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SUPPLEMENT

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Competitive and Centrally Planned Decision Making in the ELECTRICITY INDUSTRY

Comment by Lewis Evans and Neil Quigley

Introduction

In recent months there has been substantial public discussion of the increase in the wholesale electricity price in New Zealand, and the prospect of rationing of electricity supply to non-critical users during periods of peak demand during the current winter. Price increases and the potential for rationing result from the (statistically) extremely unusual coincidence of circumstances facing the electricity industry at present. These circumstances include

- very low rainfall in areas that imply low inflows to hydro storage lakes,
- high rates of economic growth increasing the demand for electricity,
- sudden very substantial write-downs of gas reserves in known fields, and
- high prices for alternative uses of gas in the form of methanol.

Discussion of the issues facing the electricity industry has elicited from some commentators the suggestion that centralised government management of entities in the electricity sector, and in particular, central government planning of investment in generation capacity, would have avoided the current problems and will reduce the likelihood of similar problems in the future. This suggestion is based on a view that higher electricity prices and potential shortages of electricity reflect a failure of the current model of competition between state-owned and private sector generators and retailers of electricity. In this paper we provide an evaluation of this view.

The Electricity Industry: An Overview

Electricity is an industry characterised by high levels of technical complexity, the need for co-ordination of continuous delivery of electricity to meet demand, and the need for co-ordination of transmission security and investment. These needs are met using sophisticated electronic communication and analytical tools to co-ordinate decentralised decision making by competing market participants.

Co-ordination

Co-ordination is critically important in two areas of electricity: the first is the co-ordination of the delivery of electricity to meet demand continuously and the second relates to the co-ordination of transmission and generation investment.

Because electricity cannot be economically stored, supply has to be matched to demand continuously at each instant in time. This is done through the spot market where at each point in time the dispatcher matches demand to supply using least-cost offered generation, across roughly 240 grid exit and injection points subject to the state of capacity of the transmission network. At the same time the quality of electricity is maintained by ancillary services such as voltage support and frequency control supplied by actions of the dispatcher and other (increasingly) automatic means.

The spot market provides co-ordination of short term supply and demand, establishes spot prices based on demand and the supply prices bid by generators, and provides surety for payments between market participants. The spot market deals only with offers to buy and sell electricity in this market: other activities, including long-term supply and hedge contracts, are outside it. Indeed, the effect of these other long-term arrangements is that only a proportion (unknown but say 20-25%) of total electrical energy is transacted at spot market prices.[1]

This decentralised co-ordination means, for example, that generator owning plants on a river system can independently decide how best to manage them subject to environmental resource consents and any other local factors, including recreation and availability of water, and offer electricity to the spot market accordingly. This approach enables decisions to be taken by those with the best local knowledge and efficiently negotiated solutions to local issues.

System Capacity and Investment

System capacity is determined by generation, transmission and distribution capacity. Demand and generation interact in determining desirable grid capacity, and a governance structure that provides for some co-ordination and enforcement of rights relating to transmission and generation investment is required.[2] Investment in generation and transmission are to a degree substitutes for the other because investment in generation requires transmission unless it is close to demand. Locational choice of generators affects the demand for transmission, and congestion (transmission capacity) affects spot prices at different locations on the grid thereby providing incentives for low cost location of generation.

Transmission investment is complicated by externalities produced by AC-current electricity which follows all available paths to an extent determined by the paths' relative resistances.[3] Where there are interconnected loop networks in the transmission grid, investment in a path that relaxes congestion on that particular path will also affect the capacity of other paths. This externatlity effect poses issues for the establishment of property rights on parts of the transmission grid and therefore issues in tying costs to the beneficiaries of investment. New Zealand is fortunate in this respect because its grid has limited loop flows as it is to a large extent a long network with only one or two significant loops. It has a long section that is DC electrical energy that does not suffer the externality problem.

A related issue concerns the ability and desire of some beneficiaries of transmission investment to free-ride on the investment of others even when there are no loop flows. This is complicated in New Zealand by the fact that the congestion rentals or profits[4] of the grid are not held by the transmission owner. Instead, they are passed through to parties

1 Long term arrangements include contracts of various sorts. They can, and, in many cases are designed to, ensure that the buyer and seller is insulated from the spot price.

2 The new electricity governance structure currently under consideration explicitly provides for such a regulatory arrangement.

3 For a discussion of the economic issues implied see Steven Stoft, *Power System Economics*, 2002, IEEE, Wiley.

4 When relative spot prices are high they produce congestion revenue over and above the value of energy losses: much the same way that good quality land can produce rents as compared to low quality land.

connected to the grid in order that the grid owner not profit from grid congestion. Together with the legal requirement that generation and retail energy companies must be separate from distribution lines companies, this allocation of congestion rentals engenders a separation between the benefits and costs of transmission investment. It may be argued that the separation is addressed contractually where beneficiaries of transmission investment negotiate and pay for grid and lines investment that Transpower or local lines companies implement. However, to overcome the free rider problem a regulatory governance structure is required that allocates and enforces associated grid property rights.

In all conceivable grid governance arrangements there are investments that relate to the performance of the grid that require investment by the grid owner. Here, as elsewhere, the interaction with regulatory rules is critical if such investments are to be carried out to an appropriate extent. There are different approaches to regulating the grid in different countries. In New Zealand Transpower as grid owner is in essence required to set charges for the use of its grid in such a way that a) imparts some volatility and unpredictability in charges to connected customers and b) which has a problematic effect on its financial position for any new investment it implements. Such regulatory arrangements can be expected to affect investment under either a decentralised or heavily centralised system.

Prices in the Electricity Market

The electricity market establishes prices both for long-term contracts and sales on the spot market. The role of prices is to convey information and accountability so that decentralised co-ordination and competition take place. Prices that reflect scarcity are critically important for the location and amount of generation investment as well as for the location and management of load (demand). Only if prices reflect scarcity will demand be appropriately responsive to the cost of energy. The long-term prices reflect the commercial judgement of suppliers and demanders of the future price of electricity, and the spot prices reflect the congestion of the grid, electricity demand and the relative supplies of fuels at the time of dispatch.[5]

The short-term co-ordination function of spot prices reflects common knowledge of the system combined with a competitive tension. The prices offered by other generators affect the offers from any particular generator that are accepted by the auctioneer: thus, there is generally an incentive to offer generation at the cost of the fuel that will be consumed by the generation activity.[6] This cost varies enormously across catchments over time, depending upon past and expected future catchment inflows and across thermal plants depending upon their fuel type. This cost variation imparts uncertainty about other participants' cost structures that renders price co-ordination across the generators uncertain, and therefore provides competitive tension. This competitive tension is mitigated somewhat by the fact that each generator knows the state of all the hydrological systems at each point in time and this knowledge too will affect offers. However, since no generator knows the commitments of other generators outside the spot market, or their expectations about the future and hence the value they place on fuel, competitive tension remains and is reflected in the offers made.

In common with all markets for an undifferentiated good, the electricity price is set by the marginal cost of supply (and this is true for both the spot market and for hedge contracts). Where gas is the most expensive fuel used it will set the price of electricity even though approximately 65% of total electricity is provided by hydrological generation. Of course in periods of water shortage we have

5 Graeme Guthrie and Steen Videbeck ("The Marginal Cost of Electricity: what is water worth?" Competition and Regulation Times, July 2002) explain how the spot prices reflect the value of water.

6 See Kevin Counsell, "Uniform vs Pay-As-Bid Pricing in Multi-Unit Auctions", *mimeo*, ISCR (www.iscr.org.nz), 2003.

the alternative of hydro-generation setting the price in the market.

There should be no differentiation in electricity price across fuel sources for the following reasons:[7]

- Electricity is a homogeneous transferable good, the source of which is usually impossible to identify, and hence its use in any demand should carry the same price;
- The opportunity cost of electricity is the same for all units of electricity in that economising on a unit of electricity from any source will reduce the use of the marginal fuel (gas);
- A high price across all units will induce hydro investment and innovation and a search for substitutes for gas: to price according to the cost of electricity by produced fuel type would de-couple price and scarcity of fuel and yield the perverse outcome of negligible demand-side management or conservation in times of water scarcity; and
- If each unit of electricity earned only its long run marginal cost[8] there would be no incentive to supply unless directed; particularly since investment is sunk, uncertainty is so important and centralised schemes are especially subject to variations across different government administrations.

The Link Between Prices and Investment in Generation

Most investments in electricity are sunk and have long engineering lives. Viable investment therefore requires long-term security of fuel supply and confidence in long term demand.

Investment decisions relating to generation may be affected by the signals provided by a spot market but, as with fuel supplies, it will be the prospect of long-term contracts of electrical energy that will provide the surety required for investment in generation. Although small reliance would be placed upon the spot market prices directly, in matching supply and demand over time and in various hydrological conditions the prices established in this market will importantly aid the development of expectations about the prospects for secure generation investment.

Spot prices are particularly effective in reflecting the state of the transmission grid and the constraints built into it. Price differentials across the grid show where congestion (losses and constraints) occur and represent the direct cost of transmission.[9] Under a decentralised system these prices provide incentives for bid and offer adjustments as well as act as network investment signals. The prices and quantities at the nodes in the grid reconcile the different expectations of the various market participants. This occurs because from the bids and offers of different parties that may have different expectations the auctioneer chooses only those that match demand and supply at least cost. The prices may or may not be replicated in a centralised system, but even if they were they would not imply incentives for actions to be taken as a result.

As with any commodity market, predictions of future market conditions are very difficult as they reconcile both expectations of the future and expectations about what other participants think of the future. The electricity industry in New Zealand provides the advantage of ensuring that competitive tension between generators increases the payoff to accurate assessments of the value of investment in future generation capacity. Investment decisions in the New Zealand electricity market reflect diverse expectations of the future including expectations about the performance of potential investments in renewable energy and other fuel sources.[10]

7 In these we assume that gas is the marginal fuel.

8 Marginal cost is the cost of one additional unit generated. There is typically no unique marginal cost as it depends upon expectations of the future about factors such as fuel prices and technical change.

9 Nodal price differentials essentially give the price of transmitting electricity between them.

It has been argued that competitive spot prices on a grid will not be high enough to cover the fixed cost element of generation costs and therefore that the resultant level of investment in generation may be too low. In fact, it will never be economically worthwhile to invest in a grid to the point that all constraints and losses are eliminated. There is thus no reason to expect prices and revenue to be so low as to not cover fixed costs of generation. Under the decentralised structure, in contradistinction to the centralised approach, the short run fuel cost of water in times of shortage is much higher than it is at other times. These periods provide rents that go to covering fixed costs and justify maintenance of, perhaps older higher cost, generation plant the practical use for which is limited to periods of high prices driven by fuel shortages.

Both the demand for electricity and the availability of fuel to generate electricity may vary to a significant extent through time. The storage of the New Zealand hydrological system is very low by world standards but it is unlikely to be desirable to build an electricity system which functions "normally" in even the most extreme hydrological and climatic conditions. It may be extremely costly to build generation capacity that allows the electricity industry to survive dry winters without significant increases in prices, since the cost of the additional generation capacity required over and above that for a normal year will be built into the base costs of the generators. In other words, cost increases in years when fuel is in short supply can only be avoided by building generation capacity that will increase all electricity prices across the market in all years. Those firms who are now expressing concern about the impact of high prices on their profitability have in the past had the benefits of lower prices resulting from the decision not to build generation capacity capable of dealing with every dry year scenario.

The incentives for investment are to a significant extent affected by factors that are external to the industry. In particular, Government policy settings relating to the environment may be particularly important in any assessment of both the cost of gaining approval for and building new generation capacity, as well as the payoffs to the operation of that generation capacity. In this respect, the Government's acceptance of the Kyoto Agreement, potential changes to the Resource Management Act, and evolving policies on conservation and renewable energy sources signal significant but as yet unspecified changes in costs (level of specific taxes) relating to different sources of fuel in the industry.

Central Planning Applied to Electricity

Central planning is now thoroughly discredited as a model for the organisation of the economy as a whole. The poor social, economic and environmental conditions of the countries that formerly made up the Soviet bloc provide ample evidence to support this view.[11] Centralised control in democratic systems raises some different issues, but the core problems of central planning transcend different political systems.

Central planning requires that the competitive tension relating to current operations and future investment, and the prices and contracts which co-ordinate this decision-making, be replaced by and internalised within a bureaucracy. The staff of the planning agency may undertake vigorous debate about the level, type and location of investment, but this can never replicate the outcome of a market structure. While the view may be reached by consensus and may incorporate a portfolio of activities, it

10 See Chris Daniels, "Outlook brighter for New Zealand's power problems", The New Zealand Herald, 4/5/03 for a list of diverse generation sources contemplated and their state of approval and comment on investment since 1996.

11 See, for example, World Development Report 1996, published for the World Bank by Oxford University Press, 1996.

cannot enable different (competing) views to be applied in a way in which decision makers are accountable for their actions. In fact, reaching a consensus generally entails trade-offs that eliminate the more remote and innovative prospects. For example, competition has produced consumer gains by providing generation investment in locations that are closer to load than was true under the centralised ECNZ system.

A key difference between centrally-planned and competitive industry structures is in their use of prices. In competitive markets higher prices provide information about demand and supply, and about the likely return to investment in new generation and/or transmission capacity. Higher prices are both the signal that new investment capacity would be an efficient use of society's scarce resources and an incentive for generators to undertake that investment. At the same time, higher prices provide those using electricity with incentives to conserve it, including through investment in more efficient appliances.[12] In contrast, one of the key problems with central planning is the fact that the plan cannot be based on the signals provided by market prices precisely because the market is absent. Planning systems may create administered prices, but these are complex and imperfect substitutes for the prices formed in markets through the self-interest decisions of actual market participants. Administered prices in centrally-planned markets are generally more rigid (since the planning structure is slower than markets in responding to new information) and less directly related to the key costs in the industry. For example, in electricity a government agency may set the price of electricity at the long-run costs of generation, but this will not provide consumers or any commercial entity planning investment with appropriate signals about the scarcity of energy. Price variation over time in response to hydrological conditions reflects the varying scarcity of water in ways that administered prices cannot.

Central planning and management performs poorly where technological change is occurring. This is because technical change is by its nature inherently uncertain. In a competitive market uncertainty will be reflected in different firms adopting and developing different technologies. Central planning and management has no role for this type of decentralised decision making, and essentially imposes "all or nothing" technological choices on the industry.

These all or nothing choices make it clear that central planning in the electricity industry would have an impact on the economy as a whole. The planned outcome is one that consumers of electricity have to live with, whether or not it is optimal, because the planning system precludes the implementation of alternative strategies by (for example) different generators and the reaction by those utilising electricity according to the state of the system. The planning process may meet the needs of the largest firms in the economy because they will be most effective in communicating and having their needs incorporated into the planning process, but the broader evolution of electricity demand in New Zealand will be much less certain, and difficult to incorporate into the planning process. Nor will it enable appropriate valuations of resources imparted by prices that would affect the activities of other actual and potential industries.

Central planning will consistently result in misallocation of resources for major investment projects. This is because the incentive of managers within the planning system is to get government to commit to projects by underestimating their costs and overestimating their benefits.[13] Once the project is approved, the absence of

12 Specifically, the current increase in prices serves to induce thermal generation to replace hydro-generation and demand side reductions to conserve water.

13 This leg may also occur in de-centralised enterprise.

commercial incentives to contain costs and meet deadlines further undermines the efficiency of the investment. In New Zealand, the Marsden B generator provides the pre-eminent example of the costs of centrally-planned electricity generation investment, though the underinvestment in telephone network capacity by the state monopoly in the 1970s and 1980s demonstrates that this was not an isolated problem.[14] In addition, the centralised ECNZ coped badly with its forecasts, investment and low-inflow years in the past.[15] Electricity prices set under the competitive market structure have on average been well below those which the centralised ECNZ sought approval for in 1991, and there is no reason to expect that a return to centralised management would result in better performance.

The rationale for central planning is usually couched in terms of national economic benefits, but in practice central planning is usually the outcome of a political process that is designed to provide benefits for particular groups in society. For example, higher prices for electricity impose costs on businesses that are heavy users of electricity and exposed to the spot market price, but this should not be confused as being in conflict with the national interest. Moreover, democratic political systems increase the complexity of discerning the "national interest" from the planning perspective, because different governments have different views and the actions of the current government do not bind future governments. In these circumstances, subsidising those industries that are heavy users of electricity would be more efficient, and provide for greater political accountability, than the imposition of a central planning system.

Conclusion[16]

The prospect of shortages of electricity this winter does not indicate any failure of the competitive market structure. In addition, there is nothing about the history of central planning in New Zealand or in other countries that suggests that we could be confident that it would have avoided the current problems facing the electricity industry or that it can do so in the future. Central planners are no more able to foresee the future than are managers of competing firms. They suffer the disadvantage of not having price signals formed from the interaction of competing firms in the market to guide their views about the scarcity of energy and the payoff to new investment.

The critical events underlying the prospect of a power shortage are by their nature all extremely difficult to forecast. The sudden writedown of reserves reminds us of the very great uncertainty of gas-field capacity even when the fields are known and being utilised. This is particularly a problem in New Zealand where we have so few fields. The economic output of the economy and the price of methanol are each very hard to forecast: even so, those whose welfare depends upon forecasts of these factors must reach a view about their levels in the future. Normally, in such cases it is better to have multiple guesses and actions taken about the future than the imposition of a single view as under central administration. In the case of electricity, some form of regulation is required but it need not remove advantageous elements of decentralised decision making.

New Zealand may be entering a period which is fundamentally unlike the past in that there is not a plentiful supply of gas, water is scarce, there are additional environmental constraints and there is even more uncertainty about optimal investment strategies. Pending technological innovation and the sudden

14 Real prices and investment approvals fluctuated substantially over time and by the mid 1980s there was substantial congestion."The Economic Efficiency of Telecommunications in a Deregulated Market: the case of New Zealand", with David Boles de Boer, *The Economic Record*, 72, 24-35, 1996.

15 See John Culy, *Electricity Restructuring: towards a wholesale electricity market*, NZIER, 37, 1992, and Galvin BV, Secretary to the Treasury. Review of Electricity Planning and Electricity Generation Costs (Treasury Paper to Minister of Finance). Wellington March 1985 [the McLaughlin report].,

16 In this short note we have not examined certain issues. We consider that they would enrich but not change our review of the pros and cons of centralised decision making. These include the controversial issues of vertical integration of retail and generation and the vertical separation of lines and energy. We note that both forms of integration have some synergies: vertical integration in the management of risk, and lines and energy in managing network losses and electricity to households. We take the same point about the state owned generators, while they are separate entities we consider that they are an important part of a decentralised system that has competitive pressures. Finally, we note that if there are substantial economies of scale in electricity, centralised management may lower costs over a decentralised system: however, this comes at the cost of competitive tension that normally engenders more innovation and dynamic change.

discovery of large gas reserves, all the economic and policy signals suggest higher real costs of energy in the future, no matter what the system. Thus, it is likely to be more important than in the past that all facets of the economy face the opportunity costs of the resources they use. Economic history tells us that this is difficult to achieve in a centralised system. The ability of foresters, farmers, fishers, canoeists and hydro generators (for example) to reconcile their water demands in times of plenty and scarcity requires consideration of the value of water in alternative uses. These reconciliations will ideally vary with localised and national water conditions, changing demand and local issues. Decentralised decision-making in markets with prices that reflect these choices will provide the most effective means of managing competing demands in the future.

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