Australian Electricity Supply: Orientations to Growth and Prospects for Sustainability

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Abstract:

In the new competitive order, Australian electricity systems have been oriented to growth of electricity sales based on low margins and the capture of market share. Electricity is a premium fuel. The second law of thermodynamics testifies to this, as does the relationship between coal-fired electricity and the negative externality of greenhouse warming. Electricity prices should reflect its status as a premium fuel. Ease of transition in such a regime would be fostered by the taking up of options for energy efficiency and renewable sources of supply.

The Australian electricity supply system produced 216647 GWh of electricity output in the year ended June 2005. Queensland had the fastest rate of growth (27 per cent) from 2001 but, despite declines in production in given years, there was also significant growth elsewhere in the system. Growth was forecast to continue ahead to 2013-14, again most rapidly in Queensland (35.4 per cent). Electricity is of course a premium fuel with many specific uses in, for example, driving machines, electric lighting, refrigeration, arc welding and aluminium smelting. It also has more diffuse applications in water heating and the heating and cooling of building space. Electricity is therefore a ubiquitous input in economic activity, but the important question which will be posed is whether growth in economic activity requires growth in electricity use in lockstep. The decoupling of electricity use from economic activity and an associated diversification of electricity production towards renewable sources could gain impetus if the perceived dangers of greenhouse warming were acted upon. Coal-fired plant with its propensity for CO_2 emissions has been a mainstay of conventional electricity supply, and this is particularly the case in Australia. In the new era of planetary environmental concern, the Australian electricity supply system faces a strong challenge. The model of “business as usual” appears to be increasingly unsatisfactory, but other models characterised by less electricity intensity and greater diversification need to be more fully articulated and made more persuasive in terms of adoption.

1) The Australian electricity supply system and its growth orientation

The prevailing mode of Australian electricity supply in the 1970s was to make investments in production capacity in response to forecasts of electricity demand. The dynamics of this essentially engineering approach were upset by intrusive economic realities: rising fuel prices and interest rates (Kellow,1996). By the mid 1980s, economic reform as it applied to the electricity supply industry led to the separation of generation, transmission and distribution functions. Transmission remained a natural monopoly, but competition in the generation and distribution sectors was seen as the means to secure required improvements in efficiency. The other vector of economic reform which was pursued most resolutely in Victoria was privatisation. Private operation of generation and distribution entities reinforced the application of the competitive principle. A somewhat paradoxical outcome of this reform process is that the electricity supply system continues to be constituted on a strong growth basis.

Growth may be fed less by an engineering commitment to large blocks of supply, but it is fostered by competition between the various generation and distribution entities (generators may be linked to distributors via vertical integration), who are concerned to produce and sell electricity in a way that promotes an increase in market share (Booth,2000;Beder,2003). Big production units with declining unit costs and associated low margins of price or cost feeds through to an emphasis upon the attainment of large sales volumes.

Having focussed on a growth orientation, growth was in fact not such a feature of the largest system that of NSW, in which electricity generated grew by 1.9 per cent between 2001 and 2005 (from 64688 GWh to 65942 GWh). Growth was stronger in the second largest system that of Victoria (5.9 per cent), and particularly strong in the third largest system that of Queensland (26.9 per cent) (Energy Supply Association, 2006). Given difficulties of supply, South Australia's electricity generation declined slightly over the 2001-2005 period, while Western Australia (12.4 per cent) and Tasmania (6.5 per cent) showed robust growth. This overall growth in electricity produced often translates into an increase in electricity used per customer, ie more electricity intensive patterns of use. Whereas in NSW, electricity consumption per residential customer remained steady over the 1999-2005 period (both electricity consumption and the number of customers grew by just over 16 per cent), it grew by 4.3 per cent in Victoria and by a substantial 6.5 per cent in Queensland. Electricity consumption per residential customer fell by 1.8 per cent for the 1999-2005 period in South Australia, but grew strongly by 9.9 per cent in Western Australia and 10.3 per cent in Tasmania (Energy Supply Association, 2006). So while the residential customer base is increasing, so typically is the intensity of use of the residential customer. As for business customers, there has been some consolidation into larger groupings so that growth of the customer base is correspondingly less (in Victoria business customers fell between 1999 and 2005). Growth in electricity consumed has been typically much stronger than growth in the business customer base, so that electricity consumed per business customer increased from 1999 to 2005 by 9.2 per cent in NSW, by 34.9 per cent in Victoria, by 31.8 per cent in Queensland, and by 4.3 per cent in Western Australia. In South Australia and Tasmania growth in electricity consumption was outstripped by growth in the number of business customers, so that the electricity intensity of business customers declined. The basic characteristic of the scenario presented is one of electricity abundance, and there are implications arising from this state of affairs which are increasingly difficult to ignore.

The Australian electricity supply system is overwhelmingly based upon coal-fired plant. Thus black coal fired plant provided 95.4 per cent of NSW capacity and 77.4 per cent of Queensland capacity in 2005, while brown coal fired plant provided 76.4 per cent of Victorian capacity. NSW black coal stations emitted 923.8 kg of CO_2 per MWh sent out, while Queensland black coal stations emitted 904.3 kg of CO_2 per MWh sent out. For Victorian brown coal stations, the comparable figure was 1299.1 kg of CO_2 per MWh sent out (Energy Supply Association, 2006). These are the driving engines of Australian CO_2 emissions, and to the extent that the atmospheric build up of CO_2 and associated greenhouse warming is recognised as a global constraint in the face of which adaptations must be made, Australia's current level of reliance upon coal-fired electricity must be questioned. Though NSW, Queensland and Victoria stand out for their reliance on coal, fossil fuels are predominant throughout the Australian supply system. Gas turbines supplement coal use in Victoria (11.7 per cent) and Queensland (8.1 per cent). South Australia relies on a mix of brown coal and natural gas to raise steam for 59.1 per cent of its capacity. Gas turbines provide 20.1 per cent and combined cycle plant 19.1 per cent. Western Australia gets 39.4 per cent of its capacity from black coal and a multi-fuel steam raising option gives 25.3 per cent. Gas turbines provide 27.6 per cent and combined cycle 6.9 per cent. Tasmania relies mainly on hydro (88.1 per cent), with brown coal contributing 9.3 per cent. So though there is some variation away from the predominant coal reliant states, the overall picture is still one of almost complete fossil fuel dependence, and the prospect for adaptation in the face of a greenhouse warming constraint looms large.

For operators in the electricity supply system, however, business as usual remains a powerful principle. Electricity production (ie system energy, GWh) is forecast to continue to grow from 2004-05 to 2013-14: by 19.8 per cent in NSW, 11.3 per cent in Victoria, 35.6 per cent in Queensland, 8.6 per cent in South Australia, 20.0 per cent in Western Australia and 12.7 per cent in Tasmania (Energy Supply Association, 2006). A significant expansion of the supply system is therefore envisaged. In this regard, CO_2 emissions and greenhouse warming are not taken into account as an operative constraint. At best they are accorded the status of a theoretical possibility. If the envisaged system expansion takes place, it is likely to be based less on coal fired than on extra natural gas-fired capacity. This has some advantages in terms of a lesser rate of CO_2 emissions. But to the extent that greenhouse warming is a real constraint, it is not a convincing change of course. A significant change of course would entail investments in improved electricity use and greater reliance upon renewable sources of electricity. Hydro is an established renewable option, predominantly as already mentioned in Tasmania. Wind is the main other renewable source which figures in ESAA reports and it has established a bridgehead in Victoria, South Australia and Tasmania. Currently across the Australian electricity supply system there is nowhere near a critical mass of alternative options to move the system away from its reliance on coal and a continued orientation to growth. If we look for a circuit breaker, we must look first to electricity prices: here we have the primary signalling device which set at an appropriate level could provide the impetus to a change of direction.

2) The pricing of electricity

Over the period 1994-95 to 2003-04, inflation-adjusted residential electricity prices increased slightly in Victoria from 15.61¢/KWh to 15.65¢/KWh, and decreased in NSW and Queensland (from 12.03¢/KWh to 11.05¢/KWh, and from 11.97¢/KWh to 11.67¢/KWh respectively) (Electricity Supply Association, 2004). Elsewhere there was an increase in South Australia, a decrease in Western Australia and an increase in Tasmania. With the exception of South Australia, inflation-adjusted business electricity prices consistently decreased over the 1994-95 to 2003-04 period: thus in Victoria the business price went from 10.46¢/KWh to 8.40¢/KWh, in NSW from 9.41¢/KWh to 7.25¢/KWh, and in Queensland from 10.95¢/KWh to 7.63¢/KWh (Electricity Supply Association, 2004). In the era of a restructured electricity industry, distributors who set retail prices purchase wholesale electricity from generators. The retail prices cited above are reflective of a system in which the emphasis is upon the expansion of sales, with prices established at a low margin above unit costs. There is currently significant interconnection between the state systems to form a national market. Spot prices established in this market have historically been lowest in Victoria ($26.83/MWh in 2003-04) and highest in South Australia ($39.31/MWh in 2003-04). In most cases 2003-04 spot prices remained fairly steady into 2004-05 except in NSW, where there was a significant increase from $36.62/MWh to $45.33/MWh (Energy Supply Association, 2006). Contract prices usually display a premium over spot prices associated with the greater certainty of delivery, but they are also the staple means of establishing market share. If the system is stretched spot prices can peak: there does not, however, appear to be evidence of the exercise of market power by, for example, generators withholding capacity. All in all, the creation of the national market has confirmed the competitive orientation of Australian electricity supply with its emphasis upon favourable prices to consumers. Regulation providing for price caps has reinforced this tendency.

The demands on an electricity system vary significantly through time. Typically plants with higher capital costs and lower running costs provide base load generation; while plants with lower capital costs (greater ease of start up) and higher running costs meet peak load demands. With respect to the Australian systems a major summer peaking problem has emerged linked to air conditioning demand. Thus in Victoria peak demands have been growing at 2.4 per cent per annum compared to 1.9 per cent for average demand growth (Energy Supply Association, 2005a, p.4). Current tariff structures are a blunt instrument in relation to the specific nature of this demand. A tariff which matched the marginal cost placed on the system by peak demand would provide incentives for better system design and allocation of load across the system. Of course tariffs which were responsive to the timing of demand across the system would require the installation of more sophisticated metering devices. These issues need to be addressed. Then there are the issues to do with general system expansion. Forecasts of projected increases in electricity production and consumption have been referred to. The Energy Supply Association predicts that in the years to 2020 the Australian electricity system will require $11 billion of investment in generation and $30 billion in associated infrastructure (Energy Supply Association, 2005b, p.1). In such an expanding system it is imperative that the price of electricity be matched to long run marginal cost, so as to enable the required investment to be financed. With electricity prices equal to long run marginal costs, consumers would pay the appropriate price to meet the cost of an expanding system: a scenario is also established where other options, for instance investment in end use efficiency or renewable sources of supply, compete with conventional supply options on an equivalent basis.

3) Greenhouse warming as a negative externality

Australia has a predominantly coal-fired electricity supply system. Black coal stations in NSW and Queensland emit 928.8 and 904.3 kg of CO_2 per MWh sent out, and brown coal stations in Victoria top this at 1299.1 kg per MWh sent out. Given the scale of coal-fired generation across the Australian system (and given also the supporting role played by natural gas as a fuel), Australian electricity supply makes a significant contribution to global CO_2 emissions. The Stern Review of Climate Change notes that current global CO_2 levels are 430 ppm, and that to stabilise these between 450 and 500 ppm would require CO_2 emissions to be at least 25 per cent below current levels by 2050. Against this, global CO_2 emissions are currently rising at more than 2 ppm each year (Stern N,2007,pp 218-219). There is on-going scientific discussion of these matters, but there is also increasing recognition that global temperature rise (greenhouse warming) will have climatic consequences that will have the potential to produce considerable economic and environmental damage. In economic parlance this is a negative externality: these are spillover costs which lie beyond the conventional costs associated with production and use. Negative (and positive) externalities are well recognised in economic theory. But they are not usually actively incorporated in decision making formulae: the negative externality associated with greenhouse warming, however, demands to be addressed.

In principle a price would be established for a tonne of CO_2 emissions which matched the damage that such a tonne of emissions would do. To operationalise this principle estimates of damage are used to establish targets for CO_2 emissions. Given a target a price for a tonne of CO_2 emissions can be arrived at by determining quotas and allowing them to be traded. Such schemes have been established internationally and are increasingly talked about in the Australian context. A more direct method would be to impose a tax on a tonne of CO_2 emissions which enables the target for overall emissions to be reached. The directness of this method makes it politically sensitive. The desirability of matching electricity prices to system long run marginal costs has been referred to. If on top of this there is an extra layer of electricity prices linked to putting a cost on CO_2 emissions, we have a dramatic departure from the present regime of “low cost” electricity. There would be substitution away from coal-fired plant with implications for coal industry employment, and potentially painful decisions for consumers about the extent of their recourse to space heating in winter and space cooling in summer etc. The more painful the transition and the more economic hardship experienced, the more dismal the scenario of adjustment to the imperatives of climate change. But a different possibility is that there could be significant ease of transition associated with a more flexible approach to electricity supply, bringing in the prospect of supply savings via adjustments at the point of end use and also by resort to a more diverse array of supply options.

4) The principle of sustainability and the relevance of the soft energy path

The idea of sustainability in relation to the use of energy is embodied in the second law of thermodynamics, which states that while energy is neither created or destroyed it is inevitably dissipated in use. Thus while the quantity of energy is maintained in an energy using process its quality will be degraded. From this perspective, a precautionary note is sounded in relation to processes which make intensive use of energy. We have seen that growth in Australian electricity supply has been such that growth in electricity consumed has exceeded growth in customer numbers, making for a trend of increase in electricity used per customer (both residential and business). The second law of thermodynamics was translated by Amory Lovins into the soft energy path, which builds around the idea that the quality of an energy source should be matched to that of an energy task (Lovins A, 1977). Efficiency in second law terms is hereby provided. A high grade energy source such as electricity should as far as possible be used in high-grade applications such as arc welding and driving machines. To use electricity in low grade applications such as space heating is tantamount “to cutting butter with a chainsaw”. On this reckoning, the Australian pattern of increasing electricity intensification per customer is indicative of significant wastefulness in use. There needs to be greater focus on the uses to which electricity is put and a corresponding assessment of alternative ways in which the ultimate task (machine operation, lighting, space or water heating, etc.) might be performed. This orientation leads to the building of a soft energy path made up of economic investments in improvements in end-use efficiency (insulation, leak plugging, etc.) and renewable sources (solar, wind, etc.), which are well matched to the requirements of the energy using task.

Investments in improved efficiency of electricity use in residential and industrial/commercial applications will be economically profitable if the electricity price is such that the value of electricity saved provides over time an economic return on the capital invested in the efficiency-improving investment. Electricity prices should as we have seen be related to the long run marginal cost of the electricity supply system. Of fundamental importance in this regard are any increases in capital costs linked to the making of requisite additions to the capacity of the system. Any additions to conventional fuel costs which might be connected with system expansion will also need to be considered. In the 1970s, depletion of oil resources loomed as a possibility. Rises in oil prices fed through to coal and natural gas and on to electricity, and a train of energy efficiency improvements was set in motion. There continue to be energy observers who point to vulnerabilities associated with the world oil reserves to production ratio (Heinberg R,2003), but the predominant current concern is the link between fossil fuel generated CO_2 emissions and greenhouse warming. To the extent that this negative externality is taken account via a carbon emissions trading regime or the direct institution of a carbon tax, there will be a pronounced increase in the price of coal-fired electricity. In a bleak scenario this could lead to widespread dislocation. But given a viable array of investments in improved electricity use in residential and industrial/commercial applications there could also be considerable ease of transition. The Australian Productivity Commission (2005) reviews the prospects for improving energy use efficiency in the Australian context and finds considerable potential for increases in efficiency (Australian Productivity Commission, 2005). Household appliances can be made more energy efficient, as can residential and industrial/commercial buildings, and there is much scope for auditing and improving the efficiency of energy using processes in the industrial and commercial sectors. An appropriate level of electricity prices will provide a powerful incentive to embark upon such programs of improved efficiency of use, but attention also needs to be paid to institutional and informational impediments which could hinder the achievement of desired goals. The Productivity Commission broadly favours private sector standards for energy efficiency improvements rather than the imposition of a national energy efficiency target. The key issue will be the market response to an increased electricity price linked to a designated carbon price; somewhat against the thrust of the Productivity Commission, it seems likely that government involvement will be called for to ensure momentum and direction in this process (which may take other forms than the imposition of a national energy efficiency target).

In 2005 renewable energy sources supplied 18.2 per cent of Australia's total electricity generating capacity which stood at 44889 MW. The predominant source was hydro and of that Tasmanian hydro. However, other renewable sources such as biomass and landfill also made a contribution, and wind was also establishing a presence in Tasmania, Victoria and South Australia. Renewable sources are characteristically diffuse and somewhat variable: their nature in the Australian context is examined in S. Dover, ed, *Sustainable Energy Systems* (1994). The capture of renewable sources requires a capital investment and, once again, there is an economic return to this investment given the savings on fuel costs (and likely extra capital costs) compared to conventional coal-fired capacity. In the presence of a carbon tax the avoided fuel cost bill is bumped up and a wider range of renewable sources are likely to become economically viable. While renewable sources provide diverse and flexible options, there may be a reservation about their ability to meet base load requirements. At this point the temptation may be to think nuclear. If coal in the presence of a carbon tax becomes more expensive, nuclear in terms of its capital and operating costs would certainly be competitive. However, if we impose a carbon tax to address the negative externality of greenhouse warming in the case of coal, surely we cannot ignore the negative externalities of the nuclear fuel cycle, linked to the possibilities of reactor accidents, the problems of long term waste disposal, the potential for weapons proliferation, etc. A commitment to renewable sources of electricity supply avoids both sets of negative externalities. It also offers the real prospect of bringing on positive externalities, such as employment generation, the development of new skill sets, and the promotion of more diversified settlement patterns, thereby favouring regional development. Australia is well placed to take a leading role in renewable energy development, and the inherent possibilities which are being brought out in the debate over climate change should be actively pursued.

5) Conclusion

At existing levels of electricity prices there exist opportunities for investments in efficiency improvement and renewable sources. The range of these opportunities will vastly increase if electricity prices rise to accommodate a carbon tax, which is matched at the margin to economic and environmental damage arising from greenhouse warming. Price is a powerful incentive to action, and it is important that it reflects the relevant elements of cost. Current Australian electricity prices do not do this: they provide a low margin on capital and operating cost and are linked to an overall strategy of sales maximisation. Even with prices at an appropriate level, however, with all the relevant elements of cost covered, a shift of momentum to a different direction of investment may not be easy to achieve. Customers, whether residential or industrial, who have been used to tapping in to grid-supplied electricity may not easily envisage the viability of alternative options. Difficulties associated with accessing relevant information is one aspect of this, sheer institutional inertia another. Market calculations can generate comparative rates of return for different investment, but for the investments to be undertaken resources have to be mobilised and relevant deployment decisions made. There is a role for government to participate in and expedite this process. The tendency in Australia has been to restructure the electricity industry and allow for private sector operation. The restructured industry is still based upon conventional, ie coal-fired, production however. What we envisage here is a new set of energy efficiency and renewable options, which will look ever more prospective in the presence of a carbon tax, but which will need to be pursued in an effective way. Government sponsored investment programs need not predominate in this arena, but they could help to establish relevant pathways. Targets for energy efficiency improvements, for example in buildings have been mentioned. Also relevant are greenpower programs, which enable electricity users to source their electricity from renewable providers. Beyond this it is possible to envisage a public investment program based on the achievement of positive externalities (and the avoidance of a dominant negative externality) and also predicated on lower rates of time discount thereby enabling a longer investment time horizon. With such a framework of calculation a new realm of energy possibilities can be brought into view, where sole reliance upon the private sector would see much less accomplished. Wind energy is a supreme case in point. Wind has made some inroads in the southern Australian states. Worldwide experience suggests, however, that wind's potential is much greater, including the provision of increments of baseload electricity. Governments could provide a lead in relation to wind energy investments with a view to eliciting the contribution which this technology is capable of making to the enhancement of energy supply. If this principle was pursued across the spectrum of energy efficiecy and renewable options, a rich store of possibilities would be unveiled: we have in one sense a stategy of adaptation, but it is a strategy of adaptation which is capable of generating significant overall improvement.

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