MARKET-BASED PRICING AND DEMAND-SIDE PARTICIPATION IN THE ELECTRICITY POOL OF ENGLAND AND WALES

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Abstract

This paper focuses upon the workings of the electricity pool of England and Wales. Created as a generators' pool, with the twin objectives of preserving order-of-merit dispatch and setting marginal-cost pricing signals, it is now evident that the system may not provide an efficient market-clearing mechanism from the consumers' perspective. Thus, over the five years since its inception, there have been repeated calls to incorporate more explicitly demand-side pricing signals into the process. A number of official reviews and various consultants have looked at the issue and there have been trial periods of active demand-side bidding. This paper reviews that experience to date.

Introduction

Restructuring and privatisation of the electricity industry of England and Wales was accomplished in March 1991. Prior to 1990, a single, integrated public utility, the "CEGB" (Central Electricity Generating Board) had operated the whole generation and transmission business of England and Wales (some 70 generating plants with a peak demand of about 48GW), together with twelve regional distribution companies. These twelve distribution companies were sold to the private sector in 1990, and are now called Regional Electric Companies ("RECs"). Two new generating companies National Power and PowerGen inherited 50% and 30% of the capacity respectively, with the remaining 20% (the nuclear plants) staying in the public sector, and operated by Nuclear Electric. A National Grid Company (NGC) has taken over the transmission business and is responsible for operating the daily Pool which is the day-ahead market place for buying and selling electricity.

NGC every day invites bids from generators (National Power, PowerGen, Nuclear Electric, Electricite de France, Scottish and Independent Power Producers) to supply power over the next 24 hours. All power must go through the Pool, even if most of the price risk is covered by hedging contracts between suppliers and generators. These bids from generators are then matched against the demand forecast to produce a least cost, half-hourly generation schedule. The price per half-hour is fixed at that of the marginal unit scheduled for that period, i.e. the System Marginal Price (SMP). There are several other payments to generators for "ancillary services", such as spinning reserve, frequency and voltage control, comprising part of what is referred to as "Uplift". In addition, as an incentive to the generators to provide sufficient capacity to the system, an extra "availability payment" is added to SMP, determined as

LOLP(VLL - SMP) with VLL : Value of Loss of Load (initially set at £2/KWh)
LOLP: Loss of Load Probability per half-hour

The Loss of Load Probability is computed 24 hours in advance, taking account of demand uncertainty and the probabilistic reliability of individual plant in meeting the load as planned. Thus, in periods where there is a lot of excess capacity, LOLP will be small and there will be little incentive to invest, whereas when capacity is short, LOLP will be high and thereby encourage investment. Whilst it has been the case that the distribution companies have hedged against pool price by the extensive use of contracts with the generators, and that much of the recent capacity investment has been strategically motivated, the basic theory is still that new capacity will ultimately be signalled by pool price expectations and the availability payments in particular.

An evident requirement of efficient marginal cost pricing in a competitive market is sufficient competition at the margin. In the UK, that has not been the case, with PowerGen and National Power effectively controlling the marginal plant and thereby setting SMP. The RECs formed consortia with IPPs to bring new generation online, but almost all the power has been contracted for base-load (ie "high-merit" plant). The extent to which SMPs are being set by active price competition is therefore questionable. In 1992, the Regulator suggested that pool prices (around 2p/kWh) were low (because most of the power was covered by price-hedging contracts) compared to the generators' true marginal costs. Over the subsequent year, prices rose to 2.7p/kWh whereupon, in July 1993, the Regulator suggested that they were too high. Following this, they returned to 2.5 p/kWh in September 1993. Price setting on the basis of the Regulator's opinion hardly seems like market forces in action. Furthermore, by 1994, the reported profits of the generators and their obvious ability to control the Pool prices finally persuaded the Regulator to impose an annual average price cap (of about 2.5p/kWh) and a requirement that the generators divest 6GW of marginal capacity in order to create more competition in SMP setting.

With all of the new plant seeking to become base-load, the view by 1994 was that the profile of plant would be departing rapidly from the efficient mixture of base-load and peaking which is usually desired in large power systems. The system appeared to need the installation of more peaking plant but the incentives for this were not there. With too much plant seeking to be base load, most of which was covered by contracts and therefore bidding into the pool at a low price, the SMP price profile was heavily distorted and a very poor economic signal of market prices. This issue was indirectly recognised in the 1994/96 price cap formula which has both time-weighted and demand-weighted targets, thus allowing relatively higher prices for peaking plant.

Given the market power of the two price-setting generators, National Power and PowerGen, and the nature of this price cap, the massive increase in Pool Price volatility which has developed during these 1995 understandable. The standard deviation of pool purchase price in the first quarter of each year has increased from 6.15 (£/MWh) in 1993/94, to 9.79 in 94/95 and reached 24.41 in 1995/96. With pool prices capped, the generators are obviously keen to maximise revenue from contracts, and increased pool price volatility would encourage both higher risk premia and levels of contracting. As a consequence, the attractiveness of investing in peaking plant, or for suppliers to contract for demand-side load management, is also very evident. In the context of this market power on the generation side, we will turn now to the demand-side issue.

Demand-side Participation

Ever since the first official enquiry[1] into the performance of the electricity pool of England and Wales, subsequent reports have invariably called for increased demand-side participation in its price-setting mechanism (eg Energy Committee[2],; Trade and Industry Committee[3,4]). The Regulator has consistently endorsed this with statements referring to "only half a market" and encouragement to the Pool Executive Committee (PEC) to introduce and maintain effective Demand-side Bidding (DSB) schemes in the Pool (Littlechild[5,6,7]). Motivating initiatives for such demand-side participation came mainly from the active and vociferous complaints of high prices (relative to pre-privatisation) faced by the large industrial users, who commissioned an influential report on the scope and rewards for DSB (Caminus[8]).

As a consequence, the Pool has indeed endeavoured to respond to these calls, with a succession of working parties examining various options. A scheme (DSB1) has been in operation since December 1993, and despite repeated criticisms that it does not go far enough, has been maintained by default, though lack of a consensus for a replacement. Furthermore, some of the major industrial advocates of DSB have opted out of the scheme, considering it ineffective. As of October 1995, a major review of the topic (by a Pool Executive Committee development group) placed 13 options on the table for further evaluation, of which 4 are now being actively considered.

The first basic question which this prompts therefore concerns the underlying motivation. Is the continuing commitment to demand-side bidding a recognition of a fundamental design fault in the Pool, or is DSB seen as just one of several possible antidotes to the current market power of the generators? Inasmuch as official encouragement to DSB initiatives has invariably occurred as an apparently secondary part of more extensive recommendations to improve competition in the industry, one is tempted to suggest the latter interpretation. Hence a crucial, initial question is whether DSB would still be an issue if there were more generators actively competing at the margin.

The official regulatory view seems to suggest that market efficiency is just awaiting more competitors. However, it will be argued below that demand-side participation is a fundamental issue for the Pool, and that its role would not disappear in the face of more competition in generation, in fact, just the contrary.

Apart from continued suggestions that the answer to efficient pricing lies with increased competition, another issue which has given DSB a "temporary fix" connotation is the belief that improved load forecasting by NGC, taking into account SMP-induced load management, could solve the market clearing problem without the need for explicit DSB (Littlechild[6]). It is argued below that not only is this technically difficult to achieve, but it is an inadequate interpretation of the full role of demand-side participation in an emerging consumer-focused market.

Thus, with official commitments to DSB being flavoured by the apparent connotation of a transitional role whilst we await improvements in the level of competition and load forecasting technology, it is not surprising that the debate on the subject has been incrementalist and the proposed solutions mostly ad hoc. Thus, it is appropriate to take a more fundamental analysis of the asymmetry in the market and the limitations this may pose to suppliers who, after 1998, will need to become more responsive to their retail business needs as consumer markets become more open and segmented.

The Generators' Pool

Although the Electricity Pool of England and Wales has been an intellectual export, with countries from Colombia to Australia taking the blueprint, as yet it is not showing the same leadership in its consumer focus. This is partly because of its heritage in seeking to translate as much as possible of the order-of-merit dispatching process from the CEGB to the new system.

There were some good reasons for this. In 1989, many experts in the industry doubted that a market based system would work for such a real-time product as electricity. Operational security seemed paramount, and risk aversion in the design appeared prudent at the time, even if in retrospect it has created only half a market. The Regulator has often pointed to the fact the "lights did not go out" as a tribute to the restructuring of the industry.

There were also some less excusable reasons. Initial attempts to create a more financially based market, based upon an extensive and more transparent contracts market, which would be pooled by the RECs (the "distributors pool") linked to a generators' pool of operational bids failed because contract prices could not be agreed within the government's privatisation timetable. The combination of an urgency to privatise before the next election and extreme risk aversion following the withdrawal of nuclear from the sale, initiated a number of quick expedient, but inefficient fixes to the restructuring. This facilitated a successful privatisation in terms of the flotation and operational security but left the legacy of an asymmetric pool.

A half-hourly price p* is set according to the marginal bid needed to meet the demand forecast q. This demand forecast does not try to out-think possible demand response through load management, and has no price elasticity built in to the SMP calculation. (Once p* has been established, NGC does a second run of their scheduling algorithm, "GOAL", for operational purposes, taking into account some price elasticity, but this does not change p*). During the following day, there is some demand-side management; the response of some load-managers to p*. Thus for p*, the total demand is q*. If q* is less than q, then p* overestimates what should be the marginal price, p**, for this lower demand. It is clear that there is an economic gain (p* - p**) to the generators from the (p*,q*) result, which is evidently not the true market clearing solution.

There is clearly a pricing asymmetry in the generators favour: an "SMP gain" if voluntary DSM reduces demand and an economic payment for reserve if voluntary DSM increases demand.

Furthermore, it is apparent that this asymmetry would persist regardless of the number of generators competing. This supply-side-only competition in the pool has generally been defended as potentially efficient on the basis of "Bertrand Competition" (Green and Newbery[9]), but it is clear that even if there were fierce competition amongst generators which forced prices down to marginal costs, the design of the pool would still deal inadequately with the demand side response. The complicating issue is that we have competition in a day-ahead market and an imperfect way of relating this to market clearing on the day. It is fair to say that this structural flaw has been recognised since the first pool review[1].

> "...It may be that the more general introduction of bidding by customers and suppliers at different nominated prices, which could then be ranked and scheduled along with the bids from the generators, would be necessary to address the issue fully. This leads into the possibility of fixed and agreed prices before the day, with uncontracted demands and

supplies on the day met a real time prices..."

a view leading to full demand-side bidding which is one of the new schemes being considered.

A more "centralised" solution that has sometimes been speculated (eg Littlechild[6]) is that NGC could attempt to forecast more accurately the market clearing price and quantity for the day. At the moment, NGC do include some price elasticity in the day ahead LOLP calculation, but not in SMP. According to NGC, there are huge estimation problems in just evaluating the price elasticity, let alone implementing a new highly nonlinear forecasting algorithm to incorporate it. Furthermore NGC observes that although some price elasticity was found for winter 93/94, they have been unable to estimate a similar effect during 94/95. The weather was evidently very different, but there was also the initial demand-side bidding scheme in operation during 1994/95.

As an aside, if indeed the current DSB scheme is removing residual demand side price-adjustment on the day, that is to its credit.

Before moving on to look at progress with demand-side bidding in the pool, it is worth finishing this section by making a few other points concerning the pool's CEGB inheritance.

1. *GOAL is not SMP Minimising.* The software used for Pooling and Settlement is an adaptation of the CEGB dispatching programme GOAL which seeks to minimise the energy costs over a day of meeting a forecast load curve. It therefore assumes bid prices are marginal costs, and that the suppliers are actually paying the bid prices. Since it is SMPs which determine the prices, and are the basis of regulation, then the objective function of GOAL is misspecified. Thus, DSBidders could be incorrectly scheduled (and allegedly have been). Yet for a portfolio generator, GOAL essentially optimises, for them, the least cost schedule of the portfolio of plant offered.

2. *Unreliability is Unpenalised.* The optimisation of the daily schedule takes no account of plant reliability in plant selection - it is not a stochastic optimisation capable of trading reliability off against bid prices. The LOLP calculation, of course, takes realiability data to compute the availability payments, and indeed we are seeing new unreliable plant (with high "disappearance ratios" replacing older more reliable plant on the system. This again is a misspecification of a more appropriate PPP-minimising objective, and would lead to incorrect scheduling of DSBidders.

Finally, in terms of summarising the rewards and penalties between the day ahead schedule and what happens on the day, there are a number of scenarios...

1. If demand is higher than scheduled, reserve payments are made
2. If generation required is lower than scheduled, and plant is constrained off, then payments for "loss of profit" are made (ie. SMP-bid price for reduced load)
3. If generator is unable to meet required schedule for technical reasons, then there is no penalty.

In all cases, of course, as we have observed, SMP and LOLP has been set on the day-ahead market.

The Demand-Side Bidding Experience, December 1993-95

In December 1993, the DSB1 scheme was introduced by the pool to encourage demand-side participation in setting SMP on the day-ahead market. Twelve large industrial customers are able to submit bids on a daily basis for the price and quantity of load they would shed at each half-hour. These bids are included in GOAL and scheduled. Thus they help set SMP. They are not at present included in the LOLP calculation, although that modification is on the agenda (Trade and Industry Committee[4]). DSBidders get paid for making capacity available to the system ie (LOLP*[VLL - Bid price]). However, if scheduled to reduce load, they are not paid anything as they would, it is argued, only be doing what they would be doing anyway. Thus, there is no reward for pre-commitment or uncertainty reduction. Furthermore, there is no incentive beyond availability payment. On the other hand, the bidders are self-dispatching and compliance is described as rather casual.

The offer of availability payments is seen as meagre by some of the strongest advocates of DSB and some have chosen no longer to participate (eg ICI). There is also the free-rider concern that their competitors are benefitting at the DSBidders expense. Nevertheless, over £7M has been paid to DSBidders from January 1994 through August 1995. Only about 7 of the 12 could be described as active, each bidding in between 5MW and 70MW per half hour period. DSBids have been less than SMP on 485 periods from April 2 1994 through Jan 24, 1995, or an average of about 1.5 times per day. The minimum DSB bid, within this set of bids below SMP, was £27.5MWh. So there has been an impact on SMP, and the active bidders have made about £1M each on average.

The Pool Executive Committee has considered many incremental variations of DSB1 scheme. As a rationale, PEC has taken the principle that innovations to the pricing mechanism should be rewarded according to the value they bring to the Pool. Thus, the "DSB95" sought to reward DSBidders with a reduction of 5% in Uplift for improved forecast accuracy and a further 5% for the provision of extra security to the system. This is consistent with greater unbundling and pricing of services, particularly those which comprise Uplift. One could think of further benefits here, such as marginal reductions in costs associated with strengthening the system.

Rather than seeking to evaluate in a possibly arbitrary way such services to the Pool, a market focused view would like to see the prices emerge from competition. This has lead to the proposal for full demand-side bidding. All suppliers bid in there price volume demand functions a day ahead. This clears for the day-ahead and then some kind of residual spot or ex post market then clears on the day. The virtues of this are in terms of full customer participation in both the day ahead and spot markets, and the consequent redundancy of LOLP. However, at present, this proposal can at best provide only an ideal target model, as the technical issues in implementing a robust version are unlikely to be addressed until after the 1998 distraction of implementing full retail competition has been resolved.

But even an idealised model is worth formulating in detail, as it can be a reference against which to evaluate more pragmatic suggestions. For example, when Chao and Wilson[10] proposed priority pricing, they showed that it tended towards the optimal spot pricing solution as the number of pricing segments increased. In a similar way it is not difficult to show that firm demand-side bidding tends towards full demand-side bidding as more participants take part.

A "provision of services" view of demand-side participation leads to a checklist of the form:

1. DSB should help to set SMP
2. DSB should reveal VLL
3. DSB should help to apportion Uplift

and these indeed tend to be the criteria under which PEC has evaluated proposals.

Within this framework, analysing the problem at a more fundamental level involves looking at the symmetry in the way in which the uncertainty between the day-ahead market and the real-time dispatching can be managed between generation and demand reduction. What is the value of uncertainty reduction and flexibility on both generation and demand sides of the market? A more symmetric treatment of generation and load management on the day would appear to be defensible. For example, whilst it may not make sense to pay DSBidders as negative generators in the day ahead market, it does make sense to pay for load reduction on the day if this is seen as uncertainty management, in the absence of a spot market. The bidding for ancillary services which NGC has implemented goes a long way in this thinking.

This line of reasoning leads to the position that;

1. The day ahead market should seek to incorporate as much firm price/quantity information from both suppliers and generators, with a view to clearing the market according to the preferences of all players. It should be in the interests of all parties to engage in this process. In the limit, the scheme should tend towards a full demand-side bidding solution.

2. In the "aftermarket", uncertainty should be managed in a symmetric way with Uplift unbundled and incentives derived equitably between all parties to balance the value of services and obligations.

Yet even this abstracted view of market clearing and the subsequent pricing of uncertainty and flexibility may not go deep enough. The PEC is constituted to administer the Pooling and Settlement Agreement between suppliers and generators, and to refine it according to a consensus of these parties. As such it has often been criticised for not fully representing the interests of consumers. In theory, and perhaps soon after 1998, suppliers who compete with each other in the same markets, will survive and prosper to the extent that they represent the interests and preferences of their customers. It is clear, however, that the Pool of England and Wales, is not, as yet, well equiped to incorporate the demand side options efficiently.

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References

1. Office of Electricity Regulation, *Pool Price Enquiry*, PO Box 276. London SW8 5DT: Her Majesty's Stationary Office, 1991

2 Energy Committee, *Consequences of Electricity Privatisation*, PO Box 276. London SW8 5DT: Her Majesty's Stationary Office, 1992

3. Trade and Industry Committee, *British Energy Policy and the Market for Coal*, PO Box 276. London SW8 5DT: Her Majesty's Stationary Office, 1993

4. Trade and Industry Committee, *Aspects of the Electricity supply Industry*, PO Box 276. London SW8 5DT: Her Majesty's Stationary Office, 1995

5. S. Littlechild, "Demand-side Bidding in the Pool", OFFER Seminar, Birmingham, 1993

6. S. Littlechild, "Decision on the Appeal against the Demand-side Bidding Resolutions of the Pool Executive Committee", Hagley House, Birmingham B16, 8QG: Office for Electricity Regulation, 1994

7. S. Littlechild, "Regulation: what OR has to OFFER", Blackett Memorial Lecture of the Operational Research Society, *OR Newsletter*, January 1996, p4.

8. *The Benefits of Demand-side Measures*, Cambridge, UK: Caminus Energy Ltd, 1993

9. R. Green, and D. Newbery, "Competition in the British Electricity Spot Market", Journal of Politica Economy 100 (5), p. 929 (1992)

10. H.P. Chao and R. Wilson, "Priority Service: Pricing, Investment and Market Organization", American Economic Review. Vol. 77, p. 899 (1987)