Introduction

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Europe is liberalising electricity in accordance with the European Commission's Electricity Directives. Different countries have responded differently, notably in the extent of restructuring, treatment of mergers, market power, and vertical unbundling. While Britain and Norway have achieved effective competition, others like Germany, Spain and France are still struggling to deal with dominant and sometimes vertically integrated companies. The Netherlands offers an interesting intermediate case, where good economic analysis has sometimes been thwarted by legalistic interpretations. Investment under the new Emissions Trading system could further transform the electricity industry but may be hampered by slow progress in liberalising European gas markets.

INTRODUCTION

Before 1990, almost every electricity supply industry was vertically integrated with a captive franchise market, either state-owned (the majority case) or under regulated private ownership (particularly in the US). In both cases the form of regulation was effectively cost-of-service regulation.[1] Electricity liberalisation starts from the premise that while transmission and distribution networks are natural monopolies requiring regulation, generation and supply (or retailing) are potentially competitive activities. Effective competition is superior to regulation in providing incentives for efficiency that are then passed on to

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1. In the US before 1973, rapid technical progress and stable fuel costs combined with regulatory lags provided similar incentives for efficiency gains as price-cap regulation.

consumers in lower prices, while recent developments in incentive regulation (such as Britain's price-cap regulation) offer the prospect of greater efficiency in the natural monopoly elements than cost-of-service regulation. Although electricity networks were typically synchronised over wide areas (e.g. over most of Western Europe under the UCTE (Union for the Co-ordination of Transmission of Electricity), and within the three synchronised networks that cover the US), trade across the borders of areas under different transmission systems operators (TSOs) were mostly guided by security rather than economic considerations. Competition and trade are obvious handmaidens, so improving cross-border electricity trade offers additional prospective efficiency gains.[2]

Electricity differs from standard commodities in important respects, in that it cannot be stored economically (except as water in a hydro system) and supply and demand must be instantaneously balanced by a system operator (another natural monopoly function). In addition, demand is typically very inelastic in the short run, with a large fraction of consumers not able to face or respond to spot or scarcity prices, and from whom supply cannot be withheld. Power lines must be operated within their limited capacity, and if quality parameters (voltage, phase angle, current) move outside tight limits, cascading power cuts may result. Power stations are capital intensive (typically average total costs can be twice variable cost), lumpy and durable (20-40 years), often requiring considerable lead times to secure planning permission and complete construction.[3] In short, managing an interconnected electricity system presents considerable challenges that have in the past argued against using decentralised market mechanisms to deliver power and guide operation and investment decisions.

Serious electricity liberalisation in OECD countries started with Britain's restructuring and privatisation of 1990, demonstrating that unbundling and creating wholesale electricity markets was feasible. In the US, liberalisation started after the Energy Policy Act of 1992, and more decisively after California started exploring liberalisation options from April 1994 (Joskow, 2004). After the British experience and liberalisation in Norway in 1991 (not to mention Australia and Chile), the European Commission decided to introduce Directives to open up the European energy markets (see Jamasb and Pollitt, this issue). The Electricity Directive published in 1996 forced the pace in a number of countries that until the Directive had not actively pursued liberalisation (see, for example, van Damme's account of the Netherlands in this issue). The design of reform remained very much up to individual jurisdictions until 2003 when the next Electricity Directive and FERC's Standard Market Design attempted to prescribe best practice market design and facilitate more efficient cross-border trade.

2. The challenges involved in realizing these gains and the options for improving cross-border trade are the subject of a special issue of *Utilities Policy* published in 2005.

3. In all dimensions, nuclear and hydro plants are at the upper extreme, while gas-fired combined cycle turbines have relaxed most of these constraints, thus greatly favoring liberalization.

The process of reform has varied widely across the EU and US, and offers the prospect of learning from the various experiences. With that (and other) objectives in mind the CMI Electricity Project was set up with support from the Cambridge MIT Institute (CMI) in 2002.[4] Meanwhile the European Commission was becoming increasingly exercised at the slow progress of creating a single European electricity market (part of the impetus behind revising the original Electricity Directive) and has been actively encouraging European Transmission System Operators to develop better trading arrangements. The Commission will review progress in 2006, and in response to this review, a number of European electricity researchers have come together in SESSA to identify good practice in market design and electricity regulation.[5]

Electricity liberalisation is of active interest to a far wider range of countries than just the EU and the US, and the IAEE was also anxious to survey progress and commissioned this special issue of the *Energy Journal* on electricity liberalisation. The happy coincidence of the interests of the CMI Electricity Project, SESSA and the IAEE allowed us to commission papers from leading energy economists for a joint SESSA-CMI conference, *Refining Market Design,* held in Cambridge, England, on 14-15 July 2004. The objective was to examine the performance of different electricity market designs in various European countries and the US. The US experience has been well covered by Joskow (2004, 2005a,b). This special issue therefore concentrates on the European experience, and the introduction reflects on views expressed at that conference, as well as introducing the commissioned papers.

The goals of market design include, as a pre-condition of continued popular and therefore political support, confidence in security of high quality supply at sustainably competitive prices. Sustainability here refers both to the ability of the sector to finance and deliver efficient and reliable electricity supply and in the environmental sense of reducing greenhouse gas emissions. Efficiency requires that energy, capacity and ancillary services are provided at least cost but at prices that allow adequate investment to be financed by the private sector. This in turn requires that the markets provide price signals for entry of new generating capacity that is efficient in location, timing, scale and fuel choice, and for dispatch that minimises social costs including environmental costs. Market integration in turn means that European costs are minimised, trade takes place guided by comparative advantage, importing competition into more concentrated markets.

Competition requires that entrants can deliver power to consumers on the same terms as incumbents, and that requires non-discriminatory access to transmission and distribution, unbundled cost-based tariffs for their use, and no informational advantages to the incumbent. Vertically integrated transmission

4. More details can be found at http://www.econ.cam.ac.uk/electricity/index.htm

5. SESSA, short for Sustainable Energy Specific Support Action, is financed by the European Commission as a European forum on electricity reforms involving both researchers and energy stakeholders. More details are to be found at http://www.sessa.eu.com/.

and generation companies can exploit informational advantages, discriminate in the provision of access, balancing and other ancillary services, and cross-subsidise competitive activities by inflating monopoly costs. British and German experiences (see Newbery and Brunekreeft & Twelemann in this issue) demonstrate that vertical integration is a major impediment to efficient market access and also to inter-TSO trade.

Full ownership unbundling of transmisison is the prize to strive for, and pressure from regulators and competition authorities should make this the least undesirable option for incumbents. If ownership unbundling cannot be negotiated, then the second-best alternative is an independent system operator (ISO), although it is harder to incentivise ISOs than TSOs with assets to bear the profit risk associated with any incentive regime. This seems to be more likely than the final option of regulatory and judicial pressure on vertically integrated TSOs to implement access and balancing arrangements that minimise consumer costs. If the TSO option is adopted, incentive regulation for transmission and distribution, ideally based on benchmarks, is a demonstrated method of improving efficiency and reducing consumer costs, and, if well-designed, without prejudicing investment and security.

Effective competition requires that individual generating companies are rarely pivotal (that is, essential for balancing supply and demand), which can be achieved by a combination of adequate spare capacity, sufficiently numerous generators or import capacity, and a competitive contract market, supported by free entry and non-discriminatory access to transmission and balancing services. Current market structures are often too concentrated to deliver competitive outcomes without close regulation, state ownership, or imposed contracts or equivalent schemes (such as the Spanish CTCs discussed by Crampes and Fabra below). Outside the Nordic market (discussed by von der Fehr et al, this issue), interconnection is typically inadequate to address country-level concentration, and absent these conditions for competition, the choice of market design is unlikely to adequately mitigate market power, although some designs may facilitate collusion more than others.

The question of market design has a number of dimensions. Clearly it should be tailored to the circumstances of each country (ownership structures, fuel sources, and institutional/legal endowments and capabilities), but it should also facilitate a move towards a single EU-wide electricity market. The EU has been able to make remarkable progress in creating the preconditions for a liberalised and integrated electricity market through a sequence of Directives and Regulations, but these can only reflect current political consensus. Whereas in the US FERC as the federal energy regulator can encourage and cajole states to adopt a standard market design, Europe lacks such a regulator and relies on consensus and comitology for progress beyond the rather sparse details of the Directives. Progress on both sides of the Atlantic has been slow – states' rights have similar salience to national subsidiarity. Creating markets which undermine impediments to market integration, perhaps starting with the regional integration of power exchanges, leading on to agreements among TSOs to integrate balancing markets to increase liquidity, might be more effective than political consensus-

building. Liquidity and integrated balancing markets are both impeded by vertical integration and poor information sharing between TSOs.

Among wholesale market designs, marginal single-priced pools have advantages in providing a reference price facilitating contracts and hence entry, and allowing scarcity-responsive capacity payments (as in the former English Pool examined by Newbery, below). However, their transparency and repeated-auction structure facilitate collusion if there are fewer than four or five comparable generation companies. Problems of gaming and collusion fall as the number of participants increases and the length of time for which bids must hold increases (so that bidding separately for each hour as in Spain or on the Dutch APX is likely to be inferior to bids that must hold for 24 hours, as in the former English Pool).[6] Power exchanges typically only trade 5-15% of consumption in the prompt market, while forward bilateral contracts are either illiquid (if profiled) or inflexible (if restricted to base and peak power). In such cases liquid balancing markets are critical to competitive entry and supply. They may also be essential for security of supply in concentrated markets where the dominant incumbent is inhibited from investing (and further foreclosing the market) and entrants are deterred by the risks of illiquid, volatile and unpredictable balancing markets or mechanisms.

Balancing markets are therefore of central importance to promoting the European aspiration of market integration that delivers sustainable competition, and offer the prospect of breaking the log-jam of political consensus-building required to deliver mandatory Directives. While that process seems to have worked quite well for telecommunications with the Communications Directives emphasising regulation to address Significant Market Power, telecoms liberalisation is both older and more amenable to *ex post* regulation than electricity. Optimists believe that the process of introducing new Directives and Regulations has accelerated and will solve these problems; realists are sceptical.

Agreement among TSOs (encouraged, supported and perhaps pressured by their local regulators) to exchange appropriate information and delegate balancing dispatch offers the prospect of creating liquidity first in the balancing or real-time market. Integrating balancing markets will reduce the required balancing volume, as some volatility cancels out, and will increase the number of competitors providing services in each market, thereby reducing balancing costs and encouraging trust in the balancing market. It may be that integrating balancing markets need to await the development of a well-functioning European day-ahead energy market, although progress is presumably more likely at a regional level first, again possibly following the improvement of day-ahead market integration. Again, vertically integrated TSOs might be reluctant to integrate balancing markets that allow more entry into their own wholesale markets and reduce generator or supply profits.

Electricity markets are likely to be more conducive to tacit co-ordination than most other markets of comparable concentration, while non-storability and

6. APX adopted the Spanish software that allows separate bids for each hour (and both power exchanges publish the aggregate supply and demand schedules for each hour). Bids are firm but in Spain they can be adjusted with new bids in the six intra-daily markets at four-hourly intervals.

a low elasticity of demand amplifies market power, requiring a more informed approach to competitive analysis by regulators and competition authorities. Creating competitive gas markets, with gas-on-gas competition through liquid spot and balancing markets (as in Britain) offers the prospect of equilibrating the effective cost of the major electricity fuel across Europe, and hence reducing cross-border generation cost differences. With less need for arbitrage trade more interconnection capacity would be freed up for importing competition into otherwise concentrated markets (as in Nordel).

Efficient trade requires efficient pricing and allocation of transmission, best achieved by nodal pricing on the Pennsylvania-New Jersey-Maryland market design. The next best solution is market coupling as practised in the Nordic market. Local power exchanges would send their aggregate bid-offer curves to an international clearing stage, which would allocate transmission capacity between countries in a procedure similar to the synchronised auctions currently proposed by the European system operators. Local power exchanges would then schedule the corresponding international flows and clear the local markets. This approach allows for netting and may work reasonably well if transmission within countries is adequate. Zones can be subdivided further if internal congestion levels increase. Again, access to full information is key to improving allocation and increasing available capacity, but requires trust that is best underlined by ownership unbundling or a regional ISO structure. Once that has been achieved, it might be sensible to revisit the appropriateness of the current technical transmission standards to see whether they are suitable for a decentralised and liberalised market.

There are two major problems with this approach. The first is the likely reluctance of local power exchanges to create and join an international clearing house, which would largely undermine their own function (and similar progress for European stock exchanges has been woefully slow). The second problem is the existence of zones with adequate uncongested internal transmission. If the zones have to be subdivided much, then one may run into problems of lack of liquidity within the zones and absence of local power exchanges to do the job.

There are also concerns about the problem of generation and transmission adequacy. Generation margins are getting tight in several European systems and there is widespread doubt that this issue could be left to energy-only markets, although this is still an open issue. Von der Fehr et al discuss this below, although in Germany and France capacity seems adequate for at least several years (Brunekreeft & Twelemann and Glachant & Finon). Any move away from energy-only markets requires a choice between the alternative mechanisms that could be used, such as the LOLP scheme (which has some attractions but also critics), capacity payments, capacity obligations, etc. The Council of European Electricity Regulators (CEER) has issued a recent document on transmission investment, where the need to guarantee an adequate return on new investment (best achieved by running public auctions to build new lines, proposed by TSOs and authorised if needed by regulators) and full recovery via transmission tariffs was emphasised. The experience in the U.S. is that unless actively encouraged,

adequate inter-TSO transmission investment is most unlikely, while building any transmission in the teeth of local environmental objections is difficult, as the failure to complete the France-Spain interconnector demonstrates.

A disagreeable implication of this is that market integration is likely to stall at the regional level, so that each region will remain largely isolated from the other regions. This might not matter too much if countries evolve similar fuel prices and make similar technology choices, as that will equilibrate electricity prices, arguably at lower financial and political cost than massive investments in interconnectors.

Finally, sustainability in the context of electricity markets has a further connotation in that the full environmental costs should be taken into account in investment and consumption decisions, so that the industry can evolve towards a low carbon future that does not prejudice the life chances of subsequent generations. This is recognised by the EU acceptance of the Kyoto targets and an EU commitment to market solutions to reflect the cost of greenhouse gas emissions. As the output of wind energy (the dominant source of renewable generation) can only be accurately predicted a few hours before dispatch, it is important that market design does not create artificial barriers for such flexibility. This operational flexibility is of particular importance for transmission and it constitutes a new challenge in transmission network operation and design. An adequate design of balancing markets is crucial here. Market design and market structure should be used to minimise the exercise of market power in short-term (and ancillary service) markets which increase the costs of intermittent generation. Efficient use of international transmission capacity will allow international balancing and should further reduce intermittency costs.

The aim of the European Emissions Trading Scheme (ETS) is to equalise the price of carbon across the EU. If it is combined with a form of allocation that does not distort investment and operating decisions, the ETS should lead to the same cost increase for marginal electricity generation by each fuel in each country, and hence would not distort dispatch, trade or investment. The main concerns are to do with distortions arising from the system of allocating emission allowances. If emission allowances are contingent on continuing plant operation, they will discourage replacing inefficient high emissions plant by more efficient low emission plant. If future allowances are allocated on the basis of generation (kWh) in some countries (rather than capacity, kW) they could distort the marginal cost of operation in different countries and hence trade. If allowances are allocated by type of plant they could also prevent the desired change in the merit order towards lower carbon-intensive plant. Several of the authors explore the consequences for investment of each country's choice of how to implement the ETS. Nevertheless, the ETS represents a considerable advance on more political and quota-based alternatives.

THE CONTRIBUTIONS

Jamasb and Pollitt define and defend liberalisation, restructuring and market integration and describe progress in the EU-15 countries, drawing on recent EC benchmarking reports. These show that the EU had already achieved about 60%

market opening by 1999 (by units sold) and 90% by 2004, substantially in excess of the legal minima. They argue that the centralised approach to market liberalisation through the Electricity Directives has succeeded in maintaining the pace of reform in the original EU-15 and in a number of associated and accession countries, and in achieving a degree of standardisation of structures, institutions, and rules in national markets. They note the problems created by initially concentrated market structures, subsequent mergers that have been waved through, and the low level of interconnection that reduces the scope for importing competition. Real prices fell from 1997 to 2004 (but so have electricity fuel costs) but the variation in network charges and wholesale prices across the EU-15 is still large, reflecting the scarcity of interconnection and the lack of cross-country benchmarking for regulation. To that extent the single electricity market has not yet arrived.

Newbery outlines the history and experience of the exemplar of electricity market reform, contrasting the effects of the different models chosen in England and Wales (ownership unbundling of transmission) and Scotland (which retained the two vertically integrated companies). Britain provides a natural experiment for the choice of wholesale market design, as the original Electricity Pool (a centrally dispatched compulsory gross marginal priced day-ahead half-hourly market with a capacity payment) was replaced by self-dispatch, voluntary bilateral and OTC contracting combined with a pay-as-bid average priced balancing mechanism and no capacity payment.

The initial market structure in England and Wales was highly concentrated, with two fossil generators setting the price over 90% of the time, but regulatory pressure and references to the Competition Commission encouraged the dominant generators to trade horizontal market power for vertical integration into supply, leading to a remarkably unconcentrated industry shortly before the New Electricity Trading Arrangements (NETA) were introduced in 2001. High prices under the Pool were responsible for considerable, possibly excess, entry and pressure to reform the Pool, but also resulted in a dramatic fall in prices once the market structure had become unconcentrated. Subsequent plant withdrawal and rising fuel prices have increased real wholesale prices to their pre-NETA level, although margins are still somewhat below entry level. NETA cost over $1 billion, created an arguably inefficient balancing market, and has encouraged the pressure for vertical integration with low market liquidity.

Von der Fehr, Amundsen and Bergman, in their paper on the Nordic market, address a critical issue for liberalisation – whether an unregulated generation and supply industry can survive the potential backlash from a period of high prices caused by shortage (in this case of rain for the hydro reservoirs). Since the California meltdown of 2000/1 (also caused in part by low rainfall in the Columbia basin), observers have become sceptical that liberalisation will survive the honeymoon period of adequate reserve margins and resulting low prices. Norway provides an encouraging counter-example of regulatory and political forbearance and of the market response to unexpected price volatility. The paper naturally leads on to an investigation of market structure, market

power and supply adequacy, looking forward to investment under the ETS carbon pricing system and the Nordic market for Green Certificates.

Brunekreeft and Twelemann discuss Germany, the heavyweight laggard of the EU reform process that had not at the time of going to press met the 2003 Directive requirement of a regulator, and with it a limited form (regulatory authorisation of the tariff-setting methodology) of regulated Third Party Access to the networks. After a cumbersome debate, the agreement now seems to be to implement some form of an ex-ante, incentive-based approach. Germany provides a fascinating example of the consequence of the failure to properly unbundle and regulate access to the natural monopoly transmission and distribution businesses, for their owners could collect profits in the monopoly segments while engaging in a margin squeeze in the competitive segments, deterring entry and facilitating mergers and increased concentration. This reached its nadir in 2002 when E.On (one of the two largest vertically integrated electricity companies) merged with Ruhrgas, the overwhelmingly dominant vertically integrated gas company.

Although the Cartel Office prohibited the merger, the Minister of Economic Affairs overruled the Cartel Office as well as his own advisors in the Monopolies Commission and approved the merger. Gas is of vital importance as competitively supplied gas offers the prospect of a similar contestable entry price for gas-fired generation throughout Europe, reducing pressures on scarce interconnectors and allowing them to widen the effective market size, improving competition. Curiously, the European Commission did not claim any jurisdiction over the merger, despite its potential impact on electricity and gas trade within the EU. This failure to appreciate the special circumstances favouring tacit collusion and the exercise of market power in energy markets has set the process of creating a competitive electricity market back significantly. The authors also note that the way in which the ETS will operate in Germany may effectively subsidise entry and facilitate both reserve adequacy and possibly market contestability.

Crampes and Fabra discuss the complicated evolution of the Spanish electricity industry from its formerly highly regulated and cross-subsidised form towards a more market-oriented structure, managed through Competition Transition Contracts (CTCs). These have limited the potentially serious market power of the duopolists in a period of resource scarcity, although providing somewhat perversely asymmetric bidding incentives into the Spanish pool. Spain has rapid electricity demand growth and high prices, but for 15 years the logical interconnector with lower-priced electricity in France has been successfully opposed, making local generation investment essential. Fortunately, the Spanish gas market structure with a number of entry points for LNG provides a similarly competitive market to that in the UK with its many entry points, and as in Britain, a dash for gas is emerging. The Spanish Government has recently reviewed and criticised the CTC system, and it will be interesting to follow how the market structure evolves with any CTC replacement, whether market power can be restrained (perhaps by contestable entry), and how the proposed Iberian electricity market involving Portugal will advance market integration.

Van Damme describes the legally fraught process of liberalising the Dutch electricity market, narrowly avoiding the Government's preferred option of a single national champion generating company. Wholesale prices are higher than in neighbouring countries, and despite apparently strong interconnections that were auctioned long-term and day ahead, constraints have supported high interconnector prices. In contrast to Germany, the proposed Nuon-Reliant generator merger was intelligently analysed with competent economic modelling, and the sensible remedy of a virtual power plant auction proposed. In contrast, the price caps imposed were appealed to the courts, who narrowly and perversely interpreted the 1998 Electricity Law.

Finally, Glachant and Finon examine the curious case of French electricity reform "in which the state-owned monopoly was not privatised, demolished, or dismantled." They consider the extent to which the competitive fringe (mainly of importers) can restrain the 800lb gorilla, EdF. Part of the problem of introducing effective competition in France is that she has a surplus of very low variable cost nuclear power, and little economic motive for new investment for the next decade. Whether a "privatised" EdF will exercise its undoubted muscles and induce entry, and whether the state-owned gas company GdF will provide effective retail competition and perhaps gas-fired generation competition or roll over and become part of EdF, remain questions for the future to answer. It may be that the French concept of privatisation (majority state-owned) allows EdF to continue its public service obligation to keep wholesale prices low (while charging domestic customers economically sensible Ramsey – more properly Boiteux – prices). This would maintain the status quo, but the rocky state of French public finances may make further privatisation and/or the exercise of market power to generate handsome dividends irresistible.

Together the authors have used their country examples to raise almost all the main issues that need to be addressed when restructuring electricity industries to open up their markets. The next stage in Europe will involve full liberalisation of the accession countries, reforms to area-wide systems operation, transmission access and pricing, and the evolution of investment under the ETS. No doubt the electricity supply industry will continue to pose fascinating problems for energy economists to study and on which to offer guidance to the various regulatory authorities.

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