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An Analysis of Market Institutions for PowerChoice

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1. Introduction

Niagara Mohawk's PowerChoice proposal has a central goal of creating competitive markets for electric power in the near term. PowerChoice would create an Independent System Operator (ISO) to manage load and, in addition, a competitive wholesale generation market in the form of a Power Exchange. The Power Exchange would operate in a manner similar to financial markets found around the world. By divesting itself of power production Niagara Mohawk would remain a regulated entity engaged in transmission and distribution of electricity. This report provides: a description of the alternative market institutions which might be utilized by the Power Exchange, a preliminary assessment of the desirability of those institutions, an evaluation of broader aspects of deregulation and market structure, and a brief conclusion which suggests research necessary to resolve questions which remain concerning the performance of alternative institutions.

2. Alternative Market Institutions

Although it is envisioned that the proposed Power Exchange would operate in a manner similar to financial exchanges, an important difference exists. The ISO would, in effect, be the single buyer in the Power Exchange. Thus, the Power Exchange must be run as a single sided market (similar to auctions conducted by the government for oil leases or auctions for art objects) rather than a two sided market which brings together buyers and sellers (such as the New York Stock Exchange). Single sided auctions are usually conducted with a single seller and many buyers. Again, the Power Exchange differs from this typical structure in that it proposes a single buyer and many sellers. However, existing evidence suggests that performance should be symmetrical (McClelland and Schulze, 1991, and Irwin et al., 1995). Thus, economic theory and the large number of experimental studies of these auction markets are likely to provide good evidence on the performance of different institutions.

Five candidate institutions might be utilized by the proposed Power Exchange: 1) The Uniform Price (or Competitive) Auction, 2) the Discriminative Auction, 3) the English Auction, 4) the Dutch Auction, or 5) the Continuous Offer Auction. The first two institutions are sealed bid auctions which involve simultaneous decisions by sellers. In these auctions all sellers must decide what offers to submit both in terms of the prices and quantities of electricity without knowledge of competitors' offers. These sealed offers are then evaluated according to the rules of the institution and the outcome is announced. The last three institutions are sequential in that participants can observe each other's behavior and respond in real time since offers are public information. The remainder of this section will describe each of these institutions in the context of their use for the proposed Power Exchange, including a few of the obvious institutional details which are necessary for their application in this setting. A summary of both the theoretical properties and experimental tests of performance will also be provided.

The Uniform Price Auction is a generalization of the Vickrey Auction (Vickrey, 1961) first proposed by Friedman (1960) that allows for multiple units rather than just one unit to be traded. The institution is often used to set dividends on preferred stock issues. This auction has also appropriately been called the competitive auction institution. For reasons that will become apparent, sellers have incentives to submit offers at prices equal to costs. Figure 1 shows how this institution might work as a Power Exchange. For exposition, assume that six sellers of power each own one facility and that the cost per kWh for each of these facilities is c_1, c_2, c_3, c_4, c_5, and c_6 in increasing order. Capacities in mW for each of these facilities are q_1, q_2, q_3, q_4, q_5, and q_6. Under the rules of a uniform price auction, sellers must submit offers which consist of a price and a maximum number of units they would be willing to sell at that price. Once these offers are submitted they are ranked from lowest

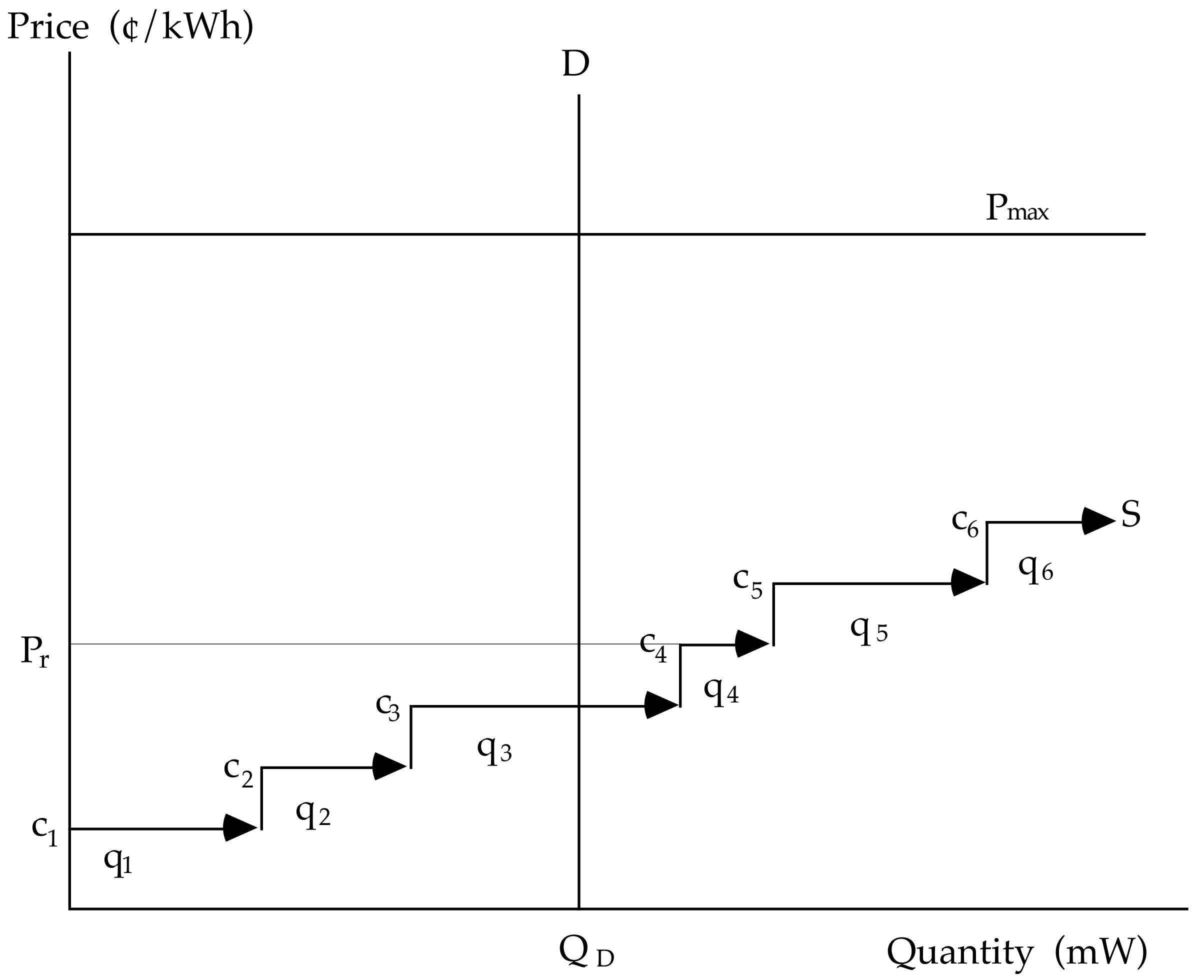

Figure 1: The Uniform Price Auction

to highest price and the lowest priced units are purchased up to the point that the number of units demanded (Q_D in Figure 1) are supplied. The uniform price paid for all purchased units is equal to the price of the first rejected offer and is called the reigning price P_r. Note in Figure 1 that the supply curve (labeled S) is made up of supplier costs because, under these rules, suppliers have the incentive to submit offered prices equal to costs. Since, in Figure 1, the first rejected offer is at a price equal to c4 (under the assumption that P4=c4), the reigning price is equal to c4. Thus suppliers 1, 2, and 3 have their offered prices accepted and each receives price P_r for q_1, q_2, and less than q_3 units respectively. Suppliers 4, 5, and 6 have their offers rejected. Note that offered quantities are defined as maximum quantities in this auction so that the purchaser can take, at its own discretion, only the part of q_3 necessary to satisfy demand. The most important feature of this institution is, however, its incentive structure. Since each of the suppliers receives a price greater than their offered price, and since submitting an offered price above cost exposes a supplier to the risk that the high offered price will result in its units being excluded from sale with loss of an opportunity to profit, firms have a clear incentive to submit offered prices equal to cost and quantities equal to capacity. This implies that the reigning price is a reliable signal of the marginal cost of the next available block of electric power and that if the currently accepted offer price has remaining capacity that that offer price is also a reliable signal of marginal cost. Thus, these prices can be used for planning purposes by the ISO.

A final point to consider is the need to include a reservation price. The maximum price that the ISO should be willing to pay suppliers in the Power Exchange is the price at which it can purchase power off the grid from the New York State Power Pool or other sources. This reservation price is shown as P_{max} in Figure 1 and is high enough in this example to be irrelevant. However, if P_{max} were to fall, for example, to between c_2 and c_3 in Figure 1, the reservation price would come into play. Purchases would be limited to q_1 and q_2 at price P_{max}, with the remaining power needed to meet demand, Q_D, coming from the grid since P_r is less than c_3.

Although the theoretical properties of this institution are excellent (see Vickrey, 1961, Milgrom, 1989, and Riley, 1989), experimental tests reveal that the uniform price auction has good, but not excellent, properties in practice. For example, Cox, et al. (1985) report that a majority of subjects bid below their valuations in uniform price auctions with many buyers and one seller. If this result generalizes to the symmetrical case of interest here (that of many sellers and one buyer), then a majority of sellers would submit offers above costs. This would, potentially, raise electricity prices and reduce efficiency below the theoretically attainable level. Fortunately, as we discuss below, the English Auction is theoretically identical to the Uniform Price Auction and thus has the same efficiency properties. However, in experimental testing, the English

Auction performs better than the Uniform Price Auction, and is more consistent with theoretical expectations. However, since no experimental tests of the Uniform Price Auction have been conducted for the many seller case, the efficiency of the institution in this setting remains conjecture.

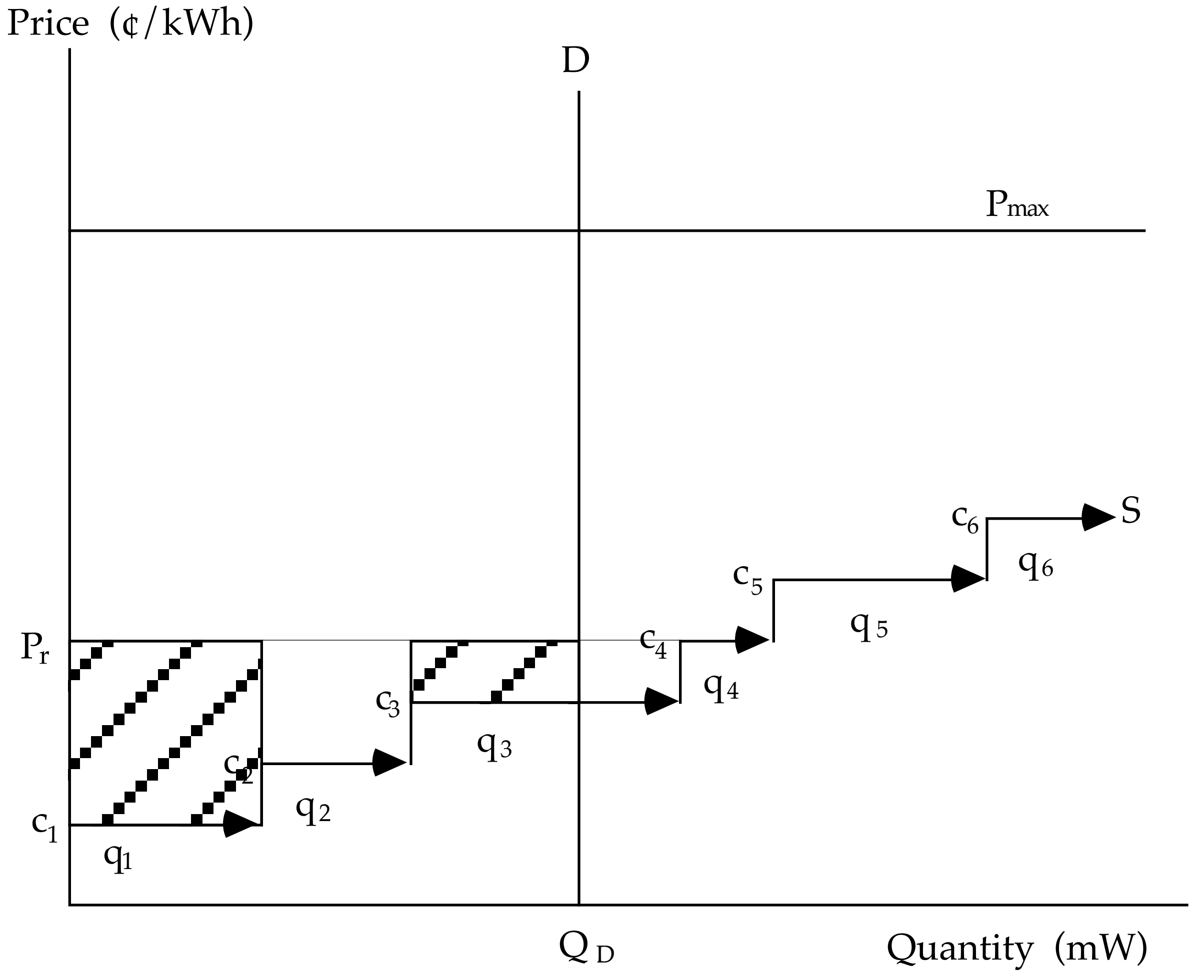

Figure 2: Profits in the Uniform Price Auction

An issue which applies to any auction with uniform prices is the possibility that a very large firm might exploit market power to raise prices. In Figure 1 it was assumed that each facility was managed by a separate firm. Now consider the case where the same firm manages two facilities with costs c_1 and c_3 and capacities q_1 and q_3. Figure 2 shows the profits (denoted by the shaded areas) earned by this firm for each of its two facilities if it behaves in a competitive manner submitting offered prices equal to costs and quantities equal to capacities. Figure 3 shows the firm's profit if it withholds its second facility (with cost c3 and capacity q3) from the market. Note in Figure 3 that the reigning price is driven up to c6 and that the profits earned by supplying q1 at this high price (shown

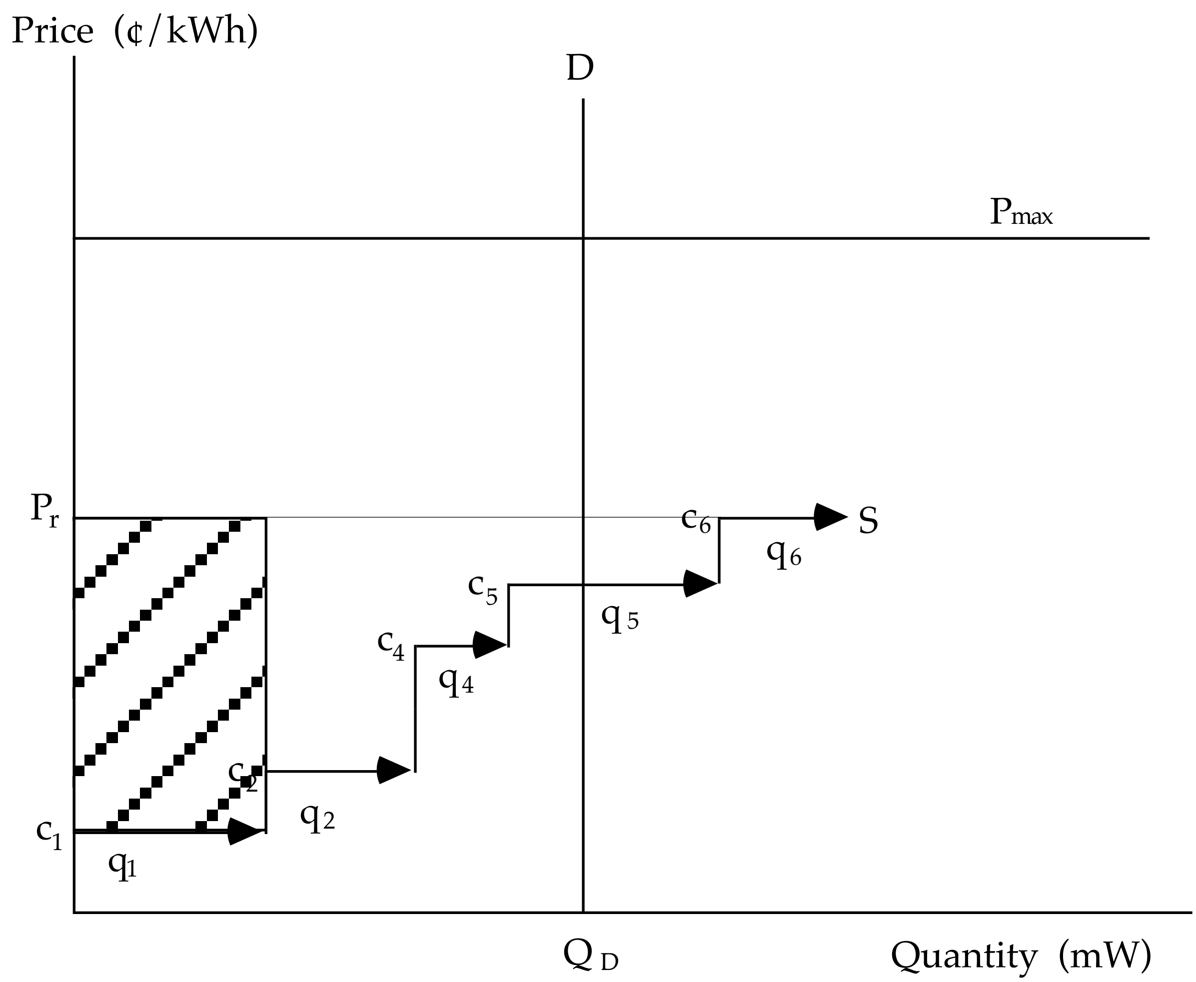

Figure 3. The effect of market power on profits

as the shaded area in Figure 3) exceed the profits earned by offering q1 and q3 in Figure 1 (the sum of the shaded areas in Figure 2). Clearly, this large firm, under the conditions described, has an incentive to withhold q3 from the market raising the price of wholesale electricity and increasing profits not only for itself but also for other competitors in the power generating industry. Two factors mitigate against such behavior. First, behavior of this sort would be obvious to knowledgeable observers and would likely draw antitrust action. Second, as the recent large number of new power producers to enter the market in New York State demonstrates, power production may be a contestable market. If a large firm were to maintain high prices in the wholesale market for electric power, new firms and capacity could well be attracted that would offer power at lower prices.

The Discriminative Auction is a generalization of the well known first price auction. Suppliers would submit offers to the Power Exchange for both price and capacity just as in the Uniform Price Auction. Again, the ISO would want to indicate a maximum reservation price it would be willing to pay. The lowest price offers are again accepted until demand is satisfied. However, each supplier whose offer is accepted is paid their offered price. Thus, each supplier is potentially paid a different price equal to the price offered by the firm to the Power Exchange. Clearly, firms no longer have an incentive to submit offered prices equal to costs. Rather firms have an incentive to attempt to profit by submitting offered prices above costs. The tradeoff that firms face is between a higher priced offer which raises potential profit versus a lower priced offer which raises the probability of the offer being accepted. Under a set of simplifying assumptions (risk neutrality and each firm knows that the distribution of costs among suppliers is rectangular), economic theory predicts that the price submitted by the i^{th} firm with a cost of c_i, will exceed costs where there are n competitive suppliers in the Power Exchange, but, as the number of suppliers becomes large, the offered prices will approach costs and the performance of the institution improves. However, if only a few suppliers are in the market, say two, then offered prices will be very high.

Experiments testing the Discriminative Auction have shown, however, that performance is worse than that predicted by theory. In other words, it is possible that offered prices will be even higher than theory predicts. Cox et al. (1985) in testing the Discriminative Auction for fixed supply and many buyers show that revenues obtained from sale of the fixed supply fall below those predicted by theory. If auction results are symmetrical for situations with fixed supply and those with fixed demand (note that this remains conjecture) these results imply that the total cost for the ISO to obtain a fixed demand for electricity using a Discriminative Auction will exceed those predicted by theory. This is important because theory suggests that the costs for obtaining a fixed quantity of electricity using either the Uniform Price Auction or the Discriminative Auction will be identical (Milgrom, 1989, and Riley, 1989). This occurs because even though sellers will submit higher offer prices in the Discriminative Auction than in the Uniform Price Auction, sellers are paid more than their offers in the Uniform Price Auction. Under the simplifying assumptions noted above, costs to the ISO for purchasing power will theoretically be the same under either auction. In fact, experimental results suggest (if symmetry holds) that costs will exceed theoretical predictions in both types of auctions. Cox et al. also show that revenues (and presumably costs) are not statistically different for the two types of auctions.

The overall conclusion concerning sealed bid auctions is that neither of the two institutions considered lives up to the theoretical properties ascribed to them. Fortunately, sequential auctions, for example the English and Continuous Offer institutions, tend to perform in a manner consistent with theoretical expectations.

The English Auction has traditionally been used in a single unit fixed supply setting to sell art, wine, or antiques. The multiple unit version of the English Auction could be utilized in the fixed demand setting of the Power Exchange as shown in Figure 4. In this sequential auction, each seller would initially submit a quantity offer indicating the maximum number of units available for sale (capacity) for each generating facility to be entered into the auction. For simplicity, we will assume that each firm owns one facility and also assume that the industry cost structure is identical to that presented in Figure 1. The auctioneer then begins the auction by starting a "clock" which sweeps down, lowering price continuously. Suppliers then progressively drop out of the auction, withdrawing their offered quantities, as the price falls below profitable levels. The clock stops when the number of units withdrawn causes supply to fall below the quantity demanded. The clock is then reset to the last price at which supply exceeded demand. This price is then paid as a uniform price to all sellers remaining in the auction which includes the last seller to withdraw in this example. The theoretical analysis of this auction is identical to that of the Uniform Price Auction and, in theory, sellers should withdraw just as price falls below their own cost. In Figure 4, at the starting price of P_{max} (which again serves as a reservation price for the ISO), all suppliers remain in the auction. However, when the price falls below c_6, q_6 must be withdrawn to prevent a loss. The price will continue to fall until just below c_3, at which point, quantity supplied falls below demand. The price is then reset to c_4, the last price at which supply exceeded demand, and sellers 1, 2, and 3 have their offers accepted at a price of c4. The English auction provides information on both c3, the current marginal cost, and on c4 the marginal cost of the next available block of power, for the ISO's planning purposes. Experimental tests of this mechanism in

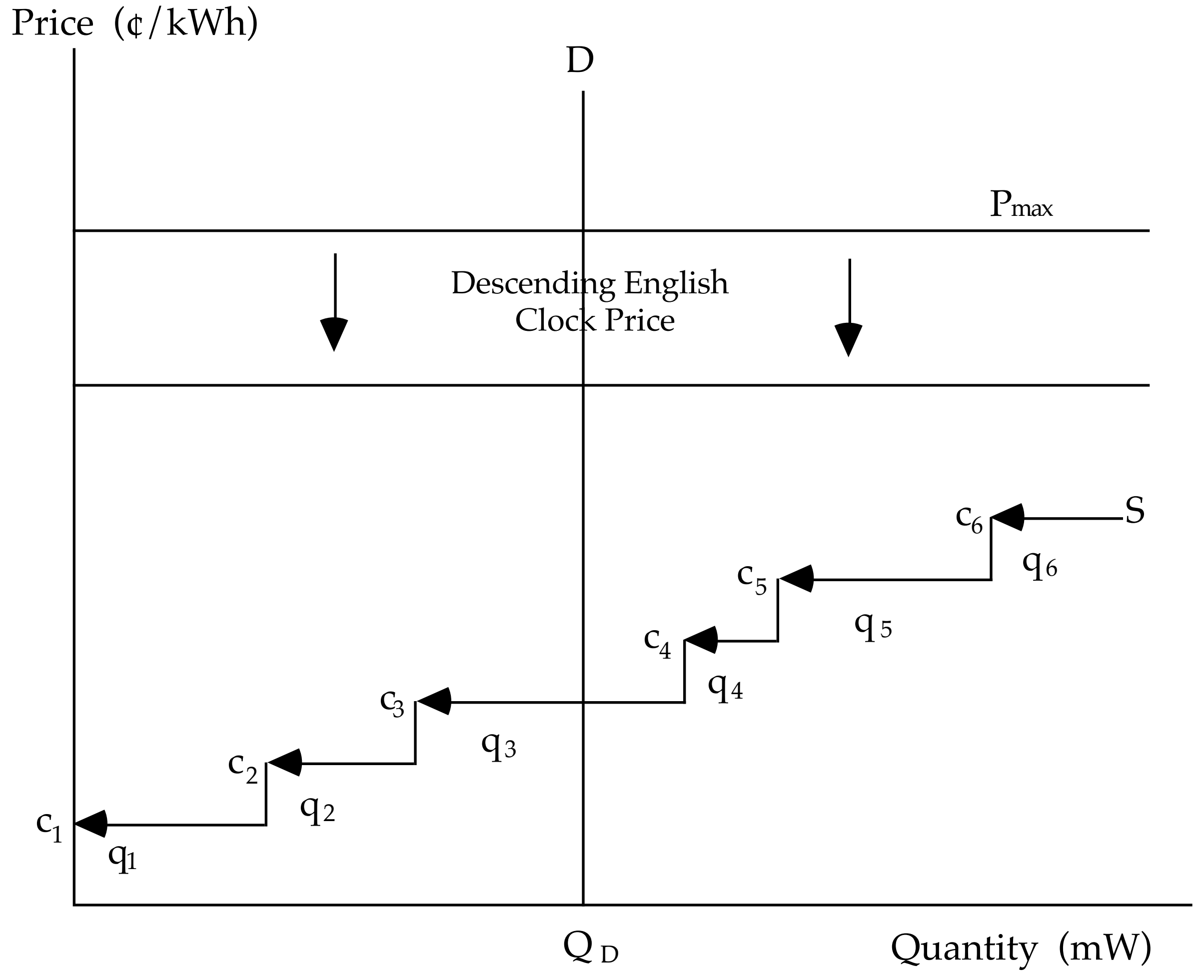

Figure 4. The English Auction

a fixed supply setting have been very favorable. Two studies, McCabe et al. (1990) and Van Huyck et al. (1993), have shown that the highly desirable theoretical properties of the English Auction are, in fact, realized in practice. Again, the caveat must be raised that these studies have been conducted in a symmetrical setting with many individual buyers and one seller.

The <u>Dutch Auction</u>, in a single unit fixed supply setting, has traditionally been used to sell flowers and bulbs in Holland. The

Dutch Auction could be adapted for use in the Power Exchange in two ways, as follows. First, as a sequential version of the Discriminative Auction, sellers would again submit quantity offers in terms of capacities for various facilities. Dutch auctions also use a "clock" price mechanism where, however, the price sweeps upwards, starting at zero. As the price sweeps upward, as shown in Figure 5, firms must decide how long to

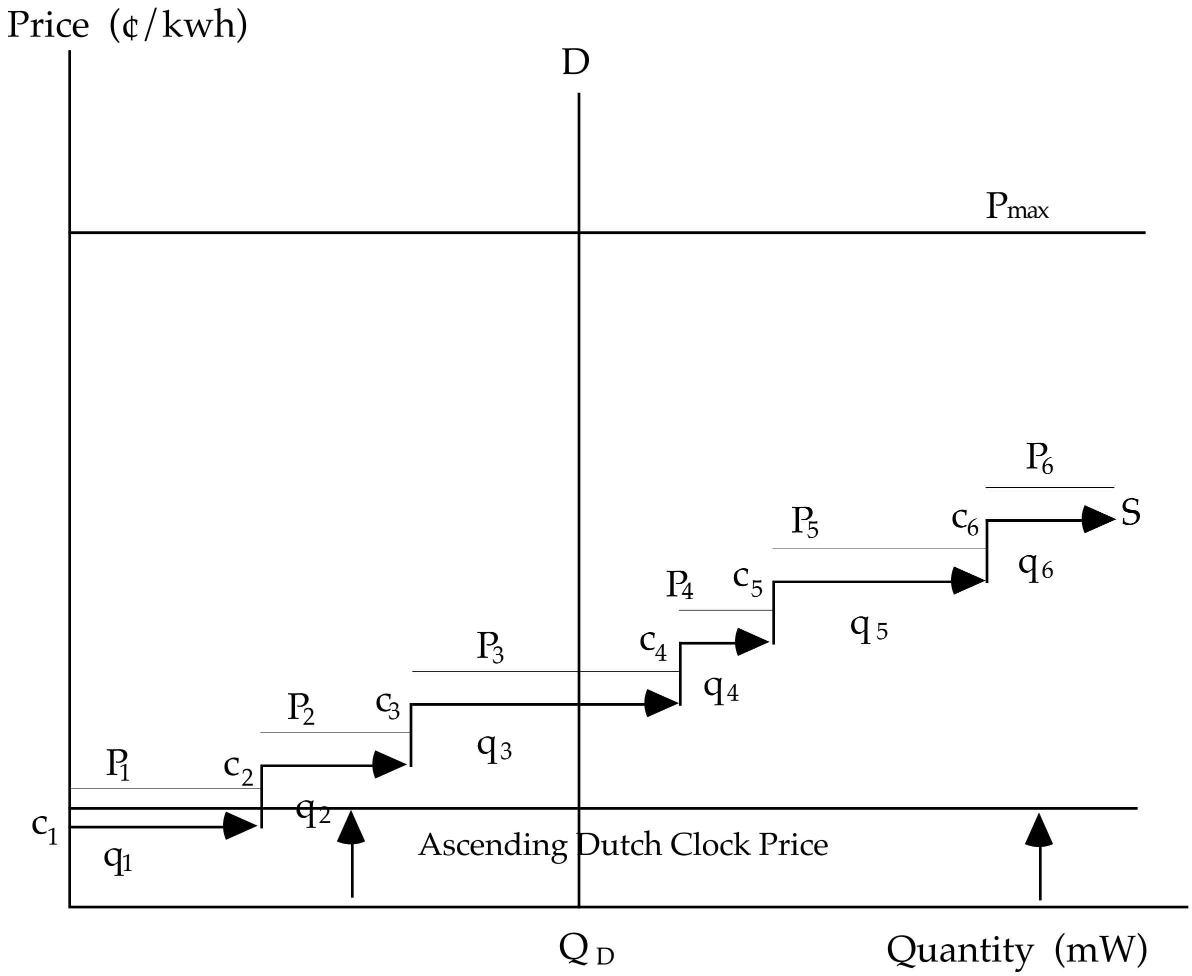

Figure 5 The Dutch Auction

wait before confirming their quantity offers. When they signal confirmation, they then commit to accepting the current clock price for those units. Thus, in Figure 5, firm 1 has delayed confirming q_1 units until after the clock price has passed c_1 so that some profit will be earned on those units. However, if firm 1 waits too long, firms 2, 3, and 4 might undercut firm 1 by committing their units first, excluding firm 1 from the market. As in the Discriminating Auction, Firm 1 will confirm at P_1 greater than c_1. Coppinger et al.

(1980) have confirmed the symmetrical prediction in laboratory experiments for the case where only one unit is sold to many buyers. The multiple unit fixed demand case awaits testing.

The second way to organize a Dutch Auction for multiple units employs a uniform price. In this case, the clock ascends and firms confirm, but all receive the price of the last accepted offer, which would be P_3 in Figure 5. Because Firm 3 is paid its offer, an incentive to submit $P_3 > c_3$ remains for it and for all other sellers as well. This Uniform Price Dutch Auction has been tested by McCabe, Rassenti, and Smith (1990) and produced more revenue than the multiple unit English Auction for the single seller case. If symmetry holds, the Dutch Auction might lower costs, but would produce prices which do not reveal marginal costs for planning purposes of the ISO.

The Continuous Offer Auction is a newly proposed mechanism closely related to the Uniform Price Double Auction that is under development at the University of Arizona for use with a smart market for electric power. The Continuous Offer Auction is composed of the supply half of this market. Another way to view this market is as a sequential version of the Uniform Price Auction which does not depend on a price clock. Suppliers in the Power Exchange would submit offers consisting of both price, $P_i=c_i$, and quantity, q_i, continuously in real time where the results of a computerized uniform price auction, exactly like that shown in Figure 1, are reported back continuously to participants. Thus, after offers are submitted, all participants are told if their bids are tentatively accepted or not and the level of the current reigning price. The market is run as a call market in that offers are not final nor are they accepted or rejected until the market is called at a predetermined time after the market opens (say five minutes). At that point in time the market is cleared as a Uniform Price Auction, so it has the same incentives for suppliers to submit prices equal to costs. However, prior to the calling of the market, offers may be revised by participants at any point in time. Typically, new offers must be improvements in that either price must be lowered, or quantity increased, or both relative to a firm's current offer. Two sided versions of this market have shown excellent performance in laboratory tests and the Arizona Stock Exchange uses the two sided version of this mechanism (see McCabe et al., 1991).

Given the need of the ISO to rely on prices generated in the Power Exchange for planning purposes, the English Auction must be viewed as a leading candidate because of its extensive testing and excellent performance. However, the Continuous Offer Auction also holds real promise and allows suppliers to revise offers in real time before the market is called. The English Auction is not "forgiving" in this sense. If cost were a dominant consideration to the ISO, the Uniform Price Dutch Auction might provide some savings. However, this conclusion is speculative given that the mechanism was tested in a symmetric single seller setting.

3. Competitive Markets for Electricity

The primary lesson from the literature on experimental economics is that the actual performance of a given form of auction is difficult to predict from theory, and there are often surprises when a new market structure is tested. Even for the simplified examples that have been presented, there are uncertainties about their performance due to changing the form of market to a set of offers with demand fixed instead of the standard set of bids with supply fixed. Furthermore, there are complications associated with the operation of an electric grid which have to be incorporated into any market structure. These complications include the stochastic nature of load, the associated need to maintain reliability, and the locational variability of transmission losses. There is an inevitable tension between the concerns of engineers, who want to ensure that all contingencies are covered, and the structure of an ideal competitive market. From an economist's perspective, the performance of a market can be jeopardized if restrictions are imposed on its structure. Unfortunately, it is generally not possible to determine in advance how a particular modification to a competitive market will affect performance. These are the types of questions that can be addressed by experimental economics.

After evaluating the experience that has accumulated with competitive markets for electricity in the UK and New Zealand, Vernon Smith (1996) identifies six characteristics that he considers should be adopted by the electric utility industry in the USA. These characteristics can be summarized as follows:

1. The dispatch of generators should be centrally controlled within a region to ensure efficiency and reliability.

2. The markets for generation, transmission and distribution should be open to competition.

3. The spot market for electricity should be two sided and include demand side bids as well as supply side offers.

4. Contracts between buyers and sellers should be financial only and not undermine the role of the regional dispatcher in #1.

5. Prices should be differentiated to reflect transmission losses for different locations.

6. Transition mechanisms should be implemented to deal with strandable assets.

It is clear from reviewing these six characteristics that Smith is a serious marketer who believes in the effectiveness of competition and wishes to reduce the role of regulation to a minimum. For example, his vision differs from PowerChoice by relying on market forces to manage transmission and distribution as well as generation (Characteristic # 2). In spite of these major differences, there are also some important similarities. There is no doubt in Smith's proposal that the operation of the grid should be controlled by engineers (Characteristic # 1) and that bilateral trades should not jeopardize this control (Characteristic # 4). In addition, he recognizes the importance of cost differentials for transmission losses in different locations (Characteristic #5), and the inevitability of reaching some compromise over payments for strandable assets (Characteristic # 6). Hence, four out of the six characteristics are consistent with PowerChoice, and it is only in the scope of competition (Characteristic # 2), and the form of the spot market (Characteristic # 3) where major differences are found.

There are some serious complications in making transmission grids competitive. For example, Smith's proposal for the ownership of capacity appears to be more closely related to a pipeline, where the direction of flow is known and the capacity is well defined, than it is to a grid. The proposal in PowerChoice to maintain a regulated Transmission, Distribution and Gas Company (TDGCo) seems to be a valid alternative to a fully competitive system. Providing open access to the grid for suppliers, and extending competition to retail customers as well as wholesale customers should result in many of the same economic benefits as full competition. Furthermore, the existence of a regulated component of the industry should make it easier to deal with transition costs in an equitable way after the total magnitude of these costs has been determined.

In summary, the structure of the electric utility industry implied in PowerChoice contains many of the same features as the competitive system proposed by Smith. The only remaining issues concern the differences in the proposed structure of the spot market. These issues are discussed in the next section, and they provide an opportunity to consider the role of experimental economics in evaluating how different types of markets perform.

4. The Performance of Spot Markets

An important feature of electricity is that it is not a standard type of commodity. PowerChoice proposes a series of different markets for capacity, energy, spinning reserve and cold reserve. There are additional considerations, such as the ability to restart an electric system after a blackout, which are also discussed. The overall result is that the proposed structure of these markets in PowerChoice is relatively complicated, and it is not clear how well they will perform. In the case of the six-month-ahead market for capacity, it is not clear that a market is the right way to deal with meeting the reserve margin required by the New York Power Pool (NYPP). Ideally, the spot market for energy and the associated financial markets for long-term contracts should provide incentives for the construction of new capacity. Nevertheless, some form of inventory of available capacity should be maintained by the ISO to help schedule maintenance and provide prior warning about possible shortfalls of capacity in the future (i.e. five to ten years ahead). This task could be coordinated with the standard reports for the NYPP.

For discussion purposes, it is convenient to distinguish three different types of sellers and three different types of buyers in the market. The sellers include 1) the GENCo, 2) power brokers representing other utilities or groups of generators, and 3) individual generators. All three types of sellers would participate in the spot market and receive time and location specific prices determined in the spot market. The buyers include 1) the TDGCo,

2) power brokers representing groups of retailers and 3) individual wholesalers. All three buyers would pay prices determined in the spot market for generation plus a fixed charge for transmission services, a fixed charge for transition costs and a variable transmission charge to cover congestion costs for trades that cross the boundaries of zones. The latter congestion costs would be derived by the ISO from the differentials in the spot market in different zones. The need to determine these costs after the fact is a potential problem for buyers, but the use of zones, rather than point-to-point calculations of congestion costs, is a practical way to avoid computational complexities and still reflect the reality that transmission losses do vary by location and over time.

A potential advantage of having an ISO in control of the operation of the grid is that other types of charges could be incorporated into the Security Constrained Dispatch (SCD). For example, environmental charges for nitrogen oxides could be added to offers from uncontrolled sources of generation in the Midwest. (These charges are similar in nature to the charges for transition costs, except that they would differ by source of generation.) These types of charges would help to level the playing field between the relatively clean sources of generation in New York State and imports from the Midwest. This mechanism for adding environmental charges is not, however, desirable for competitive markets. A much better way to reflect environmental costs is to establish markets for emissions by, for example, establishing regional caps on total emissions and requiring polluters to acquire allowances. This type of market mechanism has already been initiated for sulfur dioxide under Title IV of the 1990 Clean Air Act Amendments, but a similar market for nitrogen oxides does not exist at this time.

Returning to the buyers and sellers in the spot market for energy, the uncertainty that exists about the variable component of transmission costs for buyers is addressed explicitly in PowerChoice. A proposal is made to allow buyers to purchase Transmission Congestion Contracts (TCC) as a hedge against the uncertainty. Although this is a sensible issue to consider, it is not clear why it is different from other types of financial derivatives that could be part of the Financial Exchange. Some buyers might wish to make long-term contracts, for example, and not be subject to price uncertainty. In fact, a wide variety of different forms of contract between power brokers and retail customers, including traditional rate structures, could be supported. (The retail contracts would include charges to cover the cost of distribution and metering.) In addition, bilateral contracts between buyers and sellers and contracts between power brokers and generators could also take a variety of forms. There seems no reason to limit the types of contracts that should be allowed in the Financial Exchange. Over time, the market will determine which types of contracts are popular. However, all participants in the market who deal directly with the ISO will be governed by the rules used in the spot market and the procedures for assigning transmission and transition costs.

Three phases are proposed for the spot market; two days ahead, one day ahead and one hour ahead. The three phases are implemented for every hour. In the first phase, a combination of firm and option contracts are awarded so that the sum covers the forecasted load. Some of the options are converted to firm contracts or renegotiated in the second phase, and finally in the third phase, all options are converted to firm contracts or released. Presumably, arrangements are also made to acquire spinning reserve and cold reserve for hourly operations, but it is not clear whether these markets are part of or separate from the energy market. All firm contracts receive the hourly spot market price determined by the ISO for each zone (LBMP; Locational Based Marginal Price). Certain standards of quality (e.g. for reactive power) must be met to avoid specified penalties, and presumably there should be a substantial fine for generators that have forced outages.

Given the complex structure of the spot market, there are a number of potential problems. First, the actual cost of running the three phases for every hour would be substantial, and it appears that there would be many opportunities for strategic bidding which could distort the prices. These concerns provide the primary rationale for trying to test how well the proposed market is likely to perform.

A more ambitious objective would be to develop alternative procedures for setting prices. For example, generators that have, in effect, must-run requirements (e.g. run-of-the-river hydro, nuclear and cogenerators with a committed steam load) do not provide the same flexibility to the ISO as a combined-cycle gas turbine. Consequently, one could argue that the value per unit of energy is greater for a generator that can follow load, and provide substantial amounts of spinning reserve, if necessary, than it is for a traditional base load plant. Following this logic, different prices could be set in the three phases of the spot market. In the first phase, offers would be for a 24 hour period. In the second phase, offers would be for daytime and evening load, (8-16 hours), and there could also be a market for the daily peak period (< 8 hours). In all cases, offers could include a component for spinning reserve as well as for energy. Such a system would lower the cost to buyers of off-peak energy, but it would probably increase the weighted cost of on-peak energy. However, high prices for peaking generators are necessary to provide incentives for building new capacity because the number of hours of operation are so limited.

Finally, it is appropriate to consider the implications of having only limited participation by buyers in the spot market. In PowerChoice, curtailable demand, if it can be measured, is treated in the same way as a source of generation. Consequently, the ISO treats actual hourly load as a stochastic but exogenous factor, and the primary objective is to minimize the cost of meeting this load. The main difference from the current regulated system is that offers by generators would replace the existing cost characteristics of each generator in the dispatching algorithm.

Even though the final customers for electricity do not participate in the spot market, this does imply that the they are indifferent to prices. However, there are many other ways to provide this information. Using time-of-day meters is one obvious method, but it would also be possible to provide price information over a TV channel or on the InterNet. For example, prices for the past week could be plotted together with some annual norm, and projected prices could also be provided at a site on the World Wide Web. Customers might still be willing to respond to this type of information even though they only have an on-peak/off-peak type of meter, and consequently, they face a problem with other customers being free riders. Providing current information about prices in the spot market is only one of the standard pieces of information that are used to describe the performance of financial markets of all types.

5. Conclusion

If the Power Exchange were to be put into place today, with no further research, the most robust institution would have to be the English Auction which has performed in a manner entirely consistent with theory in experimental testing. Thus, although it has never been tested in a multi-unit, single buyer configuration, it is reasonable to conjecture that the institution would perform well. An attractive alternative is provided by the Continuous Offer Auction because of its more forgiving nature and likely efficiency. This institution has, however, never been tested in the configuration needed here. Existing evidence for the Uniform Price Auction, Discriminative Auction, and Dutch Uniform Price Auction suggests that if price signals were the most important issue, the Discriminative Auction would be preferred from this group. If minimum cost were the most important issue, the Dutch Uniform Price Auction would deserve serious consideration. Again, none of these institutions have been tested in the single buyer configuration.

Thus, our first recommendation is to select from among these institutions those which appear to be of practical interest and perform experimental tests to determine their suitability. Second, given the complex and interactive nature of the markets proposed under PowerChoice, it is critical that experimental simulations be performed where, if possible, actual members of the Power Exchange participate in the experiments to stress-test the proposed structure.

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