Reform of the Electricity Supply Industry

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Abstract: Electricity markets around the world are becoming more competitive, partly in response to technological changes. Successful restructuring requires an understanding of the sources of monopoly power in the industry, and separation of competitive from natural monopoly elements. Competitive wholesale electricity markets require transparent regulatory and cross-subsidy mechanisms. Such changes in turn make public ownership less relevant for protecting consumers. Competitive markets are also more risky for owners, and governments are not ideally suited to financing large and very risky business ventures. The arguments are illustrated by reference to the reforms undertaken in Australia in the last decade.

Resumen: Los mercados de electricidad en el mundo se están tornando más competitivos, en parte como respuesta a cambios tecnológicos. Una reestructuración exitosa requiere comprender las fuentes del poder monopólico en la industria y la separación entre elementos competitivos y de monopolio natural. Los mercados competitivos de ventas al mayoreo de electricidad requieren mecanismos transparentes de regulación y de subsidios cruzados. A su vez, estos cambios hacen que la propiedad pública sea menos relevante para proteger a los consumidores. Los mercados competitivos son también más riesgosos para las empresas, y los gobiernos no están capacitados idealmente para financiar negocios grandes y muy riesgosos. Los argumentos se ilustran con las reformas llevadas a cabo en Australia durante la última década.

In most countries, government firms have dominated the supply of electricity. Even in countries with extensive private ownership, such as the United States, Germany, Denmark and Norway, governments

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have controlled prices and regulated the industry in other ways. The traditional explanation for this situation is that electricity supply is a "natural monopoly".

Supplying electricity across an integrated network requires coordination and scheduling of suppliers for technical reasons and also to minimize costs. "Command and control" mechanisms within a firm may be more effective than decentralized market processes at solving such scheduling and coordination problems. Furthermore, if existing customers require additional electricity, or additional customers in a given area wish to take electricity service, it usually will be cheaper to use the existing network rather than duplicate that infrastructure. In many cases, additional service can be supplied without requiring *any* expansion in the existing trunk network. Many draw the inference, therefore, that an electricity network will be operated at lowest cost when one firm owns it.

When there is a sole supplier of a good or service, however, that supplier can, by restricting output, charge a price in excess of marginal cost. Since the value of the product to consumers can then greatly exceed the costs of producing it, the outcome will be inefficient. Monopoly control of a "bottleneck" facility, such as a transmission network, can produce particularly large inefficiencies. The monopoly owner would have an incentive to both underpay firms supplying electricity to the network and overcharge distributors taking electricity from it.

It has also been suggested that there are lesser, but nonetheless non-trivial, monopoly problems associated with electricity generation. This notion may be mistaken in so far as it is often based on a flawed econometric model of the production process. Even so, we will argue that economies of scale in the construction of new generating capacity imply that the capacity expansion path in a competitive industry is probably less than the most efficient imaginable.

Nevertheless, natural monopoly characteristics of electricity supply cannot by themselves explain greater government involvement in this industry. After all, the notion that governments intervene in economic activity in order to increase efficiency is grossly at variance with the evidence. We will instead argue that political intervention is targeted at other goals. Inefficiencies associated with a competitive electricity market may reduce the opportunity cost of government intervention, however, and thus could help to explain why intervention occurs more frequently in that industry.

When the efficiency of competitive outcomes increases, the opportunity cost of government involvement also increases. Competition between electricity generators has recently become more feasible and more effective at delivering lower costs and prices and better customer service. Partly as a result, many countries — including the United Kingdom, Argentina, Chile, New Zealand and Australia — have restructured and privatized their electricity supply firms. Substantial restructuring has begun even in the United States where private firms predominate. Several states are establishing competitive wholesale electricity markets and asking utilities to divest themselves of generating plant and surrender control of their transmission network. We shall use the experience in Australia to illustrate the potential benefits and costs of restructuring and privatization in the electricity industry.

1. Economies of Scale and Scope in Electricity Supply

Many recent reforms have drastically reduced the integration of the electricity supply industry. While technological changes have facilitated this trend, another influence has been a better understanding of the economic conditions of the industry.

1.1. Operating Economies of Scale

Firms using *technologies* that exhibit increasing returns to scale do not necessarily experience lower costs as output expands. Firms combine many activities, each of which uses a technology with different economies of scale. For example, management and supervision are part of the activities of every firm. Managers need to acquire information, give directions to employees, ensure that directions are complied with and so forth. These activities are likely to exhibit decreasing returns to scale. The overall economies of scale depend on the mix of activities, and how that mix varies as output expands.

For electric distributors in particular, metering use, repairing equipment, processing bills, and responding to customer complaints are all labor intensive, decreasing returns to scale, activities that are also significant components of total cost. Furthermore, as a network expands geographically, travel costs become a larger part of the cost of both metering and fault repair, raising the average costs of service. To offset some of these costs, the firm can establish regional offices. However, this increases the number of organizational layers and thus is likely to raise service costs per unit of output supplied. An increase in the *number of customers* of an electricity utility is also likely to be associated with an increase in the proportion of small customers, and an increase in the proportion of customers located in sparsely populated regions. Both of these factors will increase the average costs of supply as output expands.

Electric utilities can also often increase sales, the number of customers served, or the range of products supplied without increasing network capacity. Conversely, reductions in sales, customers, or product range do not usually allow the firm to save on capital costs. Capital investments represent a *sunk* cost that is irrelevant to the cost of marginal changes in output, so long as supply remains unconstrained by current network capacity. For *short run* changes in output, therefore, the service costs, which exhibit diseconomies of scale, are dominant.

The way new generating capacity is added to an electricity supply system accentuates the short run increasing costs. Most electricity systems experience substantial daily and seasonal demand fluctuations. Periods of peak demand may only last a few hours each year. Plant used only in peak periods therefore usually has a low capital cost but, in consequence, a high operating cost. In fact, the construction of base load capacity is justified only when the saving in fuel and other operating costs over the expected life of the plant has a present value sufficient to compensate for the large initial capital costs. Thus, gas turbines are less expensive to build than large coal, oil or nuclear base load plant but use a premium fuel. Similarly, in a mixed hydro and thermal system, the "fuel cost" of hydroelectricity is the opportunity cost of the stored water. Consequently, hydro capacity should be used in peak periods when the cost of thermal generation would otherwise be higher.

Older, higher cost plant is also used to produce higher levels of output. Newer plant often embodies technological advances that reduce operating costs. The maintenance costs, and lost time for maintenance, for older plants are also higher.

The result of these factors is that increases in the output of electricity in the short run are accompanied by rapidly rising marginal costs. Empirical analyses claiming to reveal increasing returns to scale in supplying electricity invariably include capital as a factor of production, and thus implicitly examine a long run supply function.

1.2. Investment Economies of Scale

The fact that new generating capacity is added in "lumps" indicates that there *are* economies of scale associated with investment. Many of the costs of adding to existing capacity, such as site preparation, engineering design, arranging transport of materials, procuring construction equipment and, to a lesser extent, the construction time, do not depend greatly on the size of the capacity increment. By delaying construction of new plant a larger plant size is warranted, allowing lower average construction costs per MW of generating capacity.

Figure 1 illustrates the traditional model of efficient capacity expansion when the capacity of new plant is fixed and demand fluctuates across peak and off-peak periods. For simplicity, marginal operating costs have been taken as constant at c_1 up to the current capacity q^*.

In the left panel of Figure 1, the difference between the demand price in each period and c_1 can be viewed as an implicit demand for capacity expansion. Since new capacity will be jointly provided for all periods, these demands can be summed vertically to give an aggregate demand for new capacity. The subsequent discussion will focus on this "excess demand" while ignoring complications arising from the multi-period nature of electricity demand.

The right panel of Figure 1 illustrates the "trapezoid rule". This argues that capacity should be expanded when the trapezoid of consumer surplus gain from expanding capacity from q_0 to q_1 equals the cost of that increment $(q_1 - q_0)\, c_2$. This will be true when the areas of the two shaded triangles in the figure are equal.

The efficient capacity expansion path will constrain demand in some periods — otherwise, the implicit value of new capacity would never match its added cost. If demand is not rationed by higher prices in "peak" periods it will be rationed through blackouts, brownouts or other reductions in service quality.

Now suppose that capacity increments can be of any size instead of being fixed at $(q_1 - q_0)$. There will be some economies of scale associated with the production of new capacity but eventually decreasing returns take over. The result will be a U-shaped average cost of new capacity as illustrated in Figure 2.

Hartley and Kyle (1989) examine a simplified version of this model where investment is the sole cost and where demand grows smoothly over time. A unit of consumption is defined to equal a year's

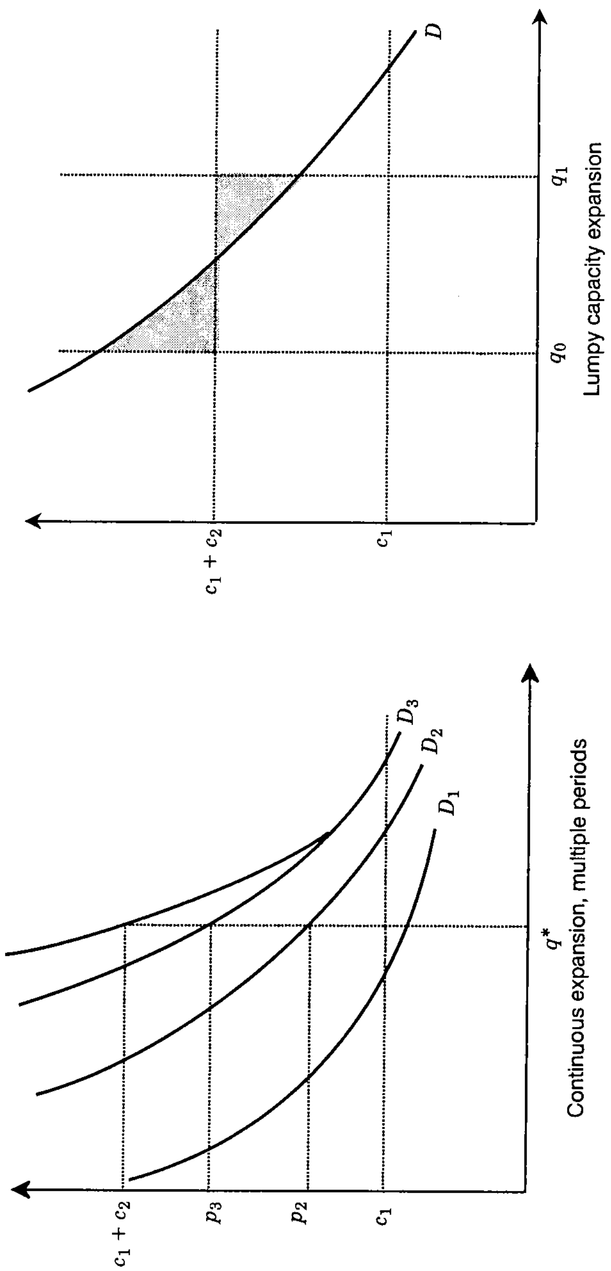
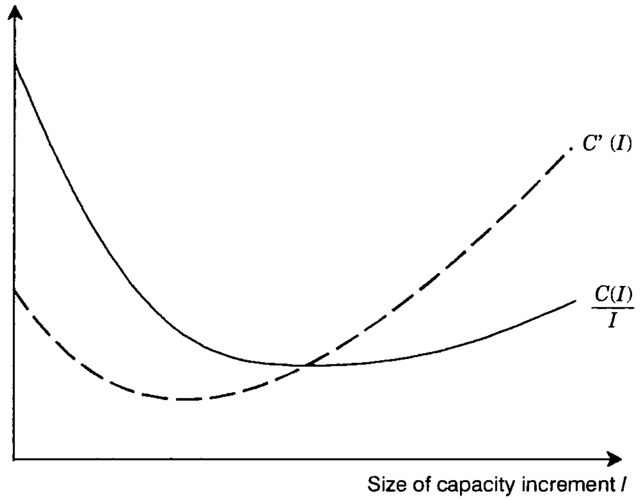


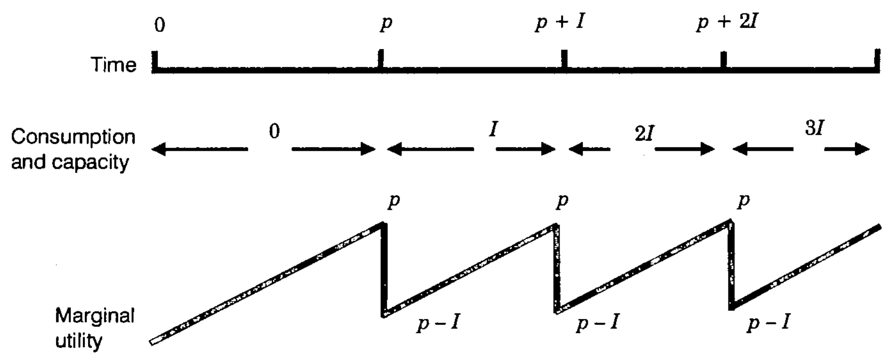
Figure 1. Efficient capacity expansion

Figure 2. Cost of capacity increments



demand growth at a fixed price. The result will be a stationary sequence of investments of size I made at intervention price p as illustrated in Figure 3. Immediately after each investment, prices fall to $p - I$. Prices then return to p over the following I units of time.

Figure 3. A Stationary sequence of investments in capacity



The present discounted revenue from a unit of capacity is given by:

$$R(p, I) = \sum_{j=0}^{\infty} \int_{t=0}^{I} (p - I + t) \exp\left[-r\,(t + Ij)\right] dt = \frac{1}{r}\left[p - \frac{1}{2} - \frac{A(rI)}{r}\right] \quad (1)$$

where:

$$A(x) = -1 + \frac{x}{2} + \frac{x}{\exp(x) - 1} > 0 \text{ for } x > 0. \quad (2)$$

Using this notation, the solution for the efficient investment size I_O and investment time (or intervention price) p_O can be written as the solutions to the two equations:

$$\frac{C\,(I_O)}{I_O} = \frac{1}{r}\left(p_O - \frac{I_O}{2}\right) \quad (3)$$

and

$$C'\,(I_O) = R\,(p_O, I_O). \quad (4)$$

Since $A(rI_0) > 0$ for $r > 0$:

$$R\,(p_O, I_O) < \frac{1}{r}\left(p_O - \frac{I_O}{2}\right) = \frac{C\,(I_O)}{I_O} \quad (5)$$

and the efficient investment path will not break even for $r > 0$. Equation (3) represents the "trapezoid rule" in this context. It implies that the cost of the investment should equal the (undiscounted) revenue arising from the increment in capacity. The efficient investment path will, however, have low prices at the beginning of each investment cycle. Thus, the discounted revenue will fall short of the investment cost. Also, from equations 4 and 5, the marginal cost of a new investment is below average cost, implying from Figure 2 that the efficient investment size is below the level that minimizes average investment costs.

It can be shown that even as $r \to 0$, so discounting makes no difference, the optimal investment size remains below the level that minimizes average cost. Our linear demand specification implies consumers are risk averse and hence value more frequent, and therefore smaller, investments with their associated smaller fluctuations in prices and marginal valuations of electricity supply.

If the investment path is constrained to ensure that the present value of revenue is sufficient to cover investment costs, it can be shown that the optimal investment size I_C solves:

$$\frac{C\,(I_C)}{I_C} - C'\,(I_C) = \frac{1}{r^2}\left[\frac{rI_C A'\,(rI_C)\,A\,(rI_C)}{1 + A\,(rI_C)} + A\,(rI_C)\right]. \quad (6)$$

A "free entry equilibrium" is an investment path that is invulnerable to profitable one-time entry when firms behave competitively in the output market. Explicitly, it is an investment rule (p_E, I_E) where all available capacity is used to produce output, investments of size I_E made at intervention price p_E do not lose money, and no investment made when $p < p_E$ makes money, assuming all future investments follow the rule (p_E, I_E). It can be shown that I_E solves:

$$\frac{C\,(I_E)}{I_E} - C'\,(I_E) = \frac{1}{r^2}\left[\frac{(rI_E)^2}{2} - rI_E A\,(rI_E)\right]. \quad (7)$$

There is also a "minimum intervention price equilibrium" where an entrant undertaking a new investment contemplates a *sequence* of investments and assumes all future entrants will also contemplate the same investment *sequence*. This equilibrium is thus less competitive, but it is vulnerable to one-time entry since by, definition, (p_E, I_E) is the only investment rule invulnerable to such entry. It can be shown that the investment size I_M in the minimum intervention price equilibrium solves:

$$\frac{C\,(I_M)}{I_M} - C'\,(I_M) = \frac{1}{r^2}\left[\frac{rI_M}{2} + rI_M A'\,(rI_M)\right]. \quad (8)$$

Using equations (3), (4), (6), (7) and (8) it can be shown that $I_M < I_E < I_C < I_O$ and $p_M < p_E < p_C$ although it is not in general possible to rank p_O relative to the other intervention prices. The ranking of the intervention prices implies that the constrained optimum cannot be achieved when anyone is free to add capacity. The unconstrained optimum may not be vulnerable to entry, however, since investments along that path do not raise sufficient revenue to cover costs.

These results should generalize. Since I_O is likely to be less than the level that minimizes average investment costs, costs would not be covered if consumers were charged the marginal cost of capacity expansion. Furthermore, if prices ration demand to the available capacity, and the interest rate $r > 0$, the discounted revenue from an investment cycle will fall short of the trapezoid of consumer surplus gain associated with an addition to capacity. Finally, competitive firms will invest "too often" and choose an investment size I that is "too small" relative to the constrained optimum. Each new entrant effectively has some "monopoly power". By choosing a smaller investment size equilibrium prices will be higher.

While the competitive outcome might be less than fully efficient, more frequent and smaller investments would also provide some benefits. Consumers value a smoother path of capacity expansion since it is likely to lead to greater stability and predictability in price movements and make it easier to plan their own future investments. In addition, more frequent investments may lead to greater technological change.

An important implication of the analysis is that investment in capacity, and the production of output using a given capacity, ought to be treated as two separate production processes. Econometric analyses that include capital along with fuel and labor as factors in a "timeless" production process will misconstrue the economies of scale in electricity generation. In particular, while the model implies that I_M, I_E, I_C, and even the efficient investment level I_O are all "too small" to fully exploit investment economies of scale, this is *no justification whatsoever* for combining generating plant into portfolios within a single firm. The model implies that there would be *no* reduction in costs resulting from such a combination.

The above discussion assumed a competitive output market. If only a few firms own most of the capacity, however, Green and Newberry (1992) show that the firms will have an incentive to restrict output relative to the available capacity. The result will be, as happened in the U. K., inefficient use of existing capacity and an artificial stimulus to investment.

Aggregating generators into a small number of firms decreases competition in the wholesale electricity market. The ostensible benefits from exploiting economies of scale, which are supposed to offset the losses associated with gaming in the wholesale market, are illusory.

1.3. Network Economies of Scale

Economies of scale are more pervasive in supplying distribution networks. It will usually be prohibitively expensive to duplicate an existing distribution network in order to extend supply to new con-

sumers. The main historical instances of an entrant producing a new network to partially replace an existing one have involved exploitation of new technologies. Consider, for example, the telecommunications market in the U. S.:

- MCI entered the long distance market by being the first firm to exploit microwave technology in place of land lines.
- U. S. Sprint based its entry into the same market on providing an entire network based on optical fiber.
- Cellular telephones based on satellite and radio technology have permitted competition in the local phone market.
- New technology may allow cable TV operators, and even electricity distributors to enter the local telecommunications market in the U. S.

New technologies might also allow electricity distribution networks to be bypassed. For example, in June 1998, Plug Power (http://www.plugpower.com/) introduced the first home to be supplied with its total electricity needs by a fuel cell. Commercial production of this system is planned for the year 2000.

New entrants have also found a niche in many network industries by providing service to a different geographical area. For example, early competitors in the telephone industry in the U. S. often supplied service to the less densely settled suburban and rural areas that had been ignored by the Bell companies.

Networks have also been duplicated. At the end of the nineteenth century, competing local telephone networks, each using the same technology, served many cities in the U. S. Lubbock, Texas still has two competing local electricity distributors with duplicate sets of wires. In Australia, the telecommunications carriers, Telstra and Optus, are currently constructing duplicate fiber optic networks.

We should also note that *construction* of new transmission or distribution lines does not display decreasing costs. Engineering firms that compete for other large construction projects can also compete effectively for construction jobs in the power industry.

Maintenance of the transmission and distribution network also could be organized on a competitive basis. While routine maintenance on a given power line might be done at least cost on a single trip, and opportunities to share plant and equipment could provide some economies of scale, offsetting diseconomies in large firms imply that several firms could compete to provide maintenance service to any one utility.

A retailer may wish to remain responsible for maintenance, however, since consumers value reduced line outages, rapid fault repair, consistent voltage and other factors dependent on line quality. Even so, some consumers are happy to take electricity service from a firm other than the owner of the local distribution network. Australian governments have recently instituted a regulatory framework to control the price and other conditions under which competitors can access networks. These access regimes appear to have diminished the monopoly power of local electricity distributors.

There is room for debate, however, about the effectiveness of access regimes. Regulated access prices are inevitably based on arbitrary cost allocations and accounting conventions. Also, the firms operating the network often have proprietary information and can shift costs from other components of their business to the network operations. It is thus often very difficult to ensure non-discriminatory access and effective competition.

New Zealand has taken the view that monopolistic behavior of the wires business is highly circumscribed by the ability of customers to by-pass their host distributor through an effective access regime. In New Zealand there is now virtually no regulation over the distribution of electricity apart from the general laws relating to anti-competitive behavior.

1.4. Vertical Integration

While distribution networks are susceptible to monopoly control, many other aspects of infrastructure industries are conducive to competitive supply. Nevertheless, we typically find that the owner of the high voltage electricity transmission grid also generates all or most of the electricity supplied to that grid and supplies services to customers.

Cost savings from combining related activities might explain these outcomes. Yet it is hard to believe, for example, that the cost savings from combining electricity generation, transmission and distribution would exceed the cost savings from combining metering, billing and customer service for supplying gas, electricity and water services.

The network characteristics of infrastructure supply industries are a more plausible explanation for vertical integration. The network owner is both a monopolist to its consumers and a monopsonist for suppliers to the network. This "two-sided monopoly" can create large efficiency losses in a disaggregated industry. A takeover of the suppliers by the network owner would not only lead to increased profits for the whole industry but also would benefit consumers. This is so even though the final monopoly outcome would still be inefficient.[1]

When the exercise of monopoly power by a network owner can be controlled, however, there may be significant gains from separating the potentially more competitive generating sector from the transmission and distribution parts of the business. This has been the philosophy behind the recent reforms in Australia, New Zealand, Argentina and the U. K., although the promotion of competition has been taken furthest in the state of Victoria in Australia.

1.5. Geographical Integration

The economies of scale associated with operating a local distribution network are often limited geographically. For example, as repair crews travel greater distances average costs increase. Even when a single firm owns a more extensive network it splits operation and maintenance into semi-autonomous regional divisions, which could often be run as separate firms without sacrificing economies of scale.

Geographical separation also allows the operating costs in the different divisions to be compared with each other. This eases the task of regulating firms and provides potential competitors to take advantage of any access opportunities.

1.6. Contracting Out

Contracting out, or competitive tendering, can also be seen as a type of "functional separation." For example, the firm operating the high

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[1] If the monopolist can charge different prices to upstream or downstream suppliers or purchasers, it could increase profits while expanding supply toward the efficient level. The monopolist's suppliers or customers are, however, likely to be made worse off by such price discrimination. The upstream or downstream firms may conceal information to make price discrimination less feasible or effective. Vertical integration may alleviate these asymmetries in information and benefit consumers as well as the monopoly network provider.

voltage electricity network and planning network expansions does not have to construct or maintain the system.

A potential problem with *mandating* contracting out is that economies of scope might be sacrificed. Another problem is that some activities that could be contracted out may be a critical component of service quality. It may be important for firms to retain control of these service dimensions if competition is to result in the best outcome for consumers.

2. Public Ownership

It might be thought that the monopoly problems associated with distribution networks explain why electricity (and other network) firms are completely owned and operated by government enterprises in many countries. For example, Klein and Roger (1996) observed:

> Important policy issues exist because many users are dependent on a common facility — such as an electricity network — that does not face head-to-head competition ... Pressures for some kind of regulatory mechanism arise soon after a new infrastructure network is set up.

A fundamental weakness of this explanation is that it appears to be based on a "public interest" view of politics. If politicians intervene to promote efficient resource allocation, however, how can we explain obviously inefficient policies like tariffs or subsidies?

In a world of complete information, only efficient policies could garner majority support.[2] Inefficient policies could always be replaced by alternatives that make some voters better off and no others worse off. In practice, however, information is costly, and information is very deficient in the political marketplace. Voters have weak incentives to become informed, and information about candidate or party performance is difficult to obtain. Many voters economize on information costs by judging politicians on *intentions* rather than *performance*. Politicians also suffer from inadequate access to information when attempting to control the behavior of civil servants or managers of publicly owned firms.

[2] This statement ignores dynamic effects. For example, Besley and Coate (1998) argue that the inability of current governments to bind the actions of future governments can prevent efficient policy choices even in a world where information is complete.

Just because deficiencies in market outcomes create a *possibility* for government action to improve matters, it does not follow that more extensive government intervention will do better in practice. The costs associated with public ownership and management of key assets and industries can be higher than the costs associated with inefficient market outcomes.[3]

The basic problem with public ownership is that it can often mean no effective ownership. Returns that would normally accrue to investors or owners are instead distributed to employees and consumers in the form of over-staffing, above market wages and conditions, or subsidized prices. Such political contests often waste resources as voters expend time and money to obtain income transfers that do not represent new sources of income or wealth. More importantly, however, nobody has a strong incentive to monitor enterprise performance and ensure returns are maximized when ownership of the returns is diffuse and uncertain.

2.1. The Importance of Information

Maximization of the gains from exchange requires accurate information on the values of goods or services to consumers. It also requires accurate information on the costs producers incur, which, in turn, depend on the values attached to alternative uses of particular resources. Generally, many different people each know only a small part of this mass of information.

In a market economy, individuals have an incentive to transmit private information to other decision-makers by responding to prices. The prospect of gains from trading exclusive rights to use and to transfer resources, and to deny access to others in the absence of agreed payments, prompts individuals and firms to reveal cost and benefit information. Prices therefore signal the value of producing goods or services to firms, and the costs of meeting demands for goods or services to consumers.

Information on current and future costs or benefits is usually unavailable to bureaucratic planners operating under "command and control". The disparate individuals who know costs or benefits often

[3] Hartley and Trengove (1986) present a formal model of publicly owned firms that further elaborates on some of the issues discussed in this section.

have no incentive to reveal what they know, and may even have strong incentives to conceal their knowledge. Thus, in general, markets utilize more accurate cost and benefit information than will be available to bureaucratic planners.

2.2. Incentives to Respond to Information

Efficient utilization of resources requires decision-makers to respond to cost and benefit signals. This is rarely a problem with private firms. Even in joint stock companies, share prices provide an easily observed and current source of information about managerial performance. The ability to purchase ownership shares and mount a take-over also encourages managers to provide a competitive return to shareholders. Managerial rewards and sanctions thus are closely linked to responsiveness to cost and return signals.

Public sector managers face weaker pressures to reduce costs. While politicians have an incentive to monitor the performance of public sector managers, they are usually more concerned to ensure politically powerful interest groups are satisfied than that resources are not wasted. The link between inadequate returns on public sector investments and a politician's re-election chances are too weak to make cost minimization a prime target of political monitoring.

Managers in the private sector also have an incentive to increase revenues as well as reduce costs. Their remuneration typically reflects both types of changes in company fortunes. By contrast, high information costs in the political marketplace typically mean that public sector managers receive much less from making good decisions than they pay for decisions that, with hindsight, turn out to be mistakes. This particularly applies to bad decisions with immediate and obvious costs, or good decisions with indirect or delayed benefits.

Excessive costs in public enterprises take a number of forms. Since a government can legislate to attenuate competition, there is an understandable tendency for those on the public payroll to seek, and obtain, a security of tenure that would not be possible where rival suppliers of the service may arise. This security of tenure is likely to diminish incentives to perform. Public enterprises are notorious for harboring inefficient work practices. Costs that amount to "feather bedding" can often obtain legislative approval, particularly with threats of strikes in crucial monopoly service sectors. Politicians may

also direct (or "encourage") public enterprises to favor particular suppliers. The beneficiaries will be a concentrated local vested interest with political influence. The costs will be difficult to associate with the non-competitive tendering process.

2.3. Differences in Technology

Private and public sector firms are likely to use different technologies to supply similar services. A private firm will attempt to pre-empt competitors by adding capacity as soon it expects it to be profitable to do so. These additions to capacity will tend to be small since the firm will anticipate that the next lump of capacity will also be built at the earliest possible date. Private firms in a competitive industry also continually search for new technologies that enable them to pre-empt their competitors by reducing costs or providing a superior product.

By contrast, a public firm in a monopoly position will have a tendency to delay construction so that it can build larger plants and better exploit economies of scale in the construction process. Management and monitoring costs will also be reduced when there are fewer plants. When investments are less frequent, however, the pace of technological change will be slower. This tendency will be exacerbated by conservative management practices that are biased against experimenting with new technologies or ways of doing things.

2.4. Capital Market Implications of Different Ownership Structures

Private capital markets allocate scarce investment funds to competing projects. Government ownership interferes with this process. It can often mean insufficient or excessive investment in infrastructure capital.

Access to investment finance is a major problem for many publicly owned firms. The returns to capital, having been previously transferred to consumers, employees or other suppliers, are unavailable to finance investments. Public enterprises thus often depend upon general tax revenues for investment funds. The acceptability of incurring costs then often depends on the government fiscal position, or political considerations, rather than economic fundamentals.

On the other hand, a government firm can borrow at an interest rate below the interest rate a privatized firm would have to pay on corporate debt, and especially below the average return investors would demand on its corporate equity. The lower rate of return may encourage investment in lower return projects. However, the rate of return on government-guaranteed debt is not the appropriate cost of capital for a public enterprise. The risks associated with a publicly owned firm are not reflected in returns on government debt and do not affect the required rate of return on that debt. In fact, an implicit or explicit government-guarantee that taxation will be used to avoid default on payments allows government to finance *consumption* or *extremely* risky investments at the *same* low interest rate. When private investments are very risky, the risk premium is high because the interest or dividend payments have to be funded by the income flow from the investment.

Private capital markets also allow those most willing to bear risks to do so. Risks associated with publicly owned assets are borne involuntarily, and often at great cost, by taxpayers, recipients of other government spending, or consumers. The use of taxation to pay interest is also very expensive. The tax-induced losses from compliance and collection costs and forgone economic activity are much higher than the typical returns on corporate equity.

2.5. *Inefficient Pricing*

Efficient resource use is unlikely when prices for a marginal unit of consumption fail to signal marginal cost.[4] Yet prices for electricity supplied by monopoly public utilities, or prices regulated by public bodies overseen by politicians, typically show substantial deviations from marginal costs. Whereas the marginal cost of supply varies by location and time of use, tariffs typically vary by customer type, and the purpose for which electricity is used, while time-related variations are absent. Higher prices for lighting and other uses with a low elasticity of demand violate the principle that the same good should sell for the same price.[5]

[4] This is not to say, however, that multi-part prices with fixed charges or infra-marginal price steps cannot be even more efficient than simple per unit prices equal to marginal costs for all units consumed.

[5] Different prices for different categories of customers are sometimes justified on the grounds that patterns of demand differ. Businesses purchasing electricity for lighting supposedly buy a greater proportion of their electricity during peak periods. However, higher prices for customer categories with higher peak demand do not give incentives for each user to economize on peak demand.

Another common practice is geographically uniform pricing even though rural customers tend to be much more expensive to supply. Such cross-subsidies appear to be more closely related to the political influence of different consumer groups than to any economic factors.

It is also very common to use block-declining (or more recently block-increasing) electricity tariffs that leave many customers on infra-marginal steps. Again, the same commodity can sell for a different price, while many consumers are inappropriately encouraged to consume when the cost of supply is highest.

Monopoly publicly owned utilities also often underpay for electricity co-generated by private firms. In particular, the price paid for electricity supplied at a bulk supply point is typically far below the price charged for identical electricity taken from the grid at the same point.

2.6. *Non-price Rationing*

A problem governments often face when they attempt to force publicly owned firms to cross-subsidize consumers is that the firm may respond to the low prices by limiting the quantity or quality of services supplied to the subsidized group. In the electricity industry, non-price rationing takes the form of blackouts and brownouts (voltage or frequency fluctuations), delays in connecting new customers to the grid, and other forms of poor customer service.

Non-price rationing of demand is, however, likely to be less efficient than higher prices. When demand is reduced by prices, the least valuable uses of the good or service are eliminated first. All consumption that is valued at less than the price being charged is voluntarily foregone. With non-price rationing, there is no guarantee that the least valued demand is eliminated first.

2.7. *Customer Service*

Publicly owned monopoly firms tend to be concerned primarily about delivering services as specified in a statute. By contrast, private competitive firms have an incentive to find and exploit any actions that can raise customer satisfaction and hence revenue.

2.8. Corporatization

Many of the costs of public ownership identified above apply to the most extreme form where there is continual and extensive intervention and oversight by politicians. The results of such intervention include poorly specified objectives, many contradictory objectives, external involvement in detailed management decisions and a weak relationship between managerial performance and managerial rewards or penalties.

Corporatization (as has been used extensively in New Zealand, for example) can eliminate some of these defects. The firm is re-constituted along commercial lines and given a separate board of directors, who are held responsible for the achievement of clear, narrowed objectives. Political directives have to be explicit and open to public scrutiny. Managerial rewards are closely related to achievement of the stated objectives.

Nevertheless, the legislation rarely specifies as narrow a commercial objective for the corporatized public firm as exists for private firms. This may partly reflect a desire to avoid the potential efficiency losses from exploitation of monopoly power, but it does reduce incentives to maximize net benefits.

Corporatization may also be favored over privatization as a way of retaining cross-subsidies or community service obligations. Even if this is not formally the case, corporatized entities are usually required to report to a legislature that will scrutinize cross-subsidies, along with employment and procurement practices.

Regulatory roles assigned to the corporation also can be misused to limit competition for customers and employees and restrict the adoption of competing new technologies. Outcomes of both the regulatory and commercial processes are likely to be superior when the two roles are placed in separate organizations.

The financial consequences of corporatization are, however, perhaps its most serious defect. Since the government retains a financial interest in a corporatized firm, it has an incentive to legislate to protect the firm from competition. Furthermore, if the government wishes to retain ownership of a vital public corporation in financial distress it

has no alternative to rescuing the firm. Even if a private firm is judged to be vital to the economy, the ability to mark down the value of assets and sell them to others means that physical survival of the firm is not tied to the financial survival of its current owners. If the managers of publicly owned corporations believe that government will always rescue them from financial distress, they will have reduced incentives to control costs.

As with all publicly owned enterprises, corporatized publicly owned firms also suffer by not having ownership claims, and returns to investments, traded in capital markets. There are no ready sources of information on managerial performance. Management usually is judged instead by reference to various accounting measures of profits, costs, market expansion and so on. These accounting measures reflect arbitrary rules, for example on depreciation or what constitutes operating and capital expenses. They also focus on past performance rather than likely future performance as is reflected in share values.

Furthermore, the market return on private ownership claims (or private debt instruments) reflects the costs of the risks associated with the income flow attached to those assets. There is no comparable source of information on the appropriate risk-adjusted rate of return on investments by a publicly owned firm. It will then be difficult to determine the efficient level of investment by the firm.[6]

2.9. Potential Offsetting Benefits of Public Ownership

Given these considerable defects of public relative to private ownership we are left to wonder why public ownership might ever have been seen as desirable. One answer is that public ownership provides greater opportunities for maximizing *political* returns. Favored groups of voters can be benefited as consumers, employees or other suppliers. As with tariffs, subsidies and many other policies, economically inefficient outcomes can persist where the benefits are concentrated on a small number of easily organized groups while the costs are diffused across many voters, each of whom pays a small amount.

[6] Securitizing the income flow to the government owners of the publicly owned firm may partially solve this problem. The government could float assets analogous to non-voting shares. The market return on those shares would reflect the risks of investing in the business — although there would also be a premium to compensate for the investor's lack of control over management decisions.

Even so, democracy, or competition between political parties, will have a tendency to limit political processes that are excessively wasteful. The key potential offsetting benefit from public ownership is that it avoids the efficiency costs of private monopoly. Precisely because publicly owned firms are not profit maximizing, they do not have as strong an incentive to exploit monopoly power. Thus, while political oversight may produce inefficiencies, it also may avoid costs associated with restrictions on output and accompanying excessive prices.

The balance of the costs and benefits of different institutional arrangements will also depend on other features of the political, social and economic environment. For example, an uncompetitive political system may produce less effective regulation of private monopoly power, but also greater misuse of public ownership for political purposes. The net result could be either an increase or a decrease in the relative efficiency of private *versus* public ownership. As another example, many of the potential capital market benefits of private ownership could be lost if domestic financial markets are not sufficiently well developed. Similarly, if potential private investors are not confident that property rights will be enforced they are unlikely to commit to large capital investments. Uncertainty about regulatory procedures or taxation arrangements also can severely attenuate incentives to invest. On the other hand, ineffective legal, political and capital market institutions will have far more pervasive effects than limiting the efficiency gains from privatizing electric utilities. Such a situation may be more an argument for reform of those institutions than an argument against privatizing electric utilities, although the question of the best sequencing of reforms still needs to be addressed.

2.10. Privatization and Revenue Maximization

A major obstacle to successful privatization is that governments often focus on the revenue raised by selling assets. While a low market value for assets can indicate that the government has not established an efficient industry or regulatory structure, a very high sale price can indicate that the market structure is monopolistic. Certainly, the government can usually maximize the sale revenue of the assets by maximizing the extent of monopoly power for the privatized entity. This will be a mistake. A more efficient market outcome is the goal of privatization. The sale of assets should not be motivated by the ability

to retire government debt, or even worse, finance current expenditures, from the proceeds.

3. Technological Change in the Electricity Supply Industry

The arguments presented above regarding the balance between private and public ownership for the most part cannot explain the recent *change* in attitudes toward the electricity supply industry. Klein and Roger (1996) suggest that it is "disenchantment with the performance of regulated or nationalized firms." Admittedly, research from academic economists, the World Bank, the OECD and others has documented the relative inefficiency of public as opposed to private firms.[7] Nevertheless, factors other than evidence or experience have influenced the change in sentiment toward the role of regulation and public ownership in electricity supply.

3.1. Economies of Scale in Generation, Co-generation, Renewable Energy Sources

New technologies, particularly combined cycle gas turbines, have greatly reduced the economies of scale in building new electricity generating plant. There has also been extensive research into gasifying coal before using combined cycle gas turbine technology rather than simply burning the coal in a furnace to produce steam.

Other trends have reinforced the tendency to build smaller gen-

[7] See, for example, Bishop and Kay (1988), Boardman and Vining (1989), Shirley and Nellis (1991), Kikeri, Nellis and Shirley (1992), Galal, Jones, Tandon and Vogelsang (1994) and Megginson, Nash and Van Randenborgh (1994). The authors of a recent World Bank Report (1995) note that the best empirical work compares the performance of publicly owned enterprises before and after privatization, divested with publicly owned enterprises, or divested firms with a hypothetical situation in which the same firm is assumed to continue under public ownership. They conclude (p. 37) that:

> In competitive markets this literature gives the edge to the private sector ... Where (the enterprises) operate in uncompetitive markets, the results and interpretations are less clear.

In one study where privatizations improve welfare in 11 out of 12 cases, the authors note (p. 38) that:

> The gains came primarily from improved productivity, increased investment, and better pricing; they occurred in both competitive and monopoly markets, in part because the regulatory framework for the monopolies was sound enough to allow private firms to function efficiently and to protect consumers.

erating plant. Environmental concerns have lead to an increased interest in using waste gases from coal mining or sewerage treatment, waste heat from industrial processes, and small hydro-electric plants to co-generate electricity. Most of these projects also involve low capacity electricity generating plants. Finally, many other projects for utilizing renewable energy sources, such as wind, solar or wave power, typically involve small capacity generating plants. Although these are unlikely to make a significant contribution over the next 10 to 20 years, they are major future forces.

A more competitive wholesale electricity market has become much more feasible as a result of the trend toward smaller capacity plants. The more competitive market has also encouraged technological development to proceed most rapidly in smaller scale electricity generating projects. The market is very rapidly becoming one that will be supplied by many producers, each of whom will be looking for every opportunity to increase supply when electricity prices are high. In this competitive commercial environment, there is less of a need for extensive government involvement or oversight. Governments are also not ideally suited to bearing the increased commercial risks now inherent in the industry.

3.2. The Falling Costs of Information Technology

Advances in computer technology have been essential for developing competitive wholesale electricity markets. Optimization problems are solved in real time to schedule generators for supply or standby status. In addition, computer and communications technology is needed to monitor how much electricity has been bought or sold by each market participant.

3.3. Advances in Metering Technology

The cost of sophisticated electricity meters has also been falling rapidly. It is now feasible for even moderate to low volume consumers to be charged prices that reflect the time-varying marginal costs of supply. Consumers then have an incentive to change the time at which they draw power — thus evening out the demand load and lowering the need for expensive new generating capacity. Producers who can supply electricity at alternative times also have an incentive to increase supply when demand and prices are at their peak.

Unless the wholesale market is competitive, however, sophisticated metering could be more harmful than beneficial. There is no point signaling current prices to consumers or producers if those prices are not truly reflective of the actual costs of supply.

3.4. Transmission Costs

Substantial technological changes in electricity transmission technology have also increased competition in wholesale electricity markets. The current capacity of an 800 kV alternating current (AC) line is around 2 000 MW. An anticipated figure for future 1 200 kV lines is 5 000 MW. A realistic maximum distance for an AC transmission is around 1 200 km.

The recent technological breakthroughs, however, have been in high voltage direct current (HVDC) transmission. The most powerful HVDC transmission used today has a capacity of around 3 000 MW, but an increase by a factor of at least two is within the capabilities of existing technology. More significantly, there are no practical limitations of line length for an HVDC line. A typical HVDC line design can have less than 50% of the losses associated with an AC line of the same power transfer capability. The per km construction costs of the HVDC line are also considerably less. However, the fixed terminal costs for HVDC equipment preclude the use of HVDC except for long lines or other special situations.

4. The Electricity Supply Industry in Australia[8]

Australia has massive and cheap coal reserves[9] with more than 80% of electricity being generated by coal. There are also substantial reserves of natural gas, but these are largely used for supplying peak demands. The Snowy Mountains hydroelectric scheme and some

[8] The summary description of the Australian industry is taken from http://www.esaa.com.au/fib.htm, which is maintained by the Electricity Supply Association of Australia (ESAA).

[9] For example, the Victorian Treasury has observed that Victoria has brown coal reserves amounting to more than 42 gigatonnes, or in excess of 1 300 years supply at current production levels!

smaller hydroelectric plants supply about 5% of the total electricity demand, and up to 20% of peak loads, in the southeast Australian grid.

The eastern Australian states have about 30 000 MW of installed capacity and total annual electricity demand on the order of 110 TWh. Electricity accounts for more than 18% of Australian's total final energy consumption. The residential sector consumes around 30% of the electricity generated while industry takes about 50%. Australian annual per capita electricity consumption, of around 8 400 kWh, is the ninth largest in the world. Electricity consumption grew at an average of 3.8% per annum over the last decade.

Australia's industrial and residential electricity prices rank fourth and third lowest respectively among OECD countries. They are bettered in the developed world only by countries with abundant hydroelectric resources.

Most of the load centers are located on the southeast seaboard of Australia. Inter-State electricity trading is through the National Electricity Market (NEM) currently connecting New South Wales (NSW), the Australian Capital Territory (ACT), Victoria and South Australia (SA). Queensland (Qld) is expected to join the NEM by 2001, while Tasmania may also join after 2000. Western Australia and the Northern Territory are not expected to be included in the national grid for some time because of their isolation.

4.1. The Restructuring Process in Australia

The electricity industry in Australia has undergone substantial, but as yet incomplete, restructuring in the last decade. The impetus for electricity reform built throughout the 1980's. A 1982 report to the Victorian state government (Centre of Policy Studies, 1982) advocated separating generation from transmission and distribution, and privatizing the generators. The report also highlighted the inferior performance of the vertically integrated publicly owned State Electricity Commission of Victoria (SECV) compared with a privately owned generator in the same state as well as overseas utilities using similar technologies (see also Hartley and Trengove, 1984 and Hartley, 1984).

In the decade or so prior to the early 1990's, the electricity industries in the U. K., Argentina and Chile were also extensively restructured. These reforms included wholesale markets for electricity, a relatively novel concept that the industry watched closely. Although the U. S. industry had used bilateral exchanges of electricity

to minimize production costs, even to this day the U. S. has not introduced a national multilateral wholesale trading market.

The privatization of many former public enterprises in the U. K. was closely watched in Australia, as was the privatization and corporatization of many enterprises in New Zealand. Both Australia and New Zealand also embarked on programs of trade liberalization and economic reform in other sectors of their economies throughout the 1980's.

An Industry Commission report (Industry Commission, 1991) documented the inferior productivity of Australian electricity utilities relative to foreign privately owned counterparts. Poor performance by the monopoly utilities owned by the state governments came to be seen as a serious impediment to further economic reform in Australia.

On 21-22 November 1991, a meeting of state leaders in Adelaide agreed that the Trade Practices Act[10] (administered by the Australian Competition and Consumer Commission or ACCC) should be independently reviewed to determine its capacity to secure a national competition policy. The subsequent Inquiry (Hilmer Committee, 1993) drew attention to excess market power held by public monopolies, such as in electricity supply, and showed how this is likely to impede the introduction of effective competition. It called for monopolies to be dismantled and for regulatory restrictions on competition to be removed.

The Hilmer Report identified three separate types of structural reform that may be required in any particular industry:

- The separation of regulatory and commercial functions to avoid a potential conflict of interest in a competitive market.
- The separation of natural monopoly elements from potentially competitive activities, because control over access to a natural monopoly might be used to stifle competition, or deter new entrants into the market.
- The separation of potentially competitive activities by splitting entities with substantial market power into a number of distinct competing entities.

After accepting the conclusions of the Hilmer Report all states and territories, meeting as the Council of Australian Governments

[10] The *Trade Practices Act* governs anti-competitive market behavior in Australia and in its original form exempted state government businesses from its purview.

(COAG), agreed in April 1995 to promote competitive market conditions under the National Competition Policy Agreements ("NCP Agreements"). The NCP Agreements established a set of principles for the structural reform, and oversight of prices, of public monopolies.

In May 1996, the governments of NSW, Victoria, Qld, SA and the ACT executed an inter-governmental agreement to introduce the National Electricity Market (NEM) through legislation ("the National Electricity Law") to apply in each jurisdiction. The guiding objectives in building the NEM were determined by the NCP Agreements and included:

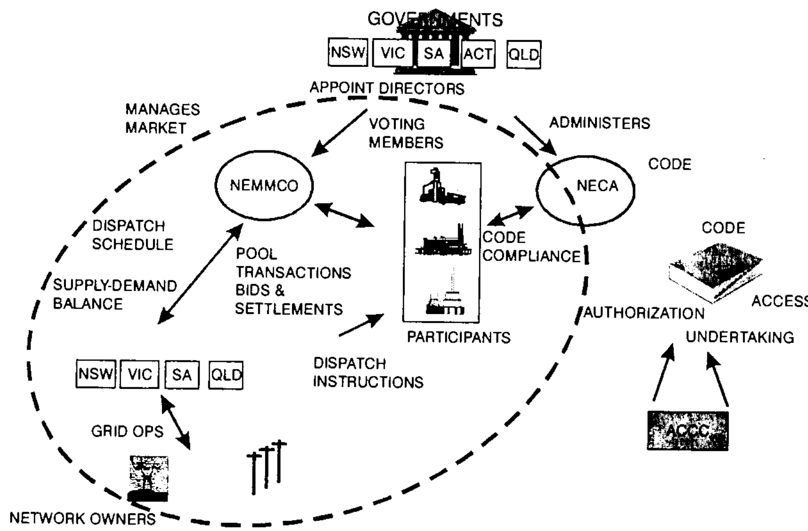
- Freedom of choice for electricity buyers.
- Non-discriminatory access to the interconnected transmission and distribution networks.
- Merit order dispatch based on bid price.
- No discriminatory legislative or regulatory barriers to entry for new participants in electricity generation or retail supply.
- No barriers to inter-state or intra-state trade.
- Uniform and cost reflective grid pricing.

The first stages of the NEM commenced April 1997. Following the Code being authorized and accepted as an access undertaking by the ACCC, the fully operative national market started in early 1998. The structure of the NEM is illustrated in Figure 4 (taken from Treasury and Finance, 1997).

The National Electricity Market Code (the NEM Code) that governs the operation of the NEM provides for:

- Prudential and technical requirements that need to be met to participate in the market.
- Daily bidding by generators of a price schedule at which they are willing to supply, and rules for the dispatch of generators on a five-minute dispatch cycle according to market demand and the bid price schedules.
- Determination of spot prices for electricity in the wholesale market as a time-weighted average of all five-minute dispatch prices in each thirty-minute trading interval.
- Establishment of the National Electricity Market Management Company (NEMMCO) clearing house and specification of its trading functions.

Figure 4. Relationships within the NEM



- NEMMCO powers of intervention to prevent avoidable load shedding.
- Requirements and obligations for the production and publication of market information.
- The conditions and procedures for market suspension.
- The procedure for making settlements between buyers and sellers based on spot prices and the quantities bought and sold during each half-hour settlement period.

The minimum spot price is zero. The maximum spot price is the Value of Lost Load (VoLL), which is set by the NEM Code Administrator and is currently $A5 000 per MWh.

To be eligible to participate in the NEM, a generator must have at least 30 MW capacity at the sent out point connected to the national grid. Generators must accept payments at the spot price for any part of their generation that is dispatched. NEM customers also must pay the spot market price for any output they take from the national pool. Sellers and buyers can also directly negotiate long term contracts. *There is no direct physical transfer between the two parties under contract.* Sellers and buyers would in effect sell to and buy from the pool at the spot price. Any difference between the spot price and the contract price is then payable to the party who would be worse off at the spot price compared to the contract price.

Buyers and sellers can also trade standardized forward contracts through the Sydney Futures Exchange. Traders in financial forward market contracts can also participate in the national wholesale electricity market after paying registration fees.

Generators and customers also pay transmission charges that depend on the average costs over a "typical" year of getting their power either to or from Sydney or Melbourne (where two pool prices are deemed to apply). The ACCC regulates transmission charges. State governments regulate analogous "distribution charges" for using lower voltage networks.

The state governments also regulate retail electricity prices for customers who are not yet eligible to select suppliers. As of July 1998, customers in NSW and Victoria whose annual consumption exceeds 160 MWh, and who have a special meter, can select competing suppliers. If they choose a supplier other than the local distributor, they have to pay a regulated charge for using the local distributor's distribution network.

The NEM Code requires a public and transparent process for implementing any changes to the transmission grid. Previously such deliberations were undertaken within the confines of the vertically integrated monopoly electricity suppliers. The NEM Code also envisages "entrepreneurial" interconnects. There are location specific components in transmission prices, and businesses will be allowed to propose new lines, and charge those using the facility, where they spot an opportunity for profit. However, the precise means of arranging for such charges has not been fully explored.

A fundamental difficulty in implementing a more market-driven approach to transmission investments is that the current NEM Code does not produce transmission prices that adequately reflect the marginal value of changes to the transmission system. A market-driven system would require a competitive market for electricity (and also for reactive power)[11] at each "node" on the transmission grid.[12]

[11] This is needed to ensure the electrical stability of the transmission system. It is not even traded in the wholesale market at this stage. Perhaps the best that could be hoped for in this regard is that options for future market developments are not precluded by the existing arrangements.

[12] The distributors have resisted the development of separate "nodal prices" that depend on the time of day. They prefer local prices that are simple "mark-ups" on "representative" pool prices at a small number of nodes with well-developed futures markets based on the prices prevailing at those "representative" nodes. With time-dependent nodal prices, the differential between local and "representative" prices would vary over time, decreasing hedging opportunities and increasing risks. The difficulties associated with such completely decentralised prices have probably been over-stated, but no electricity system in the world has yet developed a fully operational market that truly reflects transmission costs.

Moreover, the system controller can direct new developments and augmentations with the costs borne collectively, albeit after a public investigative process. A "free" resource of this nature tends to freeze out the opportunities for profit-driven activity.

4.2. Restructuring of the Industry in Victoria

Meanwhile, in parallel with the national developments, radical reform was occurring in the state of Victoria. A new government was elected in 1992 following a fiscal crisis promoted by the excessive spending of the previous administration. The credit rating of the state government had been substantially downgraded and interest payments on state debt were a significant part of annual government expenditures.

The analysis of the state electricity industry that had been completed over the previous decade provided a basis for reform. By 1993, the SECV was carrying almost $A10 billion of debt, and 30% of its revenue went to pay interest on that debt. Electricity prices in Victoria were 40% above the then most efficient Australian state (Qld) and well short of world's best practice, despite Victoria having an abundance of relatively low-cost brown coal and large natural gas reserves. Construction costs of new plant were 60% higher than would be expected under best practice, while generation availability was around 65% compared to current availability standards in excess of 90% (see Treasury and Finance, 1997).

The new government decided to dismantle and privatize the formerly publicly owned and vertically integrated SECV. In August 1993, the SECV was divided into transmission, generation and distribution entities. Following corporatization of these entities, substantial efficiency gains were realized. In 1995, generation and distribution were further disaggregated before being privatized through trade sales. Many of the winning bidders were consortia linking Australian firms with foreign (particularly U. S. and U. K.) private utilities.

As of mid-1998, almost all of the former SECV generating stations have been sold. There are now four major coal-fired, privately owned generating stations supplying electricity to NEM from Victoria. Some of the new owners have spent substantial sums restoring the stations to levels of efficiency that have astonished industry observers.[13]

There are also two smaller coal-fired stations, one of which was already privately owned before the SECV was privatized, and three relatively small hydroelectric stations (also now in private hands). The two relatively small gas-fired stations remaining in government ownership will be sold at the end of 1998. The hydroelectric capacity of the Snowy Mountains scheme will also be established as a corporatized entity in 1998 and allowed to trade into the national market on a commercial basis.

The interconnector between Victoria and NSW currently has a capacity of 1 500 MW (roughly equal to the capacity of one of the large coal-fired stations) while up to 300 MW can be supplied from SA. Following construction of an undersea link, from 2 001 up to 300 MW of hydroelectric power will also be able to be imported from Tasmania. Several small, independent power producers also operate co-generation facilities in Victoria.

A competitive wholesale market for electricity was started in July 1994, with interstate customers in NSW, SA and the ACT allowed to participate from May 1997. Because of the large number of competitors supplying to this market, very little gaming has been seen particularly by comparison with the U. K. market where the government created an effective duopoly. The Victorian experience has shown that there is much to be gained and little to be lost (in terms of economies of scale or scope) by having each generating station owned by a different private firm. As the Victorian Treasury and Finance Department (1997) notes:

> Experience since disaggregation of the Victorian generation industry has demonstrated that the generators have performed well in terms of:
>
> - increasing production efficiency;
> - increasing availability and reliability;
> - reducing operating costs;

[13] One of the stations, Hazelwood, which is over thirty years old, had been scheduled for decommissioning by the SECV. However, according to its new owners (http://www.hazelwood-power.com.au/), "the future of Hazelwood appears to be a long one. In fact, our planners are already looking at mining issues and plant maintenance schedules forty years from now".

> - reducing capital expenditure; and
> - achieving reduced prices and improved profitability.
>
> Such gains were unlikely to have been achieved with fewer generation companies.

Notwithstanding the results from (defective) econometric analyses, no material loss of economies of scale appears to result from disaggregation to the plant level.

The government also privatized the high voltage transmission grid in Victoria in 1997. The new private owner, PowerNet Victoria (PNV), is responsible for maintenance to ensure the existing high voltage transmission network performs to required standards, and also for building any extensions to that network that have been approved by the Victorian Power Exchange (VPX). The VPX is an independent statutory authority, which was established in 1993 to manage the wholesale electricity market and ensure system security. The Victorian Department of Treasury and Finance (1997) explained the rationale behind the creation of PowerNet and the VPX as follows:

> The Victorian electricity supply industry was the first in the world to separate the transmission and system control and market functions. Transmission is a regulated monopoly, with a key factor in setting PNV's transmission charges being the value of PNV's transmission assets. This may give PNV incentives to favor investment in transmission assets over system improvements that do not increase PNV's asset base. To avoid this potential conflict, the investment decision-making role has been separated from transmission ownership and placed with VPX. VPX is suited to this independent role because it lacks direct commercial interests which favor any particular network solution. VPX is specifically structured to be able to assess the trade-offs between investment options in an independent manner. There are also strong synergies between the investment decision role and VPX's other roles.

Under the NEM many of VPX's functions and responsibilities will be transferred to NEMMCO. From around mid 1998, transmission planning and other residual activities now carried out by VPX will be handled by a new statutory corporation, Victorian Energy Networks Corporation (VEN Corp).

The distribution business of the SECV was separated into five regionally based and now privately owned businesses. Each of these businesses has an effective monopoly over the distribution network within its region and a monopoly to retail electricity to non-contestable customers within its region. The monopoly over customers will be phased out in accordance with a timetable set by the Victorian Government. Customers with demand above 5 MW (about 47) were given choice in December 1994, and customers with demand above 1 MW (about 330) in July 1995. In July 1996, choice was extended to about 2 000 customers consuming over 750 MWh of electricity each year. From 1 July 1998, choice will extend to more than 8 000 customers consuming more than 160 MWh each year. Finally, from January 2001, all of Victoria's more than 2 million electricity customers, including domestic customers, will be able to choose their electricity retailer.

Customers who contract with a supplier other than their local distributor need to have a half-hourly meter installed, with a communications link to the market settlement system. The link enables the meter to be read remotely, for the purpose of settling the wholesale market. Contestable customers can buy from other retailers with a distribution franchise or registered independent traders. As of November 1997, there were 12 of the latter traders, many of them electricity distributors from other Australian states.

There has been real competition for contestable customers in Victoria. One of the distributors, Powercor reports (http://www.upl.com) that, as of December 31, 1996, they held about 46% of Victoria's contestable market (including contestable customers in their own area). Overall, more than 40% of contestable customers have contracted for power with a non-host retailer. This is similar to the U. K. experience, but in New Zealand only 7.5% of power is sold by a non-host retailer. This may be because all customers in New Zealand are contestable and it is difficult for small users to justify the added metering costs. This is likely to change, however, as metering costs fall (Treasury, NSW, 1996).

The proceeds from the privatization process in Victoria were all used to retire debt. The assets were sold for world record prices — almost $A23 billion ($U.S.14 billion) for the five distributors, three brown coal generators, minor hydro-electric assets and Victoria's high voltage electricity transmission network.[14] The resulting reduction in

[14] Participants in the process have told me that the high prices were justified because the competitive market structure gave buyers confidence that the government would not intervene and modify the rules or regulations in the future.

State debt has saved Victorians more than $700 million in interest payments in 1996/1997, allowing state taxes to be reduced and improving the state government's credit rating (Treasury and Finance, 1997).

The Australian experience has shown that creating a significant number of competing players in the generation market, with an independent transmission grid, and creating capacities for customers to choose their distribution company or retailer, can substantially reduce prices. While precise information is not readily available for commercial reasons, the press and the Office of the Regulator General (1997) have reported that electricity prices for contestable customers in Victoria have fallen about 10% on average and up to 40% for some customers. The pool price for wholesale electricity now averages close to $A15 per MWh (about US1¢ per kWh) compared with about $A40 at the start of the Victorian pool and $A45-60 for bulk supply in NSW before deregulation. This price may rise, however, as more power is bought at pool prices rather than on contract.

Table 1. Measures of Service Quality in the Victorian Electricity Industry

	1990/1991	*1993/1994*	*1996*
Average system outage (minutes)*	490	251.7	175
Availability of generators	79.8	82.7	92
Monthly residential disconnections		2 800	1 380

*Source: Office of the Regulator General in Victoria. Measurements prior to 1994 excluded the 12% of electricity distributed through the municipal authorities, which were generally far inferior to the SECV.

The Victorian process has also shown that privatization and cost reduction need not be at the expense of customer service.[15] Table 1 provides some indicative measures of supply quality in the Victorian industry in the period before and after privatization. It is notable that privatization has reduced the number of disconnections for non-payment. Conscious of their image in the communities they serve, and of the scope to save costs of reconnection (the charges for which are commonly set below their costs), the private businesses have taken steps to avoid disconnecting customers.

[15] A reduction in product quality needs not always be an inferior outcome for consumers. It is also not clear that *all* consumers should bear the increased costs of higher system reliability that might only be desired by some.

The adjustment to privatization and competition in Victoria has also imposed costs on some. The Latrobe Valley (where the larger brown coal generating stations are located) has experienced substantial reductions in electricity and coal mining jobs, with flow-on effects in other industries. In the past, many state governments in Australia insulated their electricity businesses from competition as means of providing more jobs than were required for commercial operations. However, whenever government insulates businesses from competition and structural change the resulting inefficiencies are manifest in higher prices for their consumers and reduced competitiveness for their business customers. State governments in effect both taxed consumers through excessive electricity prices and subsidized the operations of their utilities by accepting a low rate of return on the assets. In Victoria, the $A150 million net profit of the SECV in 1992 represented a return of less than one per cent on the $A23 billion at which the various businesses are valued. This poor performance is compounded by the fact that the SECV charged prices that were far higher than justified in a commercial market.

4.3. Electricity Reforms in NSW

Victoria's northern neighbor, NSW, has followed a different path in reforming its electricity supply industry. Prior to the reforms of the 1990s, the distribution businesses in NSW were operated as 25 separate entities owned by local and municipal governments. Apart from some private co-generation in the large industrial centers, the generating capacity was a state-owned monopoly, Pacific Power.

In July 1991, Pacific Power introduced an internal electricity market known as ELEX. Although this market evolved in detail over several years, it was basically a wholesale spot generation market in which output was purchased at spot prices within Pacific Power and on-sold to distributors and to direct customers under previously agreed tariff arrangements.

As part of the ELEX market, business unit profit centers and internal charging were instituted, allowing the performance of the different units to be more easily compared. The less efficient generators within Pacific Power were pressured to reduce their costs, resulting in increased plant availability, reduced start-up times, reduced fuel oil usage, and other improvements in operating efficiencies.

The ELEX market also provided experience trading in a wholesale electricity market prior to the introduction of the NEM.

As a step towards setting up the NEM, the states agreed to split their vertically integrated power authorities into transmission and generation units. In NSW, Pacific Grid was first formed as a wholly owned transmission network subsidiary of Pacific Power. The high voltage (over 132 MW) transmission network assets were transferred to this entity, which was fully separated as a statutory authority (now known as TransGrid) in February 1995.

TransGrid is responsible both for network planning, and for the power exchange and system security services. In Victoria these functions are split between PowerNet and VPX. Housing responsibility for system security and transmission network augmentation within one entity, as in NSW, gives rise to perverse incentives, particularly when augmentations are paid for by a levy on other bodies.

In May 1995, following the April, 1995, COAG meeting, the NSW government issued an Electricity Reform Statement. This statement detailed its position on restructuring the industry in NSW. The reforms included establishing an interim state wholesale electricity market, pending the implementation of national market arrangements.

On 30 June, 1995, an amendment to the Electricity Transmission Authority Act required TransGrid to implement a wholesale electricity market in NSW by the first quarter in 1996. At the same time, the government announced the amalgamation of the 25 distribution authorities in NSW into six larger state-owned corporations, each of which has financially separate retail and distribution functions. Subsequently, it announced that two generation corporations Macquarie Generation and Delta Power would be split from Pacific Power. In choosing to form *portfolios* of generators, the NSW government was influenced by (flawed) econometric studies claiming to find economies of scale beyond a single generating station. Delta has four stations with a total capacity of 4 240 MW, Macquarie has two stations with 4 640 MW capacity while Pacific Power was left with the newest station, which can generate 2 640 MW, together with a 5 MW wind farm and some hydroelectric plant. Pacific Power also has plans to add about 450 MW of gas-fired plant. Delta and Macquarie each have over twice the capacity of the largest Victorian generator and over three times the capacity of the largest Queensland generator.

In March 1996, the six NSW distributors and the two new generators were corporatized and the first stage of the NSW wholesale electricity market commenced. Generators bid in a limited fashion to produce a supply schedule, with trading taking place at an administered price. From May 1996, the pool price was set by supply and demand and participants could enter into forward contracts using the Sydney Futures Exchange. This market remained in place until replaced by the NEM in the middle of 1997.

Meanwhile, in June 1996 the NSW Electricity Reform Taskforce released recommendations for introducing competition into the retail electricity market. Under these proposals, successively smaller customers were allowed to bypass their local electricity distributor and purchase directly from the wholesale market. The timetable adopted was:

- October 1996 - customers with annual consumption in excess of 40 GWh.
- April 1997 - customers with annual consumption in excess of 4 GWh.
- July 1997 - customers with annual consumption in excess of 750 MWh.
- July 1998 - customers with annual consumption in excess of 160 MWh.
- July 1999 - zero threshold.

Following corporatization, the NSW electricity businesses reduced costs largely by reducing employment by between 10 and 25%. The failure of the largest distributor, Energy Australia, to downsize further has, however, been criticized. The *Australian Financial Review* reported that a consultant recommended that Energy Australia reduce its workforce from 3 800 to 1 800 in order to obtain costs competitive with its private sector rivals from Victoria. The board's rejection of this led to the resignation of the CEO.

In 1997, the NSW government floated the idea of privatizing the electricity generating companies. NSW government revenue from its electricity assets in 1997/98 is estimated to be $A656 million in dividends plus $A221 million in tax equivalent payments. In early 1997, Arthur Andersen valued the assets at $A22 billion. The returns therefore represent a less than a 4% return on capital. The $A22 billion estimate may, however, be conservative. Since the NSW industry is one third larger than that of Victoria, $A30 billion might be expected. At that valuation, the present return is a little under 3%. Even placing

$A22 billion from electricity asset sales into long term Australian government bonds would yield $A1540 million per annum at 1997 interest rates. Despite these and other arguments offered to the government of NSW at the time, the idea of privatization was rejected by the majority of party members including in particular the trade unions representing the electricity workers.

4.4. Operation of the Market between NSW and Victoria

Detailed information on the operation of the NEM in Australia is readily available on the web. Weekly and monthly reports are available at http://electricity.net.au/vpx.html. Figure 5 shows the system demands for electricity in the two states for the week ending August 8, 1998, and, at the bottom of the graph, the wholesale prices in the two states.

Figure 6 shows the transfer of electricity between Victoria and NSW over the same week. During the week various events constrained the interchange from Victoria to NSW for 88 half-hour periods, reducing the flow of electricity north. While some weeks have significant amounts of electricity flowing south as well as north, in almost every week that the NEM has been operating there has been a substantial net shipment of electricity from Victoria north.

The Victorian spot price was normally slightly below the NSW price, but virtually never above it. We should expect to find similar prices except when there is a constraint on the transfer of power between the two systems. If the constraint applies to shipping electricity north, the Victorian price will be lower and vice versa.

While *spot* electricity prices in NSW and Victoria are now more or less equalized by trade between the states, only a small fraction of electricity is purchased on that basis. Much of it is still purchased under contracts at prices that are lower in Victoria, reflecting the more competitive market in that state. However, wholesale electricity prices should converge toward the spot prices over time.

Figure 5 also reveals a relationship between system demands and the wholesale price. Prices tend to be higher when demand is higher.

Figure 5. Market demands in NSW and Victoria and Wholesale Prices

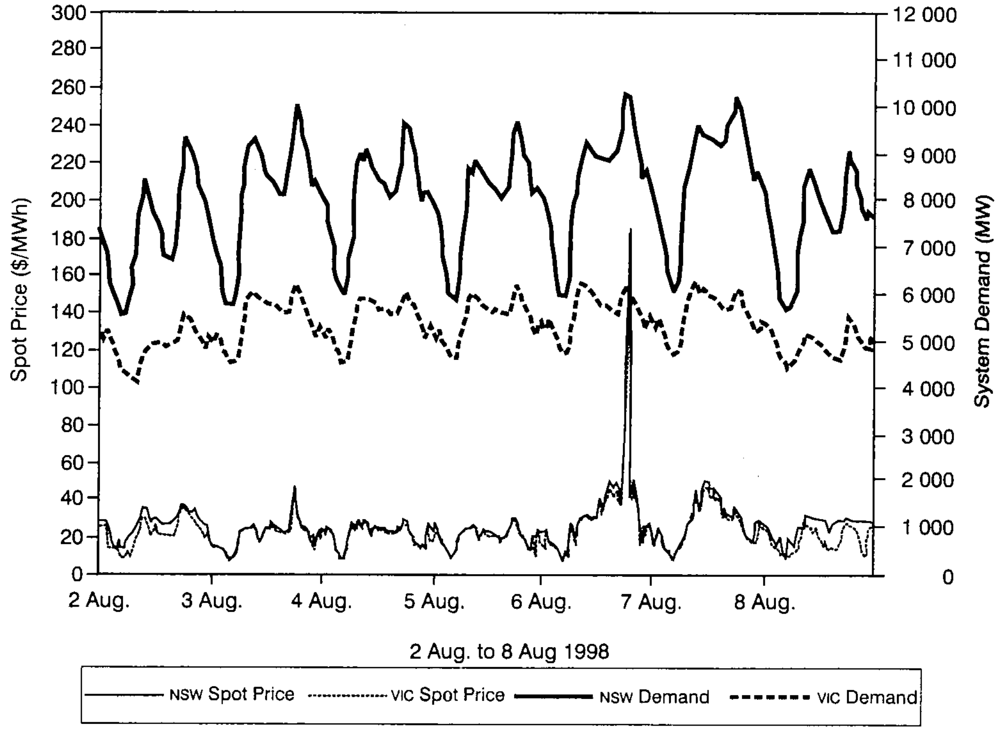
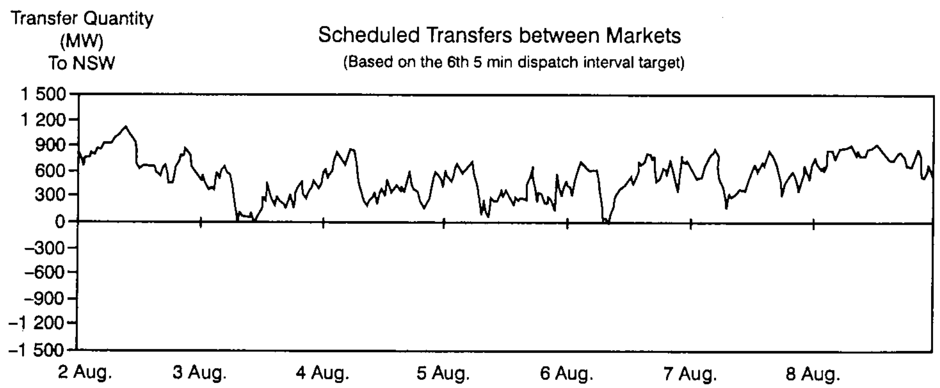


Figure 6. Electricity Transfers from Victoria to NSW



4.5. Generation Costs in NSW and Victoria

A particular "problem" for NSW is that its coal is more valuable than the brown coal in Victoria. While NSW black coal generators convert more coal to energy than do the Victorian brown coal generators, the cost of coal in NSW more than compensates for the difference. Coal mined in NSW is exported as both steaming and coking coal while Victoria's brown coal is unsafe to transport by ship since it can spontaneously combust. The cost of using brown coal in Victoria is the very low extraction cost[16] and this is well below the export price of NSW coal. Furthermore, the privatization program in Victoria, and the associated regulatory reform, has permanently reduced operating costs relative to NSW.

Tasman Asia Pacific has recently measured the productivity and costs of the electricity supply industries in Australia. The analysis provides some simple indicators of the productivity of capital and labor in the NSW and Victorian industries. These have been given in Table 2.

Table 2. Electricity Partial Capital and Labor Productivity Indicators

	1992-1993	*1993-1994*	*1994-1995*	*1995-1996*
GWh sold per employee				
NSW	2.55	2.84	na	3.68
VIC	3.22	4.44	na	4.65
Capacity factor				
NSW	55.5	53.2	52.7	53.8
VIC	60.8	64.3	na	63.4
Load factor				
NSW	64.6	64.9	63.2	64.5
VIC	69.9	na	67.6	74.5

Data source: BIE 1996 and Tasman Asia Pacific calculations based on ESAA data.

The explanation of the measures in Table 2 follows.

GWh sold per employee is an indicator of labor productivity. The labor needed to supply a given amount of energy also depends, how-

[16] The Victorian deposits are mined from open cut pits adjacent to the power stations. In most cases, the coal seems are well over 100 m thick with less than 20 m of over-burden.

ever, on other factors such as the density of customers, total length of network wires per customer, demand per customer and so on. The Victorian, but not the NSW, data also includes employees engaged in coal mining operations.

The *capacity factor* reflects average utilization of available generating capacity. It is calculated as the ratio of GWh generated annually to effective capacity in place (expressed as a percentage). A low capacity factor could indicate excessive plant failure, but it will also crucially depend on the shape of the demand load curve. If peak electricity demands differ greatly from average demand, the capacity factor will be low. The shape of the demand load curve will be partly influenced by factors beyond the control of the industry (such as weather patterns) but may also be significantly affected by electricity prices.

The *load factor* reflects fluctuations in the use of capital due to seasonal and daily fluctuations in demand. It is measured as the ratio of annual generation to the peak generated load (that is, peak demand * 8 760 hours *per annum*).

The indicators presented in Table 2 obviously cannot be taken as proof of the relative productivity of the two industries. Each of these measures suggests, however, that the Victorian industry is performing better than its NSW counterpart, and that privatization in Victoria has yielded additional efficiency gains beyond those associated with corporatization. Furthermore, there is a long history of private sector generators showing far greater operational efficiency than public sector generators. In Victoria, the privately owned and relatively small Anglesea power station consistently outperformed newer SECV stations. In more recent years the Loy Yang B station operated by Mission Energy has shown better labor productivity and availability factors than other Victorian generators. Since privatization, all three of the remaining major former SECV generators have shown marked improvements in efficiency as measured by GWh per employee and availability factors.

In terms of availability, five years ago both state systems averaged about 80% and have shown vast improvements over recent years. Three of the privatized Victorian brown coal generators now operate at over 95% availability, which is close to world's best practice. Impressive gains have also been made by NSW generators, though only one presently operates at the 95% availability level.

Forced outage rates have shown comparable levels of improvement in both states, although again the rates are somewhat higher in NSW.

4.6. *Distribution in NSW and Victoria*

Table 3 shows the relative size of Victorian and NSW retailers. There has been considerable debate about the optimum size for distributors and retailers. A complication in the debate is that the optimum size is dictated partly by geography and customer profiles.

World wide, there is a vast range of distributor sizes. In Switzerland, Norway and New Zealand, most distribution is undertaken efficiently by businesses that are smaller than all NSW distributors other than Australian Inland Energy.

In New Zealand, a 1989 Ministry of Energy report found the optimum size of distributors to be about 2 000 GWh. A report by London Economics (Treasury, NSW, 1994) showed much higher levels of scale economies — around 25 000 GWh or half the total NSW load. Again, however, this evidence is not persuasive in so far as it does not adequately distinguish between short run operating costs and long run capital expansion costs.

Victoria formed five distributors in an attempt to balance competitive pressures with a need to give each distributor a significant metropolitan and industrial load and a size that would attract international buyers. The Victorian distribution businesses appear to have demonstrated that there are no economies of scale beyond the 200 000 plus customer size. The smaller businesses consider that improved work practices and savings in overhead costs have resulted from bringing supervisory levels closer to the working operations.

While NSW amalgamated its previous 25 electricity distribution businesses into six firms, it has also opened the retail market to competition both between these firms and with new businesses. However, there are risks in creating a dominant retailer like Energy Australia in that it could exercise undue market power over customer information and line charges that could give it an unfair advantage over its competitors. Furthermore, the effectiveness of access regimes as a means of promoting competition in electricity retailing is debatable.

5. Concluding Remarks

Reform of the Australian electricity supply system is an ongoing process. While further experience with the new structure is needed

Table 3. Size of retailers in Victoria and NSW

Retail business	*Thousands of customers*	*Sales (000s GWh)*
Victoria		
Powercor	537	7.3
Solaris	234	3.5
CitiPower	233	4.4
United Energy	527	6.4
Eastern Energy	470	5.1
NSW		
Energy Australia	1 306	20.0
Integral Energy	681	11.8
NorthPower	336	3.4
Advance Energy	113	1.77
Energy South	218	3.4
Australian Inland Energy	21	0.3

Source: ESAA.

before the effectiveness of the reforms can be judged definitively, the experience to date nevertheless holds many lessons for other countries seeking to reform their electricity industry.

Corporatization in both NSW and Victoria delivered substantial cost savings relative to the old integrated public enterprise model, while privatization in Victoria yielded additional cost savings on top of those achieved under corporatization. These cost savings have also resulted in lower electricity prices without any deterioration in service quality. In fact, the privatized firms appear to be providing better service than the public enterprises they replaced.

The outcomes in Victoria and NSW also appear to refute the existence of economies of scale in electricity generation beyond the generating station level. Certainly, the privatized generators in Victoria are competing extremely well against the corporatized portfolios of generators in NSW. Since there is unambiguous evidence from the U. K. that fewer generators lead to efficiency losses from gaming in the wholesale electricity market, however, any country embarking on privatization and reform would be well-advised to sell each generating station as a separate firm.

The wholesale electricity market, along with competition for customers and new metering technology, has also meant that electricity consumers in Australia now face prices that are more reflective of marginal costs. It is perhaps too early to obtain definitive evidence of demand shifting in response to these new pricing regimes but anecdotal reports abound.

Despite the current over-capacity in the Australian supply industry there has also been renewed interest in co-generation from a number of firms. Co-generators can now benefit much more from high peak load prices then used to be the case in the past.

Perhaps the biggest remaining question is the effect of the new environment on long term investment. A backlog of potentially profitable co-generation projects means that new generation capacity will probably be added in small increments for some time. The interesting question is whether another large coal-fired plant will eventually be built or whether all new capacity will involve smaller plants than the ones currently in use.

It will also be very interesting to see how the NEM deals with investment in new transmission capacity. The current pricing formula for transmission services does not send the right signals to potential entrepreneurs interested in extending the grid. Market participants may need to become comfortable with the NEM before innovations such as time of day nodal pricing, or a market in reactive power, can be introduced.

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Market Foreclosure and Strategic Aspects of Vertical Agreements

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Abstract: This paper reviews the arguments about market foreclosure — as an incentive for vertical agreements between upstream and downstream firms — and its effects on welfare. We consider that downstream firms compete in quantities in the final good market and upstream firms compete in quantities in the intermediate good market. In this context we show that a vertical agreement must not contemplate market foreclosure, that is, upstream firms continues participating in intermediate market. Regarding antitrust policy, we show that even vertical agreements aimed at increasing input price faced by other firms may be positive from the welfare viewpoint.

Resumen: Este artículo revisa los argumentos respecto a la cerradura de mercado, como un incentivo a la formación de acuerdos verticales entre empresas fabricantes de un producto intermedio y empresas fabricantes de un producto final, y sus efectos en el bienestar. Suponemos que tanto los fabricantes del producto final como los del producto intermedio compiten en cantidades en sus respectivos mercados. En este contexto, mostramos que un acuerdo vertical no debe considerar la cerradura de mercado, esto es, las empresas continúan participando en el mercado intermedio. Respecto a políticas antimonopolio, mostramos que incluso los acuerdos verticales enfocados a incrementar el precio de mercado del producto intermedio pueden ser positivos desde el punto de vista del bienestar.

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