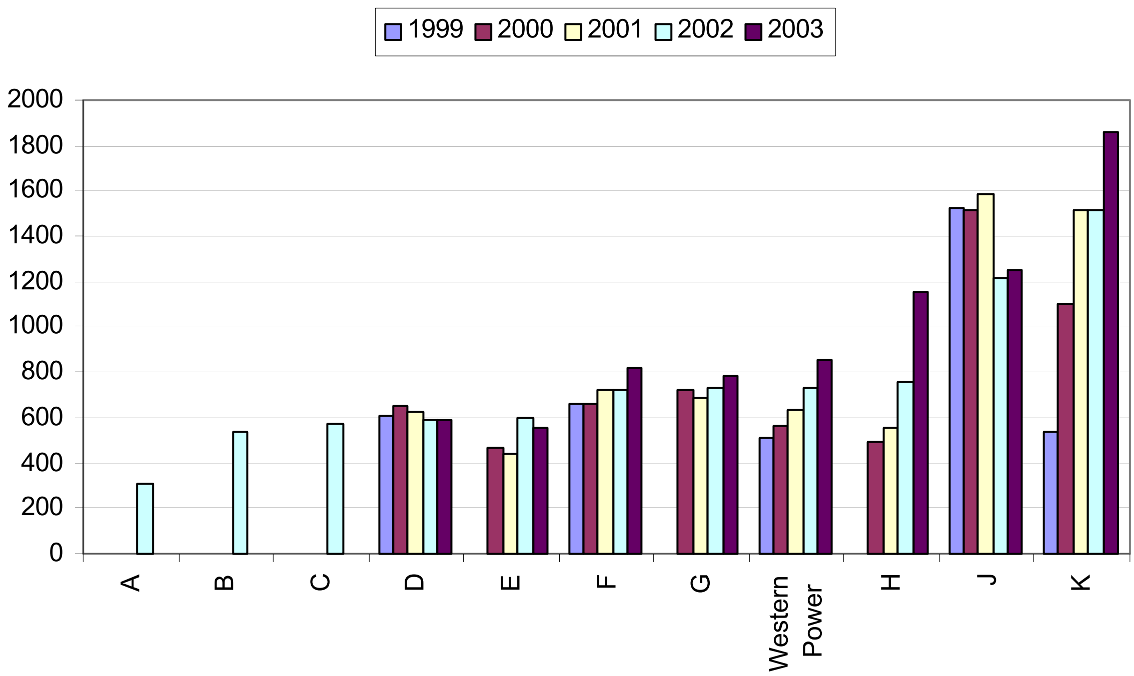


Figure 21: **Labour productivity: customers per direct employee, 1999–2003**



Western Power had the seventh highest direct labour productivity of the 11 distributors where data were available on the throughput per employee measure for 2002 (figure 20) and the fifth highest figure for 2003. However, this may reflect a lower degree of contracting out of operating and maintenance functions than that occurring in the leaders on this measure. A similar result is seen in the customers per employee measure where Western Power ranked fourth out of 11 in 2002 (figure 21). This measure generally tends to favour urban over rural DBs.

3.8 Opex efficiency

The opex cost covers distribution activities only and excludes all capital costs and transmission fees. It includes all directly employed labour costs, contracted services and materials and consumables costs associated with operating and maintaining the distribution service. All opex series are expressed in 2003 prices.

There are a number of ways of looking at the partial productivity of all non–capital inputs combined. The method chosen to normalise opex costs will have an important bearing on the relative performance of DBs. For instance, normalising opex by the system's throughput in MWh will tend to favour those DBs with dense networks and high consumption per customer. Conversely, examining the total costs of operating and maintaining the distribution network per kilometre of line will typically tend to favour distributors with a less dense network because they have a higher number of network kilometres per customer by which to deflate the opex figure.

The impact of reporting comparative opex using different normalisations is illustrated in Figures 22 to 25.

Figure 22 shows that in 2003 Western Power ranked fifth out of 13 on opex per MWh. However, the DB that has the lowest opex per MWh has narrower distribution boundaries than the other DBs and so its opex is not comparable with the rest of the sample. The urban based distributors generally perform well on this measure while the predominantly rural based systems incur higher opex per MWh. The five distributors with opex per MWh of more than $12.50 were those with substantial rural components while those with opex per MWh less than $12.50 were predominantly urban based.

Figure 23 shows that Western Power had the third lowest opex per network kilometre when compared to the other included distribution businesses. The rural based distributors generally perform well on this measure while the predominantly urban based system incur much higher opex per network kilometre. Indeed, the six distributors with opex per network kilometre of less than $2,500 in 2003 were those with substantial rural components.

Figure 24 shows that Western Power ranked third on opex per customer in 2003. While all the DBs with opex per customer of less than $175 in 2003 have substantial urban components, there is a mixture rural and urban distributors above this figure.

Figure 22: **Operating and maintenance costs per MWh, 1999–2003**

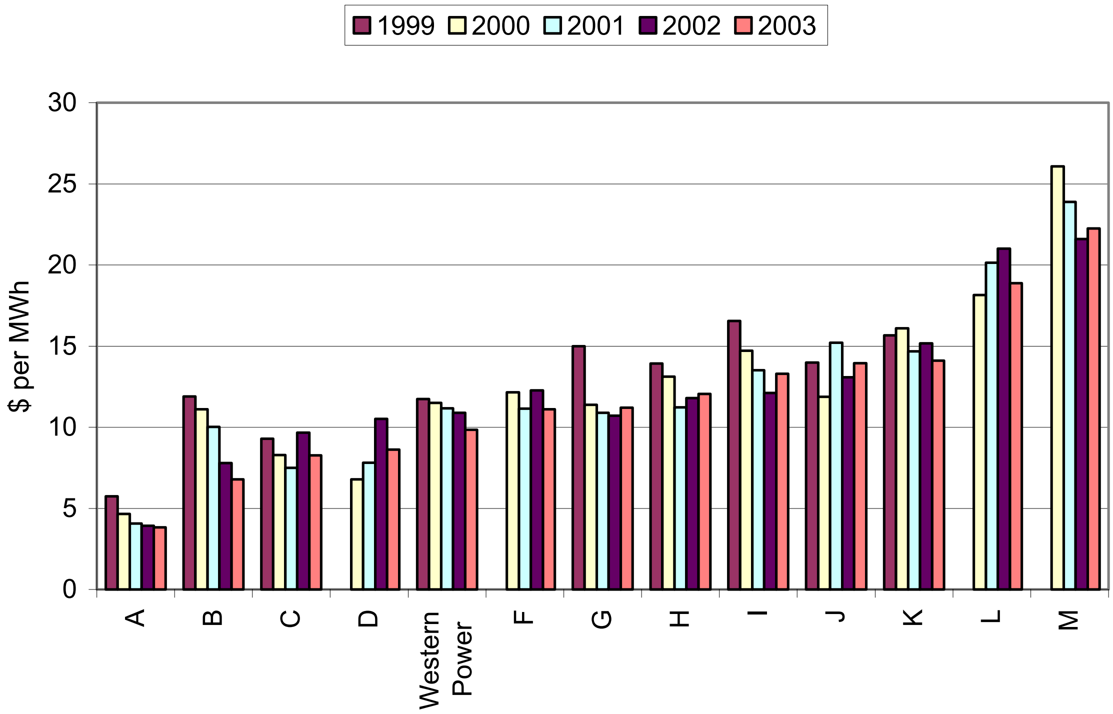


Figure 23: **Operating and maintenance costs per network kilometre, 1999–2003**

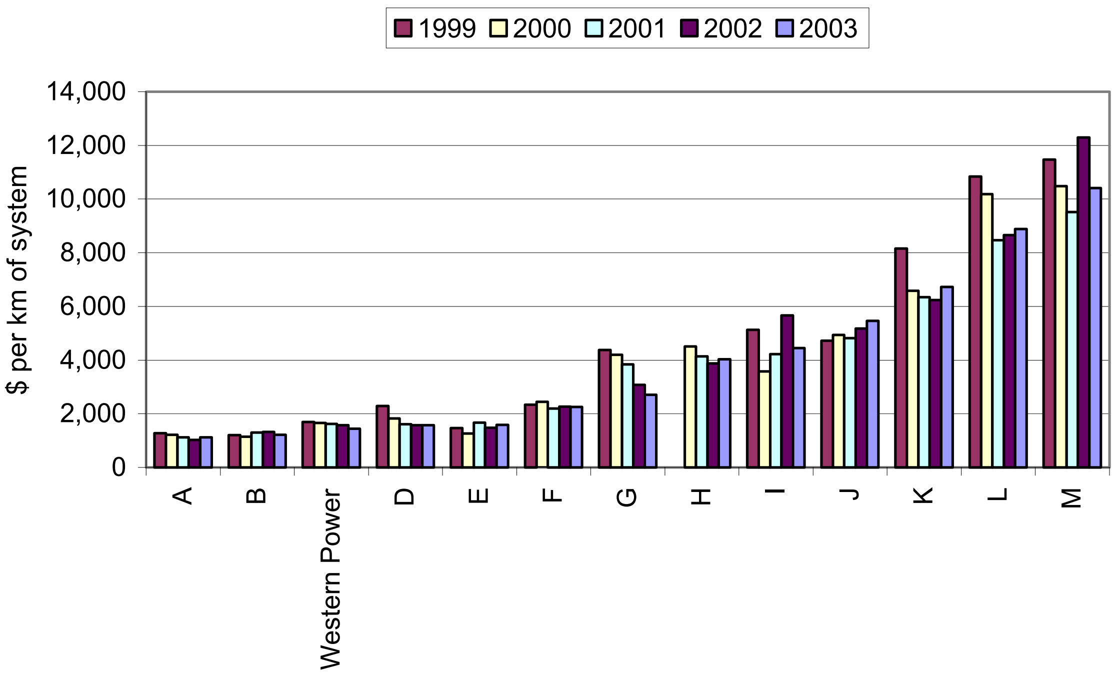


Figure 24: **Operating and maintenance costs per customer, 1999–2003**

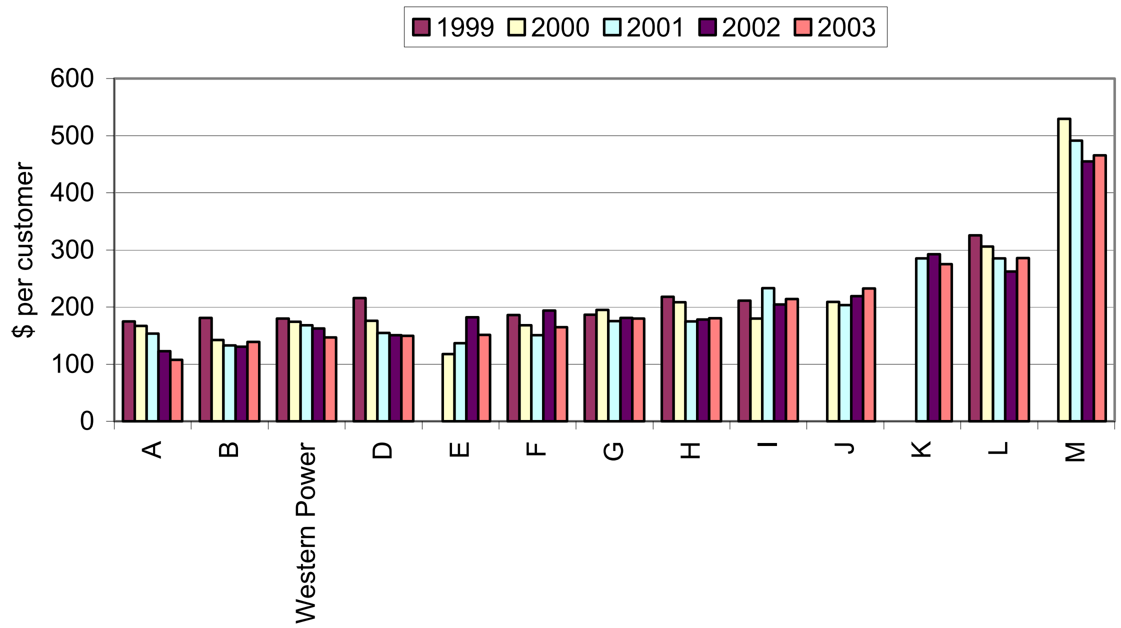
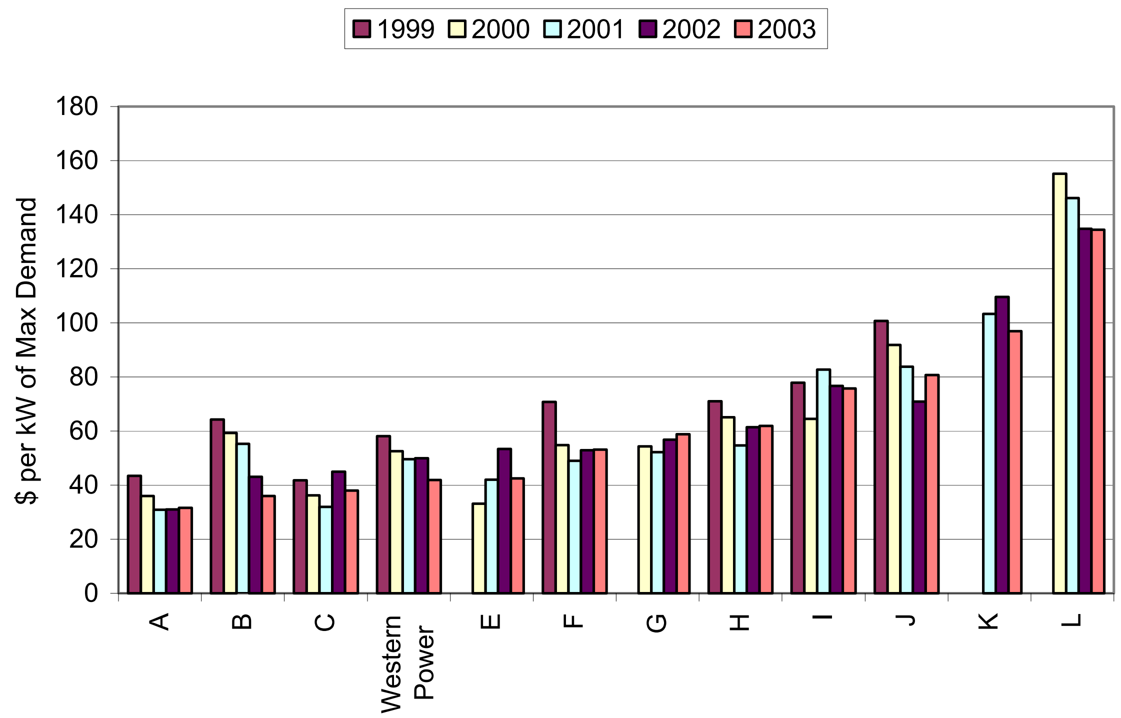


Figure 25: **Operating and maintenance costs per kW of maximum demand, 1999–2003**



Another possible basis for normalising opex is presented in figure 25. This is kW of maximum demand as the distributor has to provide sufficient capacity to meet periods of peak demand rather than average demand. There is again a distinct segregation between urban and rural based distributors on this measure with all DBs with opex per kW of peak demand less than $70 having substantial urban components and those higher than this figure being rural based. Western Power ranked fourth on this measure.

3.9 Transformer utilisation

Capital productivity is defined by the effective utilisation of assets. Network assets are purchased based on their capacity and not energy throughput. The network assets comprise two essential types — transformers and lines. Distribution lines are diverse in application and rating and do not provide a suitable basis for a performance indicator. For this reason we measure transformer utilisation.

Transformer utilisation is measured by network peak simultaneous demand divided by total installed transformer capacity separately for zone substation and distribution transformers. Although imperfect, this measure provides the best indication of asset utilisation in a distribution network.

Figure 26: **Transformer utilisation: ratio of MW maximum demand to summated transformer MVA capacity above distribution level, 1999–2003**

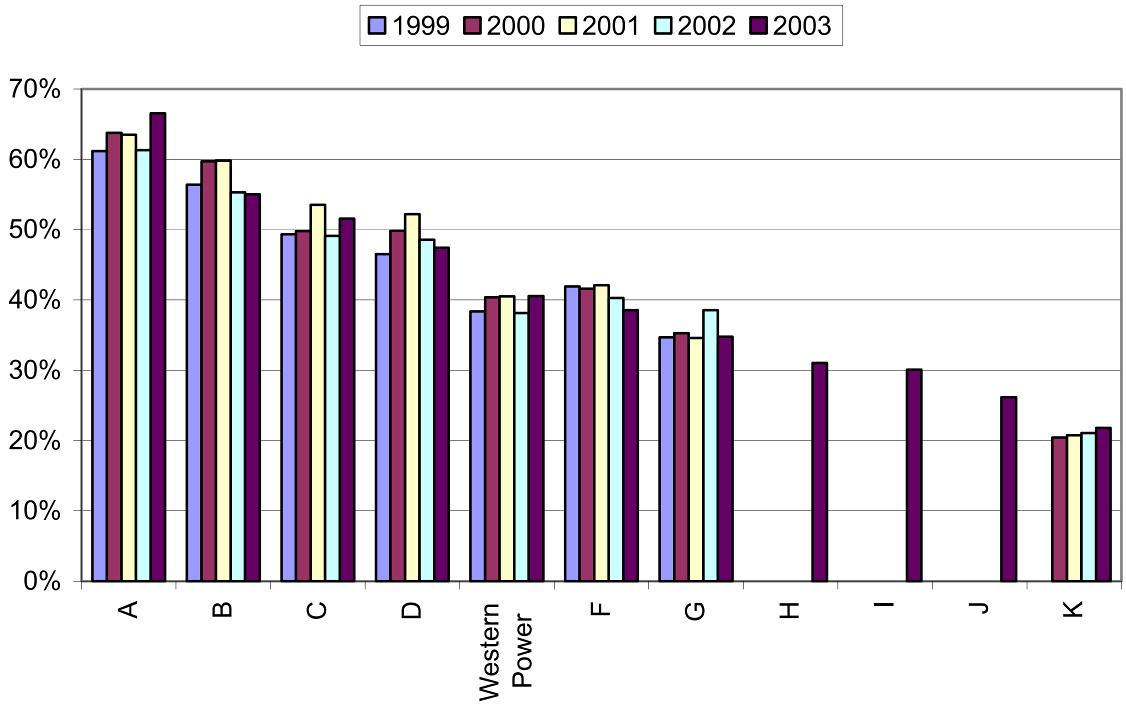
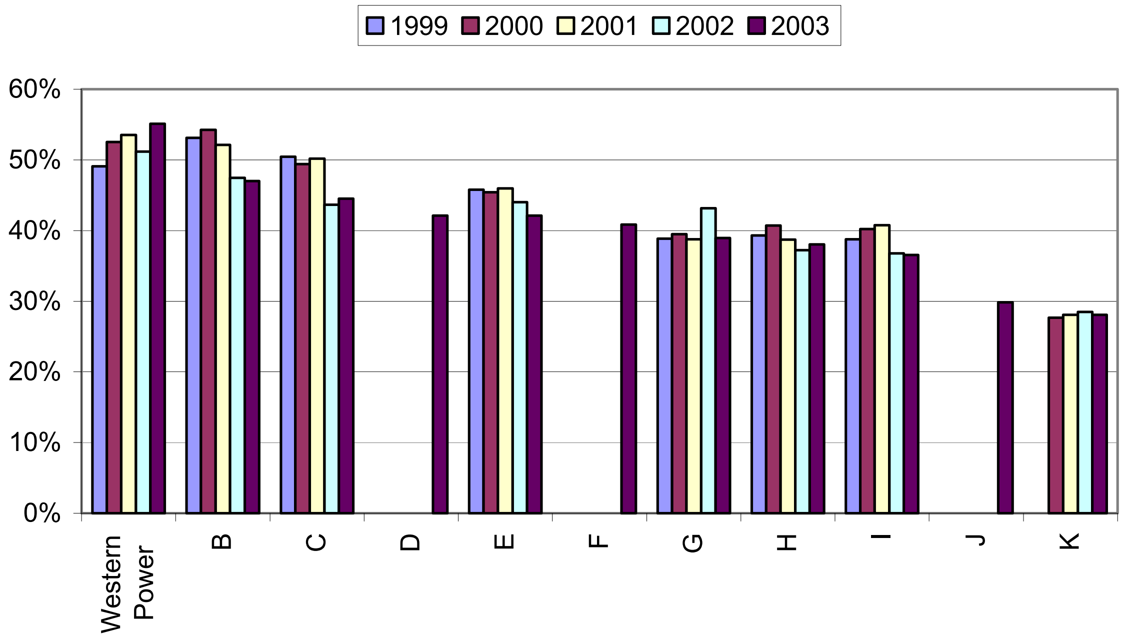


Figure 26 shows that Western Power had the fifth highest utilisation rate of transformers above the final distribution level compared to the other participating distribution businesses. It had the highest distribution transformer utilisation ranking (figure 27).

Figure 27: **Transformer utilisation: ratio of MW maximum demand to summated transformer MVA capacity at final distribution level, 1999–2003**



3.10 Capital stock efficiency

Just as there are a number of ways of looking at opex efficiency, then the efficiency of the use of the capital stock can also be examined in analogous ways. In this case we use asset replacement cost as the most appropriate measure of the capital stock. This abstracts from differences in average asset age, which will influence DORC based comparisons. The method chosen to normalise replacement costs will again have an important bearing on the relative performance of DBs. We look at the same four bases for normalising replacement costs in Figures 28 to 31.

The asset replacement cost per kWh measure presented in figure 28 generally favours urban based DBs with relatively dense networks. Western Power ranks seventh out of 12. As expected, the rural based DBs dominate the replacement cost per network kilometre series presented in figure 29 with all DBs with replacement costs per kilometre of less than $140,000 all having substantial rural components. Western Power ranks fourth on this measure.

Figure 28: **Asset replacement costs per kWh, 1999–2003**

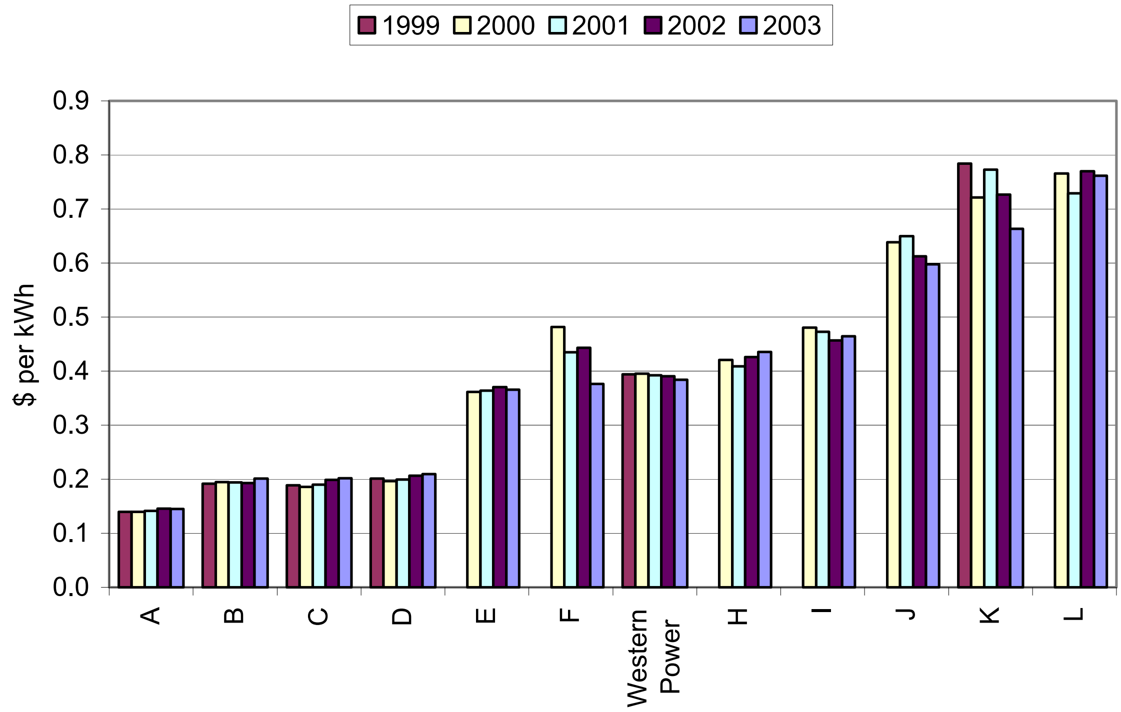
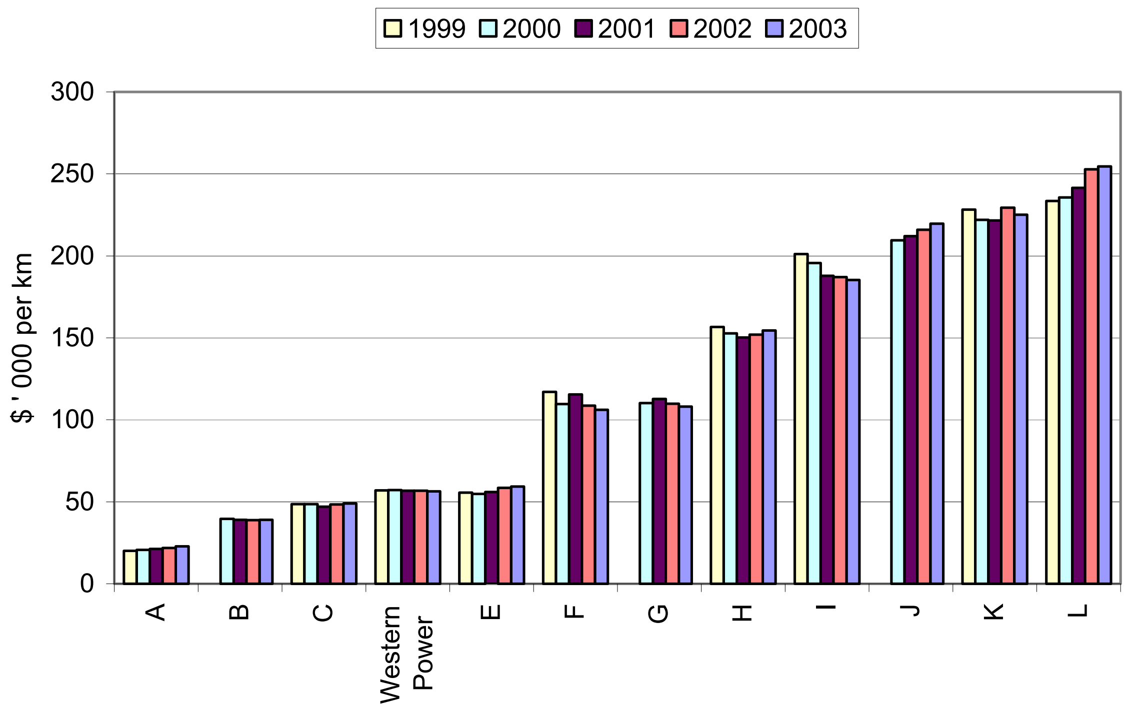


Figure 29: **Asset replacement costs per network kilometre, 1999–2003**



Western Power ranks sixth on the measure of asset replacement costs per customer which generally tends to favour urban based DBs (figure 30).

Figure 30: **Asset replacement costs per customer, 1999–2003**

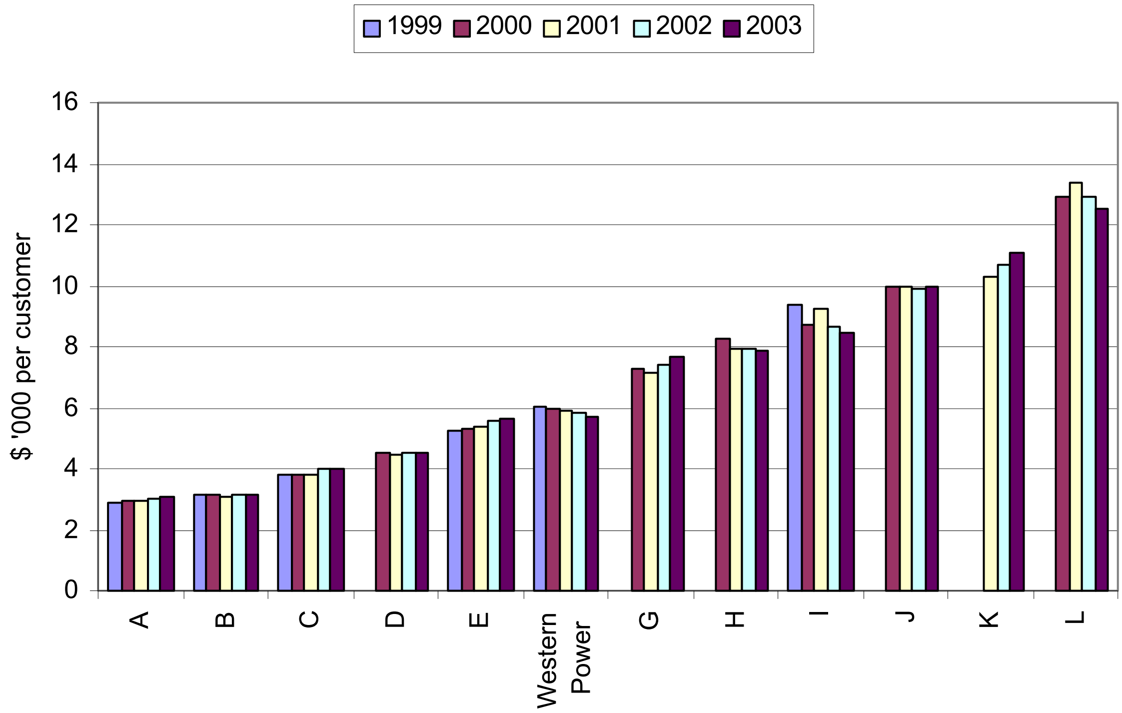
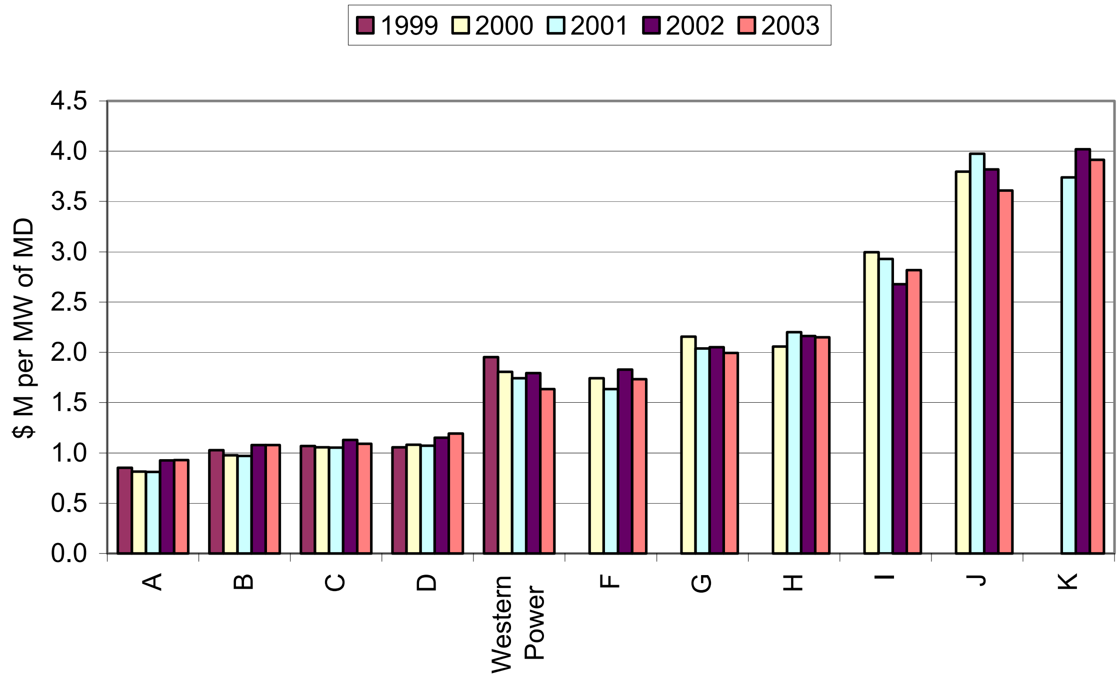


Figure 31: **Asset replacement costs per MW of maximum demand, 1999–2003**



There is less of a pattern in performance when measured by asset replacement costs per kW of peak demand with a spread of urban and rural based DBs across the range of observed performance (figure 31). Western Power ranks fifth on this measure.

3.11 Capital expenditure comparisons

As well as efficiency in using capital stocks, regulators and others are also typically interested in capital expenditure relativities across DBs. Capital expenditure requirements can arise from a range of sources including:

- meeting demand growth (new connections and customers and increased average consumption per customer);
- replacement of depreciated and damaged assets;
- initiatives to improve reliability performance;
- compliance with new regulations, including environmental requirements; and
- demand management initiatives.

Comparisons of capital expenditure are more difficult to interpret than either opex or capital stock comparisons as different DBs will face different demand growth rates, have systems of differing ages with older systems requiring more replacement capital expenditure, and have different reliability performances which may or may not be considered adequate to meet customer expectations and valuations. Given these considerations, comparisons of capital expenditure need to be interpreted with caution.

It is also less obvious how capital expenditures should be normalised when making comparisons. Capital expenditure is effectively the change in the size of the capital stock and could be normalised by, for example, the change in output. However, for the purposes of this exercise we normalise capital expenditures on the same four bases as used for our opex and capital stock comparisons. These are presented in figures 32 to 35.

In 2003, Western Power has the fifth highest capital expenditure (capex) per MWh in figure 32. It should be noted that 2003 was a relatively low capital expenditure year for Western Power and capex for 2004 is expected to be around $20 million or 12 per cent higher due to increased capex on subtransmission assets. Again the MWh basis for normalisation leads to the DBs with substantial rural components having higher values than their urban based counterparts.

Capex per network kilometre, on the other hand, again leads to the DBs with substantial rural components having low values compared to those that are mainly urban based (figure 33).

Figure 32: **Capital expenditure per MWh, 1999–2003**

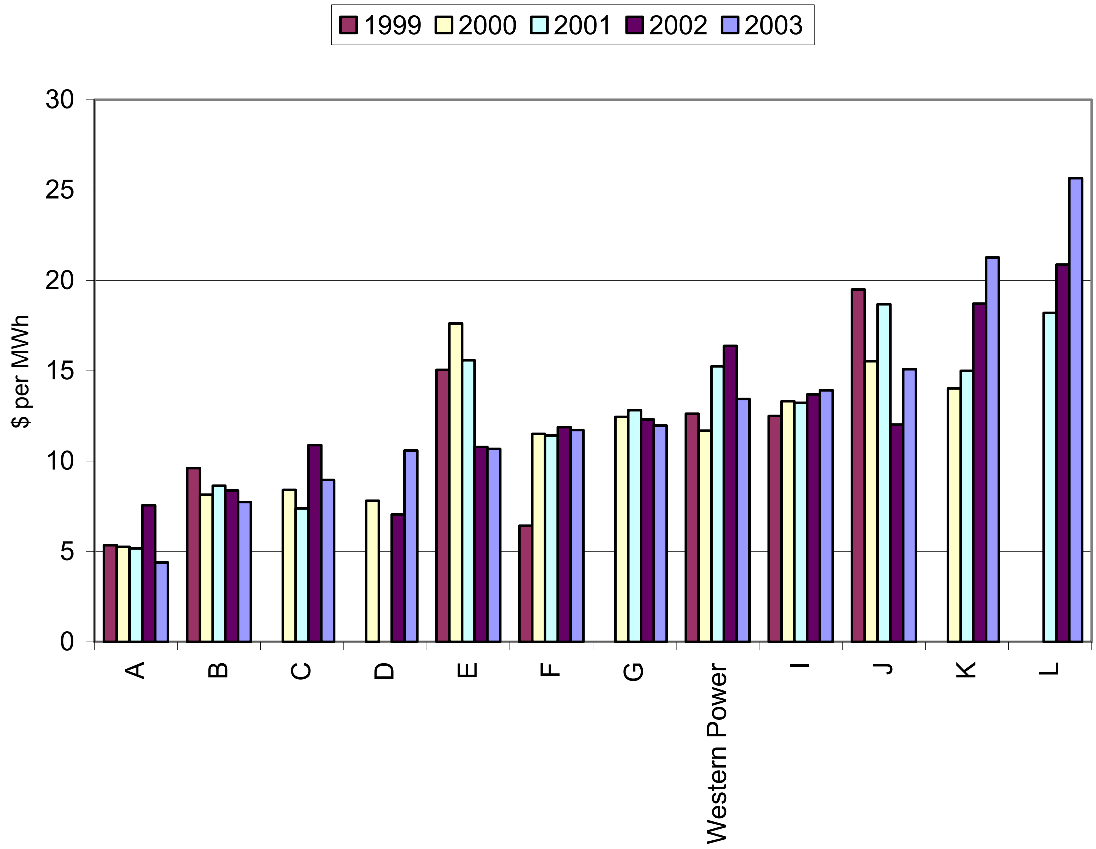


Figure 33: **Capital expenditure per network kilometre, 1999–2003**

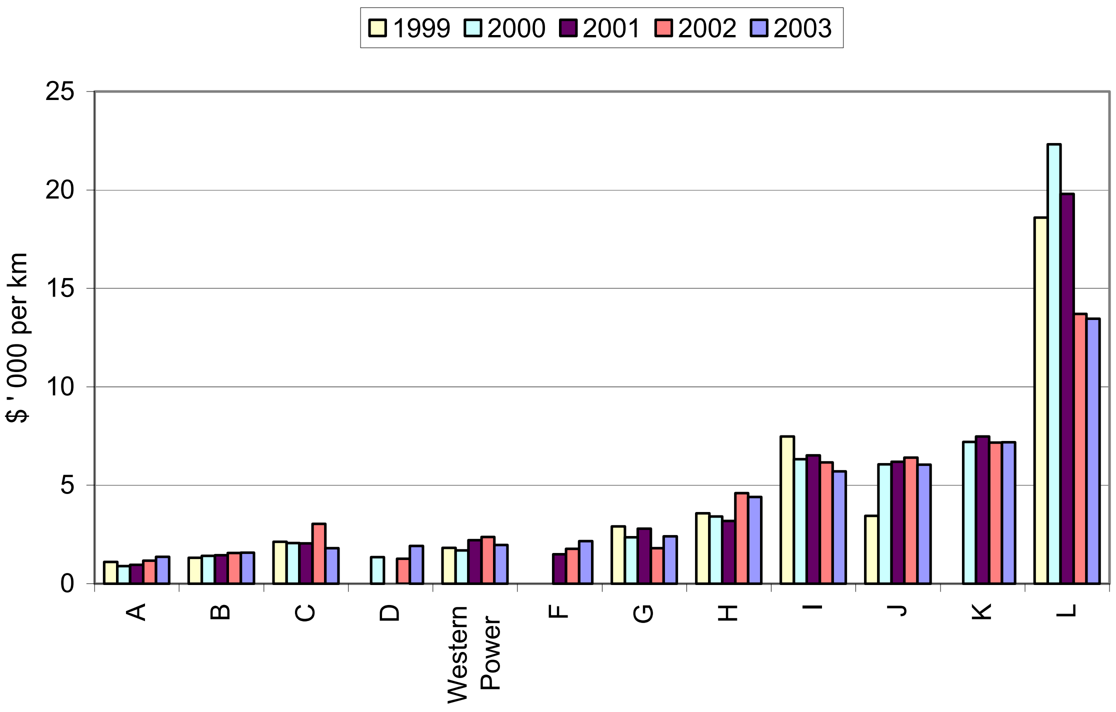


Figure 34: **Capital expenditure per customer, 1999–2003**

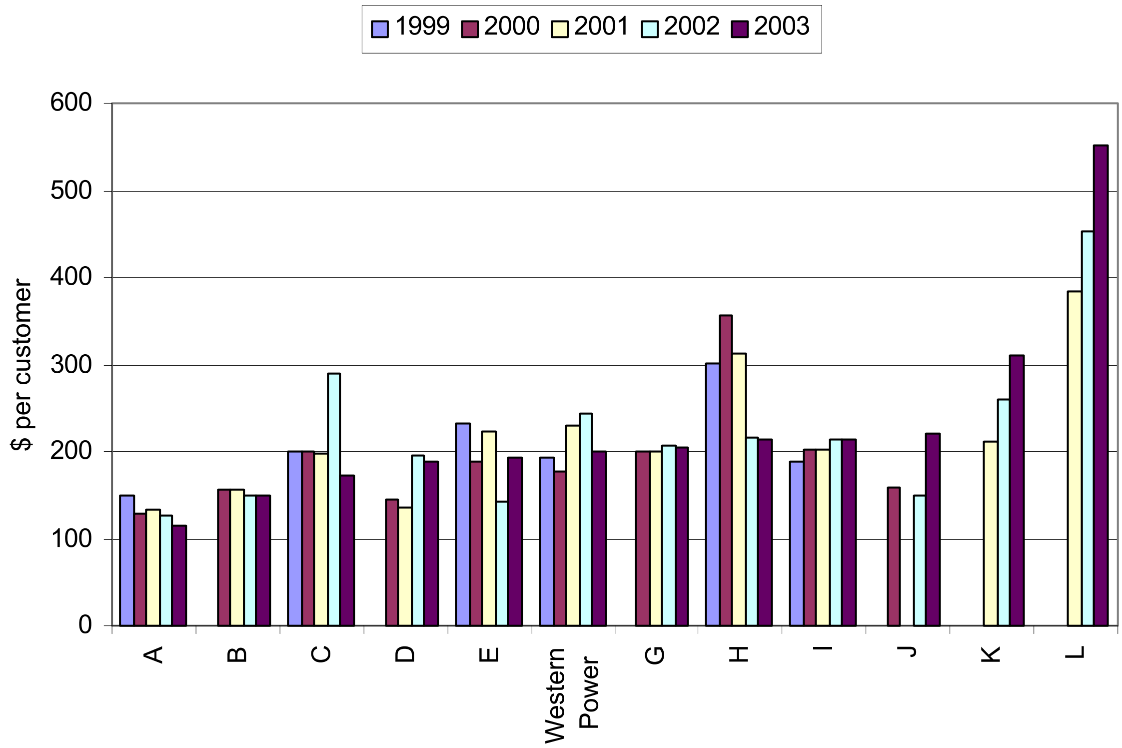
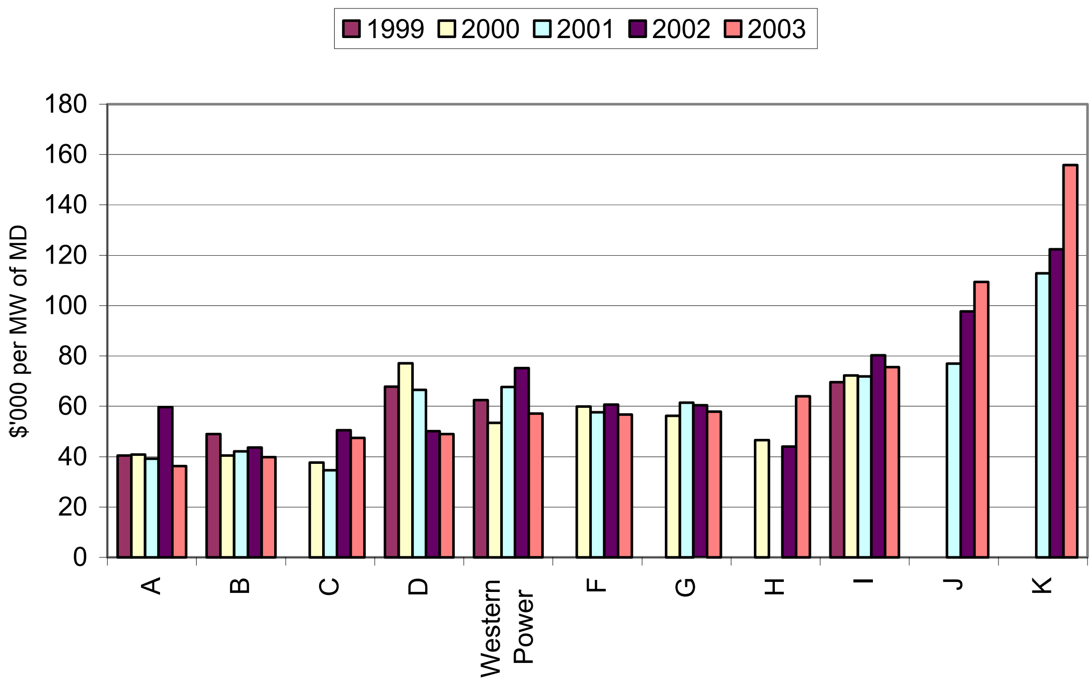


Figure 35: **Capital expenditure per MW of maximum demand, 1999–2003**



Western Power has the fifth lowest capex per network kilometre. All the DBs with capex per network kilometre higher than $3,000 per kilometre are mainly urban based.

Capex per customer comparisons tend to lead to urban based DBs having lower values than rural based ones (figure 34). Western Power has the sixth lowest value on this measure.

Finally, capex per kW of peak demand comparisons also lead to urban based DBs typically having lower values than those that are rural based (figure 35). Western Power again had the fifth lowest capex value based on this normalisation.

APPENDIX: MULTILATERAL TFP – TECHNICAL DETAILS

Caves, Christensen and Diewert (1982) developed the multilateral translog TFP (MTFP) index measure to allow comparisons of the absolute levels as well as growth rates of productivity. It satisfies the technical properties of transitivity and characteristicity which are required to accurately compare TFP levels within panel data. Lawrence, Swan and Zeitsch (1991) and the Bureau of Industry Economics (BIE 1996) have used this index to compare the productivity levels and growth rates of the five major Australian state electricity systems and the United States investor–owned system. The Australian component of these studies was recently updated by Lawrence (2002). Zeitsch and Lawrence (1996) used the method to compare the efficiency of coal–fired electricity generation plants in the United States, Canada and Australia. Meyrick and Associates (2003a,b) applied the method to derive X factors for New Zealand's electricity lines businesses.

The Caves, Christensen and Diewert (CCD) multilateral translog index is given by:

$$(1) \quad \log (TFP_m/TFP_n) = \sum_i (R_{im}+R_i^*) (\log Y_{im} - \log Y_i^*)/2 - \sum_i (R_{in}+R_i^*) (\log Y_{in} - \log Y_i^*)/2 - \sum_j (S_{jm}+S_j^*) (\log X_{jm} - \log X_j^*)/2 + \sum_j (S_{jn}+S_j^*) (\log X_{jn} - \log X_j^*)/2$$

where R_i^* (S_j^*) is the revenue (cost) share averaged over all utilities and time periods and $\log Y_i^*$ ($\log X_j^*$) is the average of the log of output *i* (input *j*). In the main application reported in the this report we have three outputs (throughput, system line capacity and connections) and, hence, *i* runs from 1 to 3. We have five inputs (operating expenses, overhead lines, underground cables, transformers and other capital) and, hence, *j* runs from 1 to 5. The Y_i and X_j terms are the output and input quantities, respectively, described in section 6.1. The R_i and S_j terms are the output and input weights, respectively.

The formula in (1) gives the proportional change in MTFP between two adjacent observations (denoted *m* and *n*). An index is formed by setting some observation (usually the first in the database) equal to one and then multiplying through by the proportional changes between all subsequent observations in the database to form a full set of indexes. The index for any observation then expresses its productivity level relative to the observation that was set equal to one. However, this is merely an expositional convenience as, given the invariant nature of the comparisons, the result of a comparison between any two observations will be independent of which observation in the database was set equal to one.

This means that using equation (16) comparisons between any two observations *m* and *n* will be both base–distributor and base–year independent. Transitivity is satisfied since comparisons between the two distributors for 1999 will be the same regardless of whether they are compared directly or via, say, one of the distributors in 2002. An alternative interpretation of this index is that it compares each observation to a hypothetical average distributor with output vector $log\ Y_i^*$, input vector $log\ X_j^*$, revenue shares R_i^* and cost shares S_j^*.

With the index number MTFP approach there is scope to capture density related operating environment conditions by the specification of multiple outputs. For example, in previous studies, output specifications that focus on energy delivered have tended to favour dense urban distributors while output specifications that have focused on the network's capacity as measured by MVA–kilometres have tended to favour low density rural distributors (Tasman Asia Pacific 2000a,b). Incorporating both the energy delivered and network capacity measures of distribution output leads to a more even–handed treatment of urban and rural distributors. By choosing multiple outputs such as energy delivered, MVA–kilometres and connection numbers, it is possible to incorporate aspects of density such as customers per kilometre and energy delivered per customer into the MTFP measure directly in an analogous fashion to how this is captured in multiple output econometric cost functions (see Tasman Asia Pacific 2000a,b; Pacific Economics Group 2000a,b; Meyrick and Associates 2003a,b).

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