

Electricity Markets: Should the Rest of the World Adopt the United Kingdom's Reforms?

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RITAIN WAS ONE OF THE FIRST COUNTRIES TO liberalize its electricity industry when it restructured and privatized the industry in 1990. Since then, a number of countries and a handful of U.S. states

have undertaken their own electricity reform programs. At least a dozen more states are in the process of adopting legislation to restructure their industries over the next two to three years.

Policymakers everywhere have analyzed and tried to learn from Britain's experience, adopting some of the features of the British system but modifying others. Now the British government has embarked on a radical reform of the electricity industry and is proposing "New Electricity Trading Arrangements," or NETA. The changes to the electricity market are to take effect in the fall of 2000. Some of the changes will bring Britain in line with what other countries have done, but other changes will be unique.

Is Britain 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 Britain's lead on some of these changes? I believe the answer to both questions is a decisive "no."

Although proposed reforms to introduce demand-side bidding and encourage financial innovation make sense, the British government's proposal 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. For instance, new combined-cycle gas turbine plants have recently been built with as little as 200 to 300 megawatts of capacity, about one-fifth the capacity of most nuclear power plants. Competition in

generation services is therefore deemed workable. Restructuring has been designed to foster competition and to create incentives for efficient investments in generation assets. Some of the most costly decisions made under regulation or state ownership have involved investments in generating plants that turned out to be inefficient and uneconomical. Incentives to make efficient investments, therefore, could lead to substantial savings.

Though the idea of competitive, unregulated generation is one of the cornerstones of electricity reform programs, reformers continue to debate how to structure a competitive market for generation services. One of the basic questions is how much to centralize trading. Britain's centralized market has been at one end of the spectrum. That 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, trading is less structured; 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 the United States and other countries fall somewhere along the Britain-Norway spectrum.

Technical features of electricity generation and transmission require that at least last-minute trading take place through a centralized system operator. First, electricity cannot be stored—demand and supply must always be in balance within a transmission system. The typical transmission system connects electricity producers and consumers over a large area, and actions by any producer or consumer can affect everyone else connected to the system. For instance, all states but Texas east of the Rocky Mountains form one synchronized 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 last-minute demand surges (e.g., from increases in the use of air conditioning on hotter-than-expected days) are met by new generation and that last-minute plant outages are met either by additional generation or reductions in demand.

Second, electrons follow the laws of physics without heed to 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 sold through bilateral contracts or sold in a day-ahead market, that additional power either must be used by a customer or another plant must reduce its production concomitantly. 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 would need to internalize the effects their last-minute decisions could have on system stability.

In California, balancing and other last-minute trades take place through a market administered by the Inde-

pendent System Operator (ISO). Norway similarly effects last-minute trades through a market operated by the transmission system owner, Statnett. Even the proposed British reforms envision a centrally coordinated market for last-minute trades.

THE PROPOSED REFORMS IN BRITAIN

THE PROPOSED CHANGES TO THE ELECTRICITY MARKETS in Britain have been spelled out in a series of documents, including a government White Paper issued in October 1998 and a July 1999 report by the gas and electricity regulatory agency, the Office of Gas and Electricity Markets (Ofgem). 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 restructuring of the electricity industry. 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 generators, in which they specify 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 highest bid that must be accepted to meet forecast demand. All sales take place at the system marginal price, although parties can sign financial contracts around Pool prices.

With the proposed reforms, or NETA, the British government hopes that trading will become 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. NETA also aims to incorporate demand-side bidding into the market. These 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, each generator be paid its bid instead of the last accepted bid. In the language of economics, the proposal is to switch from a market organized as a uniform-price auction to one organized around a discriminatory auction.

In the rest of this article I will lay out some of the basic features desirable in electricity markets and then discuss the British government's stated reasoning behind its proposed reforms, commenting on the likelihood that the reforms will achieve the government's 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.

Importance of Auction Rules The rules of an auction influence how aggressively the parties will bid, who will win,

The firm with two plants submits two numbers: the amount it requires to generate power from one plant and the amount it requires to generate from both plants. For instance, if all firms bid their costs, Firm A would bid \$15, Firm B would bid \$16, and Firm C would bid \$5 to generate one unit of electricity from one plant (it would choose the inexpensive plant) and \$25 to generate two units of electricity from each of its two plants.

In a discriminatory auction, the auctioneer buys power from the seller(s) who submit the lowest bids and pays them what they bid. In 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. Continuing with the example, suppose the auctioneer knows that only two units of electricity will be needed. The least

costly way of meeting that need would be to procure one \$15 unit from Firm A and one \$5 unit from Firm C. In a discriminatory auction, Firm A would receive \$15 and Firm C would receive \$5. In a uniform-price auction, the price offered to both bidders would be \$15. In that case, the auctioneer would pay Firm C a higher price than it bid.

The apparent tendency of a uniform-price auction system to pay some producers more than they would bid in a discriminatory auction is an illusion.

and how cheaply a contract will be procured (or, in a sale auction, how much money the product will sell for). One set of rules determines how an 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 electricity markets, 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 that determine how parties' bids affect the prices they are awarded.

Economists have well-developed models of auctions, and they 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.

Example I will set the stage for the later discussion with an example that illustrates some of the differences between discriminatory and uniform-price auctions. Consider an auction where there are three suppliers, Firms A, B, and C. Firms A and B own one plant each, and it costs \$15 to generate a unit of electricity from Firm A's plant and \$16 to generate from Firm B's plant. Firm C owns two plants, one with a generation cost of \$20 per unit and one with a generation cost of \$5. Assume that all four plants are the same size and that each generates 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. Firms with one plant submit one number indicating the payment they require to generate power.

The notion that a uniform-price auction pays some bidders more than they bid has been particularly bothersome to proponents of reform in Britain. But few, if any, economic principles support their proposed solution, which is to switch to a discriminatory auction. The apparent tendency of a uniform-price auction system to pay some producers more than they would bid in a discriminatory auction is an illusion.

Returning to the example, *if each bidder is well informed* about the other's likely bid and about the required amount of electricity, Firm B would *not* submit a price of \$5 for its first unit of electricity in a uniform-price auction. The firm would know that it had one of the two cheapest plants available and that all competing plants had costs of \$15 and higher. In fact, if we allow firms to submit bids different from their costs, both Firm A and Firm C would bid \$15.99, just below the cost of the second most expensive plant. In other words, they would bid the expected market-clearing price.

Unfortunately, the superficial argument that the discriminatory auction will lead to lower prices for low-cost generators has won out. The British government has made the discriminatory auction a central component of NETA.

What are the desirable characteristics of electricity markets? And will the proposed reforms in Britain support those features? I will describe the desirable characteristics in the next section and assess the proposed reforms in the section after that.

FEATURES OF AN EFFICIENT MARKET

Efficient Pricing A principal characteristic of any efficient market, whether or not it is run as an auction, is that the

prevailing price is close to the marginal cost of producing the product. Meeting that condition requires that sellers do not have incentives to raise prices above their marginal costs. For instance, a monopolist has an incentive to raise its price because it knows no one can undercut it. Generally, the more sellers there are in a market the less likely it is that anyone can raise prices above marginal costs without being undercut by a competitor. How do uniform-price and discretionary auctions fare in terms of this analysis?

Uniform-Price Auctions These auctions give some sellers an incentive to raise their prices above their costs. Consider a firm with several generating plants. The firm knows that if some of its plants are likely to be among the marginal plants in the bidding (the plants with highest accepted prices), the prices it submits for those plants will set the prices it receives for the output of all its plants. The firm therefore has an incentive to try to submit above-cost prices for those plants that are likely to be marginal. The firm knows that if it raises the price for a potentially marginal plant too much, that plant might not be called, and the profit from operating the plant will be lost. On the other hand, if the firm raises the price for the potentially marginal plant by just enough so that the plant still sets the market price, that price will be earned by all of the firm's plants. Plants that earn the price of the marginal plant but have submitted lower bids are called "inframarginal" plants. The more inframarginal plants a firm owns, the greater its incentive to raise the prices submitted for its potentially marginal plants. (That incentive is 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:

- Plants with high fuel costs submitted bids that reflected larger markups above their marginal costs than plants with low fuel costs.
- For plants with the same fuel costs, National Power (the larger supplier) submitted higher bids than PowerGen.
- Bids for a given plant would rise slightly on days when more of the firm's capacity at other, typically inframarginal plants became available.

Discriminatory Auctions Although the ability to set the price for all inframarginal plants may drive bids higher in uniform-price auctions, discriminatory auctions also can foster high bids. There is a phenomenon called the "winner's curse" in auctions and it can have a profound effect on bidding in markets where bidders are paid their bids and where all bidders have imperfect information about the likely market-clearing price.

There could be imperfect information because of uncertainty about the level of demand. To illustrate the point, consider the earlier example of Firms A, B, and C. If the firms knew that there would be two units of demand, the market-clearing price would be \$15.99, just below the price for the second most expensive plant. If the firms knew there would be three units of demand, the price would be \$19.99, just below the price for the most expensive of the four plants. Now consider the decisions faced by Firms A and B. With uncertainty about whether demand would be two or three units, each firm would have to decide whether to bid \$15.99 or \$19.99. If one of them believed demand would be two units and bid \$15.99, it would be paid only \$15.99 even if demand turned out to be three units and it could have bid \$19.99. Knowing that, bidders in discriminatory auctions try to avoid the winner's curse by submitting higher bids.

Implications for Britain The presence of the winner's curse argues for a uniform-price format; the presence of inframarginal capacity argues for a discriminatory format. Whether the winner's curse, inframarginal capacity, or some other factor has a greater influence on price probably depends on the specific attributes of a market.

In any event, the proponents of reform in Britain who argue that a discriminatory auction will lead to lower prices are probably wrong. Under a discriminatory system, the plants that used to submit very low bids in a uniform-price auction probably would raise their bids to be closer to the bids of those plants that were setting the price under the uniform-price system. In fact, low-cost plants that have good information about other suppliers' costs are likely to submit bids that are just below the market-clearing price.

Efficient Production The British reform documents fail to mention the possibility that with discriminatory pricing low-cost producers may overestimate how high they can bid and still be called, thus pricing themselves out of the market. If that were to happen very often, there would be real inefficiencies in the market, because plants with high marginal costs would be run before plants with low marginal costs. Consumers would pay too much if expensive plants were run while less expensive plants sat idle.

How might low-cost plants price themselves out of the market? Suppose all bidders try to estimate the market-clearing price and bid about the same amount. Then, whether or not a specific plant runs would be arbitrary and not closely related to the plant's cost.

It is true that low-cost plants might bid more conservatively because they would stand to lose more profits if they were not run. But a firm's ability to predict the market-clearing price depends on how much information it has about the rest of the market. If a firm is too optimistic about market prices, even its less expensive plants may be priced out of the market.

Under a uniform-price auction, a firm could submit low bids for its low-cost plants, guaranteeing that they would be run whatever the market-clearing price.

Efficient Entry As I discussed earlier, 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 electricity prices down, therefore, is to ensure that firms are not discouraged from either entering the market or building new, more economical power plants. A number of factors can influence a firm's decision about whether to build a plant, including the cost of building the plant, the price the firm expects to pay for fuel, and the price it is likely to receive for power generated. The organization of electricity trading influences only the price received for power, so I will focus on that.

In a discriminatory-auction market, profits for inframarginal plants depend on accurately forecasting the market price. Firms that think they are good at guessing the market-clearing price are more likely to build more capacity or to enter in the first place. The more plants a firm has the better it can gauge the market-clearing price, because it has more information about the costs and availability of plants, namely, its own. If, for example, a firm with many plants has a large plant with low running costs that is shut down suddenly for mechanical reasons, the firm knows that the market-clearing price is likely to be high. Thus, firms in a discriminatory-auction market may have a strong incentive to build new plants, whereas smaller firms or prospective entrants may consider the market too risky. That could lead to less competition and, therefore, higher prices.

Profits for inframarginal plants in a uniform-price market do not depend on accurately forecasting the market-clearing price. Thus, in a uniform-price market, large firms are less likely to dominate, small firms are more likely to expand, and new firms are more likely to enter. That leads, of course, to greater competition and, therefore, lower prices.

THE OBJECTIVES OF BRITAIN'S REFORMS

BRITAIN'S OBJECTIVES ARE PARTLY TO MAKE MARKETS MORE efficient, along the lines I have just discussed, but there are other aims. I will now consider how well the proposed reforms might serve the reformers' aims.

Keep Prices Low It is clear that prices for wholesale power in Britain have been above competitive levels. Ordinarily, it would be hard to say that with much certainty because it is almost impossible to determine what prices and profits would be in a competitive market. To do that requires 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 composed almost entirely of the cost of fuel burned in generating electricity. That cost is a function of the price of fuel and the efficiency with which a plant converts fuel into electricity. Because Britain's electricity industry was in the public domain until four

years ago, there are detailed data on plant efficiency; those data generally remain relevant to plant operations. (The now-privatized firms consider plant efficiency data competitively sensitive and guard them quite closely.)

For a study published recently in the *American Economic Review*, I obtained information on plant efficiency rates, fuel prices, and availability levels and used that information to calculate marginal costs. I then calculated the difference between the prices paid for electricity and the marginal costs of generating it. From 1992 through 1994, on average, prices were 25 percent above the costs of the last plant needed to generate electricity in a given period. That suggests prices would have been substantially lower had they been set competitively. Since 1994, fuel prices have come down but electricity prices have not fallen accordingly. That suggests profits have risen and provides further evidence that prices are not responding to competitive forces.

The regulatory body that oversees the electricity industry (formerly OFFER, now 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, 10 since 1990), instituted a cap on Pool prices in 1994-96, and, most substantively, 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. Since 1990, National Power and PowerGen have been steadily losing market share, as measured by total kilowatt-hours of electricity generated. Nonetheless, plants owned by one of the two firms set the marginal Pool price more than 60 percent of the time during 1998. Unfortunately, the divestitures that took place in 1996 were structured as leases, and the lessee was forced to make large per kilowatt-hour lease payments. That effectively raised the acquirer's marginal costs and, therefore, the price at which it must offer electricity.

What about the prospects for lower prices under the proposed market reforms? As I have explained, simply switching to a discriminatory auction and encouraging bilateral trading is unlikely to drive prices down. No matter the design of the auction, companies will not sell at prices that are lower than those they think the market will bear.

Further, the proposed reforms do not address the high level of concentration in the industry. And if the discriminatory system encourages further concentration and discourages entry, as I have suggested it will, the prospects for lower prices may be even dimmer than under the current system.

Let Consumers Buy Directly from Producers One of the objectives of the proposed reforms is to try to get more consumers directly involved in the market. Currently, only a small number of consumers buy directly from the Pool and pay the Pool price, which is set half-hourly.

Most consumers buy through wholesale suppliers. But only a small fraction of those consumers pay the Pool price;

the rest purchase at a price that is fixed for a longer period of time, so that wholesale suppliers bear the price risk. Contract prices generally reflect a premium to wholesalers for bearing that risk. Presumably, all consumers that are willing to bear the price risk can do so now by signing contracts that are tied to the half-hourly Pool price. The reforms, therefore, are not likely to change the fraction of consumers that expose themselves to variations in prices.

Consumers will bear the price risk to the extent that they can shift their usage of electricity from periods when the Pool price is higher to periods when it is lower. Producers have less of an incentive to drive prices up if they know that consumers will respond to higher prices in a given half-hour by shifting or curtailing their usage. But because not all consumers buy directly from the Pool, Pool prices only indirectly reflect the extent to which consumers will shift or curtail their usage.

Producers that are directly aware of consumers' price-responsiveness are likely to keep their prices down. A discriminatory auction is not needed to convey consumers' price-responsiveness. 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 consumers and wholesale suppliers can manage their exposure to wholesale price swings is to buy forward and futures contracts, which promise them the right to buy power at certain prices during certain periods. Generally, the more financial instruments for which there is liquid trading, the easier it becomes for wholesalers and consumers 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.

There is now some organized forward trading in Britain, but not a lot. There have been suggestions that parties are afraid to enter into such contracts because the Pool price, to which forward contracts are tied, can be manipulated by the dominant generating firms.

There is nothing inherent in a uniform-price market that makes it easier for dominant producers to manipulate prices. The generating companies are able to manipulate Pool prices simply because there are so few generators and they consequently wield considerable market power. The move to a discriminatory-price system would, if anything, lead to greater concentration in the electricity industry.

SUMMARY AND CLOSING NOTES

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, NETA, involve switching from uni-

form to discriminatory pricing, and this may lead to inefficient production. Although prices in the Pool have undoubtedly been higher than marginal costs, a switch to discriminatory pricing is unlikely to solve that problem, given the dominance of a small number of generating companies.

NETA also aims to encourage financial innovation and active demand-side participation. Both initiatives are likely to push market prices down, but neither relies on the adoption of discriminatory pricing.

Finally, NETA seems biased toward less-efficient coal-burning plants, to the possible detriment of more-efficient gas-burning plants. For instance, there is the suggestion that the uniform-price auction has encouraged too much entry by firms with low-cost gas plants, which can bid close to zero and still earn the market-clearing price. 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 eventually will drive prices down toward entrants' costs. Coal plants may end up supplying less electricity as they are supplanted by gas plants, but only to the extent that the gas plants are more efficient.

Because a discriminatory auction compensates companies based on their ability to predict the market-clearing price rather than on their relative efficiency, and because coal plants currently dominate the industry, owners of coal plants generally will predict prices more accurately. Hence, adoption of a discriminatory auction would cause coal plants to be used more than they are under the uniform-price system. That would subsidize the coal industry at the cost of higher electricity prices for consumers. In that light, one must suspect that NETA represents a victory for political considerations over economic arguments.

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