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Electricity Markets: Should the Rest of the World Adopt the UK Reforms?

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Electricity Markets: Should the Rest of the World Adopt the UK Reforms?[1]

By Catherine D. Wolfram[2]

Britain was one of the first countries to liberalize its electricity industry when it restructured and privatized in 1990. Since then, a number of countries and a handful of US states have undertaken their own electricity reform programs. At least a dozen more states in the US are currently in the process of adopting legislation to restructure their industries over the next two to three years.

Policy makers everywhere have analyzed and tried to learn from the experience in the UK, adopting some of the same market features but modifying others. Now the British government has embarked on a radical reform of their electricity industry, called the Programme to Reform the Electricity Trading Arrangements or "RETA." The changes to the electricity market are slated for September 2000. Some of the changes will bring the UK in line with what other countries have done, but other changes will be unique. Is the UK poised to leapfrog the rest of the world, adopting every market feature that has proved successful and modifying those that have not? Should the rest of the world be following the UK's lead on some of these changes? I believe the answer is a decisive "no" to both questions. While proposed reforms to introduce demand-side bidding and encourage financial innovation make sense, the government's proposal

[1] Forthcoming in Regulation (Cato Institute, Washington, D.C), Fall 1999.
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to pay suppliers their bids rather than the market clearing price will not help achieve the stated goals of fostering competition and lowering prices.

Electricity Market Restructuring

Electricity restructuring initiatives around the world have been based on several principles. It is generally recognized that any economies of scale in the production of electricity are exhausted at the level of a medium-sized generating plant. Competition in generation services is deemed workable, and restructuring has been designed to foster competition and create incentives for efficient investment in generation assets. Some of the most costly decisions made under regulation or state-ownership involved investments in generating plants that turned out to be inefficient and uneconomic. Efficient investment incentives, therefore, could lead to substantial savings. Transmission and distribution services, the “wires” that carry power from generating plants to customers, still have natural monopoly characteristics. In most restructured systems, companies owning and operating the transmission and distribution systems have been left under state ownership or as regulated local monopolies.

Though the basic idea of competitive, unregulated generation is one of the cornerstones of electricity reform programs, debate has continued among reformers about how to structure a competitive market for generation services. One of the basic questions is how centralized trading should be. Britain’s centralized market has been at one end of the spectrum. The market, called the Electricity Pool of England and Wales, has been the only forum through which wholesale buyers and sellers of electricity can trade. In Norway, by contrast, trade is less structured and buyers and sellers can sign private bilateral contracts, broker deals through various private traders or trade in one of several organized markets. There is an organized forward market, an

organized market for trading one day ahead and a market for last minute needs. Restructured markets in other countries and in the US fall somewhere along this spectrum.

Technical features of electricity generation and transmission require that at least last-minute trading take place through a centralized system operator. First, electricity is non-storable, so demand and supply must balance in real time within a transmission system. The typical transmission system interconnects electricity producers and consumers over a large geographic area, and actions by any producer or consumer can affect everyone else connected to the system. For instance, the whole United States East of the Rockies except Texas is part of one synchronized Alternating Current (AC) network. Areas within the system can become isolated if transmission lines become congested, but absent transmission constraints output in Maine can affect the system in Florida. System operators are responsible for ensuring that any last-minute demand surges (for instance if a day turns out hotter than expected, resulting in an increase in air conditioning) are met by new generation and that any last-minute plant outages are either met by additional generation or reductions in demand.

Second, electrons follow the laws of physics without heed of contractual arrangements. It is impossible to assign output from a specific plant to a particular customer. If a generator that is connected to the transmission grid decides to produce more electricity than it has either sold through bilateral contracts or sold in a day-ahead market, the power enters the system and must either be used by a customer or met by a concomitant reduction at another plant. Again, the system operator is responsible for dealing with the supply overload. At least for now, it is prohibitively costly to provide buyers and sellers with all of the information they need to internalize the effect of their last minute decisions on system stability.

In California, balancing and other last-minute trades take place through a real-time market administered by the by the Independent System Operator (ISO). Norway similarly has a last minute Regulation Market operated by the transmission system operator, Statnett. Even the proposed British reforms envision a centrally coordinated, last minute Balancing Market.

The Proposed Reforms in Britain

The proposed changes to the electricity markets in the UK have been spelled out in a series of documents, including a government White Paper issued in October 1998 and, more recently, in a July 1999 report by the gas and electricity regulatory agency, Ofgem.[3] The documents summarize the impetuses for reforms and outline the proposed changes.

The Electricity Pool of England and Wales (commonly referred to simply as "The Pool") has become the focal point of all things that are perceived to have gone wrong with the electricity industry restructuring. In many ways, the current reform program aims to create a market as different from the Pool as possible. Administratively, the Pool has operated as follows. Every day is divided into 48 half-hour periods and a single price covers all purchases and sales in each half-hour. Pool prices are based on bid schedules submitted daily by each generator detailing the prices at which they would be willing to supply power from each of the plants they own. The bids are ranked from lowest to highest and are used, together with the capacity offered by each plant, to construct a supply curve that indicates the least expensive way to meet a given level of demand. Using demand forecasts for the following day, the administrator determines a "System Marginal Price" for each half-hour period based on the bid of the most expensive generating unit

[3] Until recently the regulatory agency overseeing the electricity industry was called the Office of Electricity Regulation or "OFFER." OFFER recently combined with the Office of Gas Regulation and renamed the Office of Gas and Electricity Markets "Ofgem."

needed to meet forecast demand. All sales take place at this price although parties can sign financial contracts around the Pool prices.

With the proposed reforms, or RETA, the British government hopes that trading becomes less centralized. It aims to offer parties the opportunity to sign private bilateral contracts and envisions that organized electricity trading will develop on several exchanges. RETA also aims to incorporate demand-side bidding into the market. These first two changes mimic the market design in other countries, such as Norway, where they are generally considered successful. The government is also recommending that in all markets for electricity, including the last-minute balancing market, generators be paid their bids instead of the last accepted bid. In the language of economics, the proposal is to switch from a market organized as a "uniform-price" (paid highest accepted bid) auction to one organized around a "discriminatory" (pay-as-bid) auction.

The rest of this article lays out some of the basic features desirable in electricity markets, and then discusses the British government's stated reasoning behind their proposed reforms, commenting on the likelihood that the Reforms will achieve the objectives. In so doing, I hope to dispel common misperceptions about electricity markets.

Electricity Auctions

The characterization of electricity markets as auctions merits comment. Auctions are simply organized markets where goods are awarded to bidders based on specific rules that determine who wins the auction and the price the winning bidder pays. Auctions can be used either to sell products (e.g. wine, artwork, or the right to drill for oil in the Gulf of Mexico) or to award contracts to potential suppliers (e.g. for road construction projects). Auctions of the second type are called procurement auctions, since a product is being procured rather than sold. Electricity markets are structured as procurement auctions.

Auction rules are central to understanding how aggressively parties will bid, who will win, and how cheaply a contract will be procured (or, in a sale auction, how much money the product will sell for). One set of auction rules determine how the auction proceeds. For example, in some auctions, an auctioneer calls out bids and bidders actively indicate their willingness to continue participating, for instance by flashing bidder cards. In other auctions, including those in the electricity market, bidders privately submit their bids to the auctioneer without communicating any information to other bidders about how much they are willing to pay. This article focuses on another set of rules, those determining how parties' bids affect how much they are awarded through the auction.

Economists have well-developed models of auctions, and have studied how bidders will bid and what prices will be set given different auction designs. Many of the points in this article draw on those economic models.

Auction Example In order to discuss specific attributes of electricity markets, it will be useful to refer to a simple example that elucidates some of the differences between discriminatory and uniform price auctions. Consider an auction to supply electricity where there are only two suppliers, Firm A and Firm B. Each supplier owns two plants. Firm A's two plants are identical, and it costs $15 to generate a unit of electricity from each plant. Firm B has one plant from which it costs $20 to generate a unit of electricity and one plant from which it costs $5. Assume that all four plants are the same size and generate only one unit of electricity. The auctioneer asks the firms to submit their bids in sealed envelopes without talking to one another about what they will bid. Bidders are asked to submit two numbers: the amount they would require to generate power from one plant and the amount they would require to generate from both plants. For instance, if all firms submit their costs as their bids, Firm A would bid $15 to generate from one

plant and $30 to generate from both plants. Firm B would bid $5 to generate from one plant (if it was only supplying one unit of electricity instead of two, it would choose the inexpensive plant) and $25 to generate from both plants.

In a discriminatory auction, the auctioneer buys power from the seller(s) who submit the lowest bids and pays them their bids. Under a uniform-price auction, the auctioneer also buys power from the seller(s) who submit the lowest bids, but he pays each successful bidder the highest accepted bid. In the example, if the auctioneer knows that only two units of electricity will be needed, the least cost way of meeting that need would be to procure one $15 unit from Firm A and one $5 unit from Firm B. In a discriminatory auction, Firm A would receive $15 and Firm B would receive $5. In a uniform price auction, the price offered to both bidders would be $15. Note that in that case, the auctioneer would be paying Firm B a higher price than it bid.

The fact that a uniform-price auction pays some bidders more than they bid has particularly bothered proponents of reform in the UK. Unfortunately, there are few, if any, economic principles that support their proposed solution to switch to a discriminatory system. In the example above, if both bidders are well informed about what the others are likely to be bidding and about how many units of electricity are needed, Bidder B would not submit a price of $5 for his first unit of electricity. The firm would know that it had one of the two cheapest plants available and that the plants it was competing with all had costs of $15 and higher. Given that, the most sensible thing for it to do would be to submit a bid of $14.99. In a uniform price auction, it makes sense to submit very low bids to ensure that you win if you know that your bid is unlikely to set the winning price, but this logic no longer applies in a discriminatory auction. Unfortunately, the rhetoric behind the discriminatory auction arguments have won out, and the UK government has made the auction format a central component of RETA.

Features of an Efficient Market

What are the desirable characteristics of electricity markets? And, will the proposed reforms in the UK support those features? This section describes ideal characteristics of electricity markets. The next section describes the UK government's stated rationale for the reforms, assessing the likelihood that the design changes will accomplish those goals.

Efficient Pricing One of the principle characteristics of any efficient market, whether or not it is run as an auction, is that prices are close to the marginal cost of producing the product. On the one hand, this requires that sellers do not have unilateral incentives to raise prices. For instance, a monopolist has the incentive and ability to raise prices because it knows no one will undercut it. Generally, the more sellers there are the less likely it is that anyone can raise prices above costs without being undercut by a competitor. In addition, whatever sellers' unilateral incentives, markets should be designed to minimize the opportunities for firms to collude, either explicitly or tacitly, to raise prices. (This is the domain of antitrust regulators, but it is better not to leave collusion concerns entirely to antitrust enforcers.)

Uniform price auctions give some sellers a unilateral incentive to raise prices. Consider a firm with a number of generating plants. The firm knows that the bids it submits for units that are likely to be marginal may set the price for all of its units. The firm has an incentive, therefore, to try to raise the bids for the plants likely to be marginal. If it raises the bid for a potentially marginal plant too much, that plant might not be called, and the profit from operating that plant will be lost. On the other hand, if the bidder raises the bid of the marginal plant slightly and it ends up setting the market price, the higher price is earned by all of the firm's plants. Plants that earn the marginal price but have submitted lower bids are called "inframarginal" plants. The more inframarginal plants a firm owns, the more of an incentive it has to raise the prices

submitted by plants likely to be setting the marginal price. Similar incentives are not present in discriminatory auctions.

There is some evidence that inframarginal capacity has an effect on electricity bidding in England and Wales. In a study published in the Rand Journal of Economics, I analyzed bids submitted by the two dominant electricity generators, National Power and PowerGen. I found three examples of the effects of inframarginal capacity. First, I considered plants with high marginal fuel costs because those plants are likely to be used after other plants are already operating. Plants with high fuel costs submitted bids that reflected larger markups above their marginal costs than plants with low fuel costs. Second, I found that the larger supplier, National Power, submitted higher bids for similar plants. Last, I found that bids for a given plant were slightly higher on days when more of the capacity owned by the same firm that is typically inframarginal to that plant is available.

While the ability to set the marginal price for all inframarginal plants may drive bids higher in uniform-price auctions, discriminatory auctions also can give incentives to submit high bids. There is a phenomenon called the "Winner's Curse" at work in markets where bidders are paid their bid and where all bidders have imperfect information about what the market clearing price is likely to be. For example, in electricity markets, the market-clearing price is a function of how high demand is, since with higher demand, more expensive plants need to run to meet demand.

Assume that there is a distribution of possible demand levels. For example, in the example above, assume that bidders do not know whether there will be two units of demand or three units. If participants knew that there would be two units of demand, the market-clearing price would be $15, since $15 is the price of the third most expensive plant. If participants knew

there would be three units of demand, the price would be $20, the price of the most expensive of the four plants. Consider the two plants whose running costs are $15 and assume they are owned by different firms, Firm A and Firm C. With uncertainty about whether demand would be for two or three units, each firm would have to decide whether to bid $15 and be more likely to be called under either demand scenario but only get paid $15 or bid $20. If one of them believed demand would be for two units and bid $15, it will only get paid $15 in the case demand is three units because it is less optimistic about demand than the other firm. Knowing that is the case, bidders try to avoid the Winner's Curse by submitting higher bids.

There have been several markets where bidding switched from uniform-price to discriminatory, and researchers have tried to unravel whether the Winner's Curse distorts bidding more than the incentive created by inframarginal capacity. For instance, the Mexican government changed the format they used for auctions of Treasury bills. The evidence is largely inconclusive.

Generally, therefore, auction theory has identified two effects. The presence of the Winner's Curse argues for a uniform-price format while the influence of inframarginal capacity argues for a discriminatory format. Whether the Winner's Curse or inframarginal capacity will have more of an effect on the level of prices is probably a function of specific attributes of a market, and it is not clear which effect will be stronger in electricity markets.

UK reform proponents seem to be arguing that a discriminatory auction will "create more competition" and lead to lower prices because bidders that used to be bidding zero will now have to submit competitive bids. As demonstrated in the auction example presented above, this reasoning is questionable. The bidders who used to submit very low bids most likely will submit bids that are closer to those of the plants that were setting the marginal price under the uniform

price system. In fact, if they know how their costs compare to other suppliers, they are likely to submit prices just below them and not provide any competition. If low cost producers err and price themselves out of the market, output will not be produced at the lowest possible cost. I will address this last point in the next subsection.

The RETA documents also suggest that the fact that the uniform price auctions set one price facilitated tacit coordination among the bidders. This claim is unsubstantiated and does not make that much common sense. One can imagine a number of ways for firms to coordinate, and presumably if that is their intent, they will continue to collude despite changes in market design. Discussions about whether something makes it easier for firms to collude are at best speculative and should not be the basis for a dramatic market reform.

Efficient Production The major drawback to using a discriminatory auction to try to provide competition for the plants that were setting prices under the uniform price auction is that it might actually work too well. If plants that formerly submitted very low bids to ensure that they were used end up having to try to guess the marginal price in the market, they might sometimes guess too high and not end up selling while more expensive plants that make better guesses do. If that happens too frequently, there will be real inefficiencies in the market as plants with high marginal costs are being run before plants with low marginal costs. Consumers will pay too much if expensive plants are being run while less expensive plants sit idle.

The reform documents fail to mention this issue. If all bidders are trying to figure out what the marginal price is likely to be and are bidding close to the same amount, whether or not a specific plant runs is likely to be more arbitrary and less a function of its cost. Cheap plants are likely to bid more conservatively since they stand to loose more profits if they do not get dispatched. There will no doubt be other factors that affect firms' abilities to predict the market-

clearing price such as how much information the firm has about the rest of the market. As a result, there could be situations where none of the very cheap plants owned by a company that is overly optimistic about price levels will be run. Under a uniform price auction, the company could submit low bids for its very cheap plants, guaranteeing that they would be run whatever the market-clearing price.

Encourage Efficient Entry As discussed above, prices are more likely to be competitive and equal to firms' marginal costs if there are many suppliers. One of the most effective ways to keep prices down, therefore, is to ensure than entrants are not prevented or inhibited from building economic electricity generation plants. A number of factors can influence a firm's decision about whether or not to build a power plant, including the costs of building the plant, the prices the firm expects to pay for fuel and the price it is likely to receive for power generated. The way in which electricity trading is organized only influences the last factor, so I will focus on that.

In a discriminatory auction, the price a firm is likely to receive depends on how good it is at forecasting the market-clearing price. In the example above, the firm with the $5 generator had to try to identify the costs of the other plants it was bidding against as well as the number of plants that would be needed to meet demand. In reality, there are a number of additional factors that would influence the market clearing price, including plant outages, fuel costs, and the opportunities generators have to sell into different markets. In the uniform price setting, profits for inframarginal plants did not depend on accurately forecasting the market price.

In a discriminatory auction, firms that think they are good at guessing where the market-clearing price will be are more likely to build more capacity or enter in the first place. For example, firms with more plants are better able to gauge the market-clearing price because they have information about the availability of their own plants. If they have a large plant with low

running costs that is shutdown suddenly for mechanical reasons, they know that the market-clearing price is likely to be high. Big firms, therefore, may have a strong incentive to build new plants, while smaller firms or firms without any existing capacity will consider the market too risky. Eventually, this could lead to less competition and higher prices.

The Objectives of the UK Reform

The objectives of the UK reforms are partly to make the market more efficient along the lines described above, but the government has articulated other aims as well.

Keep Prices Low It is clear that prices for wholesale power in the UK have been above competitive levels. Ordinarily, it is hard to say this with much certainty because it is virtually impossible for researchers to assess either how high prices would be if they were set competitively or how large firm profits are. Doing so involves obtaining information about firms' marginal costs and their economic profits. True economic profits differ from reported accounting profits for a number of reasons, and accurate cost information is kept confidential. In the electricity industry, however, production technologies are straightforward and, short-run marginal costs are almost entirely comprised of the cost of the fuel burned by a plant to generate electricity. A plant's fuel costs, in turn, are a function of the price of the fuel and the efficiency with which the plant converts fuel into electricity. Because the industry was recently in the public domain, detailed data is available on plant efficiency levels and the information is generally still relevant to plant operations four to six years after privatization. The privatized firms now consider plant efficiency levels competitively sensitive and guard them quite closely.

For a study recently published in the American Economic Review, I obtained information on plant efficiency rates, fuel costs, and plant availability levels and calculated the system marginal costs. I then calculated the average difference between prices and the marginal cost of

using fuel to generate electricity. From 1992-1994, prices were on average 25% above the costs of the last plant needed to generate electricity in a given period, suggesting that if prices were being set competitively, they would be substantially lower. Since 1994, fuel costs, which are the main input cost for electricity-generating plants, have come down though prices have not fallen accordingly. This suggests margins are now higher and provides further evidence that prices are not responding to competitive forces.

The regulatory body overseeing the electricity industry—OFFER, which was succeeded by Ofgem—has taken several steps to address the high price levels. The regulator has issued a number of reports on pool prices (at last count, ten since 1990), he instituted a cap on pool prices in 1994-1996, and, most substantively, he required the dominant generators, National Power and PowerGen, to divest of some of their generating capacity.

The plant divestitures had the potential to increase competition in the industry and lower prices. National Power and PowerGen have been steadily losing market share since 1990 in terms of the total kilowatt-hours of electricity generated. Nonetheless, plants owned by one of the two firms set the marginal pool price over 60 percent of the time during 1998. Unfortunately, the divestitures that took place in 1996 were structured as leases and the leasee was forced to make large per kilowatt-hour lease payments. This effectively raised the marginal price the acquirer faced for each unit of electricity generated, thereby raising the prices it bid for the divested plants.

What about the prospects for lower prices under the proposed market reforms? As explained above, simply switching to a discriminatory auction and encouraging bilateral trading is unlikely to drive prices. No matter what forum they are trading in, companies will not sell at prices that are lower than what they think the market will bear. If the new system discourages

entry, the prospects for lower prices may be even dimmer than under the current system. Unfortunately, the reforms do nothing to address the small number of firms and high concentration levels in the industry, and those factors most likely have much more to do with the high prices than the organization of the market.

Let Customers Transact Directly with Suppliers One of the objectives of the market reforms is to try to get more consumers directly involved in the market. Currently, only a small number of customers buy directly from the Pool, and the rest buy through wholesale suppliers. All of the customers that are buying directly from the Pool pay the Pool price. Only a small fraction of the customers buying from the wholesalers pay the Pool price. The rest purchase at a price that is fixed for a longer period of time, so the wholesale supplier bears the risk of losing money if Pool prices go above the contract prices. Of course, the wholesalers make money when the Pool price is below contract prices. Contract prices generally reflect a premium to wholesalers for bearing this price risk.

Presumably, all customers willing to bear price risk can do so already by signing contracts that are tied to the Pool price. The Pool reforms, therefore, are not likely to change the fraction of customers exposing themselves to variations in half-hourly prices. Customers will bear price risk if they can alter their demand to take advantage of low Pool prices and shift demand out of periods when prices are high. If the generators know that higher prices in a given half-hour will lead some customers to either shift their demand to other hours or to curtail their demand, they have less of an incentive to drive prices up. The problem is that the extent to which customers will curtail their demand is only indirectly reflected in Pool prices.

Having an active demand side that is able to convey consumers' price responsiveness to the generators is likely to keep prices down. In no way does it require having a discriminatory

auction. In a number of procurement auctions, including the Norwegian electricity market, demanders submit bids indicating how much they will consume at various price levels. The market clears at the price where the total demand is equal to the total supply.

Encourage the Development of Financial Markets One way for customers and the wholesale suppliers to manage their exposure to wholesale price swings is to buy forward and futures contracts, promising them the right to power at a certain price over a certain time period. Generally, the more financial instruments for which there is liquid trading, the more options wholesalers and customers have to style contracts that provide inexpensive electricity but expose them to a certain level of price risk. Also, economic theory suggests that the presence of forward contracts can promote competitive pricing in the spot market. Currently in the UK, there is some organized forward trading, but not a lot. There have been suggestions that parties are afraid to enter into such contracts because the Pool price, the price forward contracts are tied to, can be manipulated by the dominant generating firms.

There is nothing inherent in a uniform price market that makes it easier for the dominant producers to manipulate prices. The generating companies are only able to manipulate the prices in the Pool because there are so few of them and they consequently wield considerable market power. The move to a discriminatory price system does not address the key factors stifling financial innovation in the electricity sector.

Conclusion

This article has laid out some of the basic features of an efficient electricity market and commented on the extent to which the reforms proposed for the Electricity Pool of England and Wales will promote them. Economists have identified two basic characteristics of efficient markets: production should take place at the lowest possible cost and prices should be equal to

the marginal cost of production. The British government's proposed trading reforms involve switching from a uniform-price market to a discriminatory market. Discriminatory pricing may lead to inefficient production. Prices in the Pool have undoubtedly been higher than marginal costs, but switching to discriminatory pricing is unlikely to solve this problem given the current market structure, which is dominated by a small number of generating companies. Without addressing the market power problem head-on, the changes are unlikely to promote an efficient electricity market.

Several other objectives of the proposed reforms are sound. The reforms aim to encourage financial innovation and active demand-side participation. Both initiatives are likely to push market prices down, but neither relies on the change in price-setting arrangements.

The documents outlining RETA express an explicit concern that the Pool rules are biased against coal generating stations. For instance, the arguments suggest that the uniform price auction has encouraged too much entry by firms with inexpensive gas plants who know they can bid close to zero and still earn the market-clearing price. As discussed above, plants that can make money at market-clearing prices must be at least as efficient as the marginal plants and should not be discouraged from entering the market. Enough entry will eventually drive the prices down closer to the costs of the entrants. Coal plants may end up supplying less electricity as they are supplanted by less expensive gas plants, but only to the extent that the gas plants are more efficient.

Since a discriminatory auction compensates companies based on their ability to predict the market-clearing price rather than based on their relative efficiency, owners with coal plants will inevitably have more accurate predictions than owners with gas plants from time-to-time. Hence, coal plants will be used more than they were under the uniform-price Pool. This achieves

a subsidy for the coal industry at the cost of higher electricity prices for consumers. In light of the explicit concessions to coal interests behind RETA, one suspects that political considerations have overwhelmed economic arguments.

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