

Auction Design for Standard Offer Service

During the transition to a competitive electricity market, when a consumer does not select an electricity provider, who provides service to the customer and at what price? An auction for this “standard offer service” is a market-based way to assign the service responsibility and to determine its price. We explore the design issues in establishing rules for such an auction.

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In a competitive market for electricity, consumers will select electricity providers based on information about the alternative providers. However, this information may not be available or reliable prior to the move to a competitive market. Indeed, some of the most critical information in selecting a provider, such as the provider’s reputation for the supply of electricity at competitive prices, may not be known until several years after the shift to competition. Hence, it makes sense to provide for a transition period during which consumers are not forced to select a provider, but rather receive service under “standard offer” terms.

Standard offer service can also be used to guarantee a rate reduction to consumers. For example, in Massachusetts, the utilities and other parties negotiated stipulated prices, which mandate at least a 10% rate reduction for customers who take the standard offer service during the first year. These stipulated prices define a ceiling on the generation component of unbundled electricity prices, and hence set the reserve price in the standard offer service auction.

An open auction is a market-based way both to assign this standard offer service obligation and to determine competitive discounts from the stipulated prices. The design of the auction for standard offer service can greatly affect the efficiency of the assignment and the prices consumers pay for electricity.

In this paper, we explore the design issues of a standard offer service auction. This is not an academic exercise. Standard offer service auctions are already being implemented. Utilities in Massachusetts are perhaps furthest along in this process. New England Power Service Company (NEPSCo), a subsidiary of New England Electric System (NEES), has scheduled the first standard offer service auction for the fourth quarter of 1997.¹ Because of the prominence of the NEES auction, we will specifically address the design choices made by NEES and suggest how the design can be improved.

¹ Throughout we refer to this auction as the NEES auction, rather than naming one of the NEES affiliates (e.g., NEPSCo, Massachusetts Electric Company, Nantucket Electric Company or Narragansett Electric).

Since the NEES design may be a model for subsequent designs, we feel that a comparative assessment is warranted.

It should be emphasized that a goal of the auction is not to schedule efficient dispatch. This is best accomplished in the day-ahead and hourly markets. Rather this auction simply facilitates trading in these later markets by assigning the load responsibility early on.

We begin by discussing principles of auction design, and use the standard offer service setting to illustrate these principles. Next we present our recommended design, which conforms to these basic principles. Then we discuss the NEES design, focusing on how our recommended approach differs from the NEES design.

I. Principles of Auction Design for Electricity Supply

A. Establish the Objective of the Auction

Design cannot be discussed without first specifying the goal of the auction. In the case of standard offer service the primary goal is clear: consumers first. The auction should produce the lowest cost, reliable long-term sources of electricity available in the current market. A second goal is that an open and transparent competitive process be used to establish these lowest-cost sources. A transparent auction yields a fair process in which the marketplace provides much of the regulatory oversight. Fortunately, these two goals are not in conflict. A well-designed auction encourages the open competition that is the clearest sign that the best possible terms have been found for consumers.

Reliability is an important component of the primary goal. It does consumers little good to get promised low prices only to find that these prices vanish when firms default on their promises. To guard against this possibility, bidders must provide sufficient financial security to assure that they will fulfill their commitment to provide electricity at the terms bid.

In the context of the standard offer service auctions contemplated by utilities in Massachusetts, and reflected in the settlement agreements with various other parties, an important auction objective is to promote participation in the auction over the entire transition period (1998-2004). In general, increased participation can be expected to result in increased competition, to the benefit of customers.

B. Identify What is Being Sold

One of the virtues of an auction is that it forces the auctioneer to fully describe what is being sold. In many cases this is obvious. A fish auctioneer simply displays the fish for all to see (and smell). Standard offer service is much more complicated, but the same idea applies. The more clearly the auctioneer can describe what is on the block, the more competition is fostered.

In essence, standard offer service is an auction for load responsibility. A winner in the auction is committing to meet its share of the standard-offer load at specified terms. One major complicating factor is that the standard-offer load is highly uncertain. Although we have decades of experience predicting the demand for electricity (both in energy and peak terms), we have no experience on how quickly consumers will move off the standard offer service. Moreover, the attrition rate is difficult to predict, since it depends fundamentally on retail market prices, set at the time of electricity consumption. Hence, while we can be clear about what is being sold (load responsibility), the quantity being sold is determined ex post, perhaps several years after the auction.

Quantity uncertainty is an important complication that the design must address. Ultimately, this uncertainty should be borne by the bidders, since it is the bidders that have the generating capacity to meet the load (assuming the utility divests its generating capacity). However, the definition of "quantity"

can have a large impact on the extent of the uncertainty and its impact on the auction. This issue will be addressed in the next section.

C. Encourage Participation by Serious Bidders

A key element of any good auction design is that it encourages bidder participation. Whether the goal is economic efficiency, maximum revenues, or lowest costs, greater bidder participation improves auction outcomes. Hence, the design should reflect in part the preferences of potential bidders. The following are ways to encourage participation by serious bidders:

1. Reduce Bidder Participation Costs

The most direct way to encourage participation is to reduce the cost of participating. Entry fees should be modest. Deposits should be fully refundable (with interest). The auctioneer can further reduce costs by providing detailed information on what is being sold and information that would help the bidder evaluate its worth (demand by class, class load shapes, and other characteristics of demand). One might think that these costs would be insignificant, especially for the largest bidders. However, what the auctioneer is attempting to do is to get the marginal bidder – the one that is sitting on the fence – to participate. These marginal bidders are often essential to vigorous competition. Without them, the large bidders have a much greater opportunity to exercise their market power in the auction. Although it is essential to have appropriate bid deposits to assure that the bidders are serious, care should be taken in not setting deposits so high as to discourage participation.

2. Limit Complexity

Although new, computerized auction designs sometimes overcome important limitations of traditional auctions, the complexity of these designs may raise bidder participation costs. Complexity is especially a problem for the smaller bidders. These bidders may not have the resources to work out all the issues generated by the complexity. Hence, they may go into the auction with an incomplete analysis and hope for the best, or they may simply decide not to participate. Wise bidders will often opt for the second option.

One must evaluate complexity from the bidder's perspective. For example, a first-price sealed-bid auction has very simple rules (high bidder wins and pays its bid) compared with an ascending auction, which involves bid increments, timing issues, stopping rules, etc. However, from the bidder's perspective the ascending auction is simpler. With an ascending auction the simple strategy "bid up to your valuation" is a good rule of thumb. In contrast, with a sealed-bid auction, no simple rule of thumb can be followed. "Bid less than your valuation" is a good start, but how much less? To answer this question the bidder must conduct a careful equilibrium analysis that involves assessing what the other bidders may do.

It is not so much the length of the rules that increases complexity, but rather the strategic issues that the rules generate. Rules that can be "gamed" are the most problematic. Bidders will invest substantial resources to identify loopholes in the rules. These opportunities for gaming increase participation costs for everyone, and are especially harmful to small bidders.

Some amount of complexity may be needed for the auction to effectively meet its objectives. A good design strikes the right balance between necessary complexity and low bidder participation costs.

3. Reduce Bidder Uncertainty

Bidders dislike uncertainty. Indeed, bidders will expend resources to try to reduce uncertainty. Thus, uncertainty is often a substantial source of participation costs. The auction rules can greatly influence the amount of strategic uncertainty that the bidders face. Some uncertainty is unavoidable, but the auctioneer

should do what it can to reduce strategic uncertainty. Rules that expose the bidders to large gambles not only reduce auction efficiency, but discourage participation by marginal bidders. The risks are simply not worth taking for these bidders.

The loss in participation due to bidder uncertainty is especially important in the standard offer service auction. The reason is that in this auction nonparticipation is a viable option. In most auctions, nonparticipation means that you are out of luck – you don't get the good. But in a standard offer service auction, an electricity supplier can still supply electricity to end users, just not as standard offer service. If the risks are too large, the supplier simply decides to compete with the auction winners after the auction, rather than during the auction. Indeed, competing ex post has the advantage that the supplier avoids the obligation to serve at specified prices. Instead, the supplier can participate in the ex post market and offer service that reflects the supplier's current opportunity costs.

4. Eliminate Possible Conflicts of Interest

Conflicts of interests arise when one of the bidders is affiliated with the auctioneer. In standard offer service auctions, the Distribution Company that is holding the auction may wish to participate in the auction, either directly or through an affiliate. This is potentially a problem, since the auctioneer has access to within-round and between-round bidding information that is not public to the other bidders. To avoid this conflict of interest – if the Distribution Company or an affiliate elects to participate in the auction – it is necessary to delegate the actual running of the auction to a third party, ideally a professional auctioneer. The auctioneer implements and enforces the rules of the auction, and makes all decisions in cases where the rules allow discretion.

II. Overview of an Effective Auction Design

This section provides a concise description of our recommended auction design. We give two variations, both of which yield similar results. In the first design, the bidders submit bid schedules in each round of bidding. The second design is an ascending-clock auction – in each round, a bidder simply bids its desired quantity at the price specified by the auctioneer. Motivation for the designs is presented in later sections.

The designs are based on two overriding considerations, both essential to promoting competition.

- To encourage active bidding, there must be clear winners and losers in each round and at the close of the auction.
- To reduce bidder uncertainty and participation costs, the auction rules should be as simple as possible, without encouraging gaming or inefficient outcomes.

The following auction design promotes an economically efficient assignment of the load responsibility for standard offer service by adequately addressing these considerations. The proposed auction is comprised of two ascending-bid auctions, to be conducted in sequence:

Full-Term Auction – The full-term auction will require bids consisting of a quantity and a single fixed or “full-term” discount from stipulated wholesale prices across all years. Winners take on a seven-year obligation to provide the specified quantity at the specified discount from the stipulated prices. The full term auction precedes and takes priority over the single year auction, in order to encourage participation in early years when the standard offer load is the highest. Any load obligation remaining after the full-term auction is auctioned in the single-year auction.

Single-Year Auction – The single-year auction will be for the portion of the standard offer load obligation remaining after the full-term auction closes and will be conducted immediately following the full-term auction. The single-year auction allows bidders the flexibility to bid discounts to stipulated

wholesale prices for specific years in the transition period. In this auction for the (remaining) load obligation, the bidding for each of the individual years is held simultaneously.

A. Auction Design using Bid Schedules

To be auctioned are 100 shares of the load responsibility for each year. These shares are sold in an ascending auction format, in which the service obligation for each year is on the block at the same time. Suppliers bid for shares of the service responsibility over a series of rounds until no bidder is willing to improve any of its bids. This format is similar to the successful FCC auctions for radio frequency spectrum. Before the auction, bidders make a deposit, which determines the maximum number of shares they are eligible to bid on.

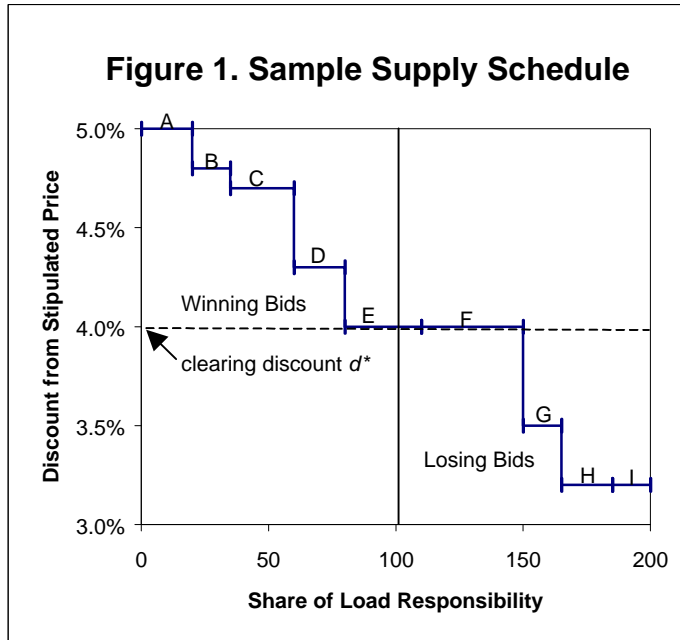
The two auctions introduced above are conducted in sequence. First, the full-term auction is held. Bids in the full-term auction are for a specified share of load responsibility across all years. At the conclusion of the full-term auction, the single-year auction is held. The single-year auction is for any remaining shares that did not sell in the full-term auction. If all 100 shares are sold in the full-term auction, then the single-year auction will not be held. In the single-year auction, bids are for shares in a specified year. The single-year auction begins (if necessary) immediately after the full-term auction. Each bidder's initial eligibility in the single-year auction is its initial eligibility in the full-term auction less its winnings in the full-term auction.

The rules for both the full-term and the single-year auction are nearly identical. We begin with a description of the full-term auction and then point out the differences in the single-year auction.

1. Full-Term Auction

In each round, each bidder tenders a supply schedule as a group of bids. A bid is a pair (s, d) , where s is the number of shares and d is the discount (in percent). A winner of s shares at a discount d is obligated to serve $s\%$ of the standard offer service load in each year at a discount $d\%$. A bidder can submit as many bids as it likes, subject to its eligibility as initially determined by its deposit.

At the end of each round of bidding, the bids are ranked in descending order of discount, then in ascending order of time-stamp (earlier bids are ranked higher) to form the aggregate supply schedule. Starting with the largest discount, bids are designated as winning bids until the cumulative shares reaches 100. All other bids are designated losing bids. The winning bid with the lowest discount defines the clearing discount d^* . After the final round of bidding, all winning bids are awarded at the discounts bid. The example in Figure 1 illustrates how the clearing discount is determined. A bid is also referred to as a "step," since each bid represents a step on the supply schedule.



The following are the activity rules for the full-term auction:

Eligibility Rule: The bid deposit determines a bidder's maximum eligibility. A bidder must submit bids totaling 100% of its eligibility in the initial round, otherwise the bidder's eligibility in the full-term auction is reduced to the number of shares bid for in the initial round.

Opening Rule: A new step in the bid schedule can be submitted only in the first round.

Sorting Rule: In each round, the steps are sorted in decreasing order by discount, and then in increasing order by time-stamp. Steps are designated as winners, until the cumulative shares exceed 100. (If the total shares bid is less than or equal to 100, then all steps are designated as winners; no steps are rationed or frozen.) The next step is rationed as follows:

Rationing Rule: The first step that straddles 100 – that is, with cumulative shares greater than 100 – is split into two steps: a winning step with shares so that cumulative shares are exactly 100 and a losing step for the remaining shares of the step. All steps further down the schedule are losing steps.

Exclusion Rule: A losing step from the prior round is frozen after the current round if its discount is not improved (i.e. its discount is not raised above the previous round's clearing discount by the minimum bid increment). Frozen steps can never be improved. However, frozen steps remain binding bids. In the event a winning bidder fails to sign the contract at the end of the auction, the lost supply will be filled by frozen steps in the order they appear on the aggregate schedule. All steps are automatically carried over to the next round.

Revision Rule: A step can be divided into two or more steps with total shares equal to the initial step. (This allows a bidder to raise its bid on only part of a step.) A step can be revised only by improving the previous clearing discount. That is, the revised step must bid a new discount that is more than the previous clearing discount by at least the specified minimum bid increment.

Closing Rule: The full-term auction stays open until a round goes by with no improvements.

2. *The Single-Year Auction*

If not all of the 100 shares are sold in the full-term auction, the remaining shares are sold in the single-year auction. The single-year auction will commence immediately on completion of the full-term auction. The rules are identical to the full-term auction with the following exceptions. In each round, each bidder tenders a supply schedule for each year as a group of bids. A bid is a triple (y, s, d) , where y is the year, s is the number of shares, and d is the discount (in percent). A winner of s shares in year y at a discount d is obligated to serve $s\%$ of the standard offer service load in year y at a discount $d\%$. Rather than having a single supply schedule, as in the full-term auction, there is a separate schedule for each year.

The following are the activity rules that are specific to the single-year auction (i.e. all other rules provided above for the full-term auction apply, with these exceptions):

Eligibility Rule: A bidder's initial eligibility in the single-year auction is its initial eligibility in the full-term auction (determined by its bid deposit) less any shares won in the full-term auction. A bidder must submit bids totaling at least 25% of this initial eligibility in the first round, 50% in the second round, 75% in the third round, and 100% in the fourth round. Failure to maintain these activity levels results in a reduction in eligibility.

Opening Rule: A new step in the bid schedule can be submitted only in the first four rounds.

Closing Rule: All the yearly markets stay open until a round goes by with no improvements in any market. Hence, all markets close simultaneously.

B. Auction Design using Ascending Clock

A simpler but nearly equivalent design has bidders respond in each round with the quantity desired at the discount posted on the auctioneer's clock. The differences between the full-term and single-year auctions are the same as above. Hence, only the full-term auction is described below.

In the initial round, each bidder submits a bid indicating the number of shares it desires at a discount of 0% off the stipulated prices. If the total shares bid is less than or equal to 100, then the auction ends with each bidder winning the number of shares it bid. If the total shares bid exceeds 100, then the discount is raised by one clock increment and a new round begins. In each round, each bidder bids the number of shares it desires at the specified discount. If the total shares bid is greater than 100, then the discount is increased by one clock increment and the process repeats. If the total shares bid is less than or equal to 100, then each bidder wins the shares bid at the specified discount.

Rationing Rule: Any remaining shares are awarded to those that reduced their bids in the final round. The bidder with the smallest percentage reduction has its bid reduction filled first. In the event two or more bidders have identical percentage reductions, the smaller absolute reduction shall be favored. This rationing mechanism ensures that shares not bid at the highest clock discount are awarded at the next highest discount.

Activity Rule: The shares bid in any round cannot exceed the bidder's eligibility. Eligibility is initially determined by the bidder's bid deposit. If a bidder bids less than its eligibility, then in the next round its eligibility is reduced to the shares bid in the prior round. Hence, a bidder can only decrease its shares bid as the discount increases.

The table below gives an example. At a discount of 0%, 200 shares are bid. Hence, the "clock" increases by one increment to 1%. The total shares bid drops to 160 at a 1% discount. The process continues until the total shares bid is less than 100 (round 7). At this point, the auction ends. Shares are awarded to bidders based on the shares bid in round 7 at a 4.5% discount. The bidders that reduced their bids in round 7 are rationed so that the total shares awarded equals 100. In this case, there was a

reduction of 4 shares (101 to 97), and 3 of these 4 will be awarded at a 4% discount. Thus, the bidder with the largest percentage reduction in the final round is rationed by one share.

Round	Discount	Total Shares Bid
1	0%	200
2	1%	160
3	2%	135
4	3%	115
5	3.5%	108
6	4%	101
7	4.5%	97

III. An Auction Design for Standard Offer Service

A. Auction Load Responsibility by Year

We begin with the key question: what is being auctioned? There are three dimensions to a bid in this setting: time, price, and quantity. Time is the year of standard offer service. The auction is to produce supply schedules for each year in the transition period, here assumed to be seven years.² Price is the discount from the prices stipulated in the settlement agreement.³ For example, the stipulated prices from the Massachusetts utilities' settlement agreements are shown below:

Year	1	2	3	4	5	6	7
Calendar Year	1998	1999	2000	2001	2002	2003	2004
Price (cents/kWh)	3.2	3.5	3.8	3.8	4.2	4.7	5.1

The quantity dimension requires some thought. There are three possibilities.

1. Energy Auction

The first approach is to let energy be the unit of quantity. For example, the NEES auction is for 178 energy blocks in each year.⁴ Each energy block is 150 GWh of delivered energy. A bid is for the rights and obligations to supply the specified maximum annual amount of standard offer service energy to customers' meters at a specified discount from the stipulated prices. Hence, a bid for 10 blocks in year 2 at a 5% discount obligates the bidder to supply up to 1,500 GWh of energy to customers' meters in year 2 at a 5% discount from 3.5 cents.

However, of critical importance to the bidders is knowing the consequence of a bid: under what circumstances and how much does a bidder supply. A bid for ten blocks (1,500 GWh) does not mean that the bidder will supply 1,500 GWh of energy in the specified year. Rather the final bids at the end of the

² The length of the transition period for several Massachusetts utilities has been set at seven years under the terms of settlement agreements.

³ In the event that the auction is undersubscribed, the Distribution Company provides the remaining standard offer service to customers. In some cases, the generation affiliate bears the responsibility to provide the service to the Distribution Company with no discount to stipulated wholesale prices.

⁴ The NEES auction is for 178 blocks through the first seven years and 40 blocks for years eight through twelve. The forty blocks that continue to year twelve correspond to the expected standard offer service load for Narragansett Electric Company, whose service territory is in the State of Rhode Island, where the transition period has been set as twelve years. For illustration, we focus here on the Massachusetts transition period of seven years.

auction are used to create a supply schedule for each year. Then on a monthly basis, NEES estimates the annual requirement for standard offer service in GWh. For example, on March 15, 1999, it may estimate that standard offer service will require 15,000 GWh (100 blocks) from April 1, 1999, to March 31, 2000 (this estimate does not take into account any attrition from standard offer service during the year in question). It then adds a 25% safety factor to yield a maximum energy need of 125 blocks. Then NEES moves up the supply schedule for 1999 and designates the first 125 blocks (i.e., the best discounts) as winning bids and the bidders are notified. If the smallest winning bid was 3%, then the bid for 10 blocks at 5% would be a winning bid and that bidder would be obligated to serve $10/125 = 8\%$ of the standard offer load for every hour during the next period (say, April 1999). If the smallest winning bid was 6%, then the 5% bid would be designated a losing bid. In this case, the bidder is told that it will not be asked to serve at any time in the remainder of year 2. All winning bidders face identical load curves.⁵

Although the auction is cast as an energy auction with bidders bidding for 150 GWh energy blocks, it should be clear from the description above that this energy auction is fundamentally an auction of the load responsibility. The 25% safety factor, together with not taking account of attrition for standard offer service, make it extremely unlikely that a supplier will actually be asked to supply the maximum energy quantity. Hence, all the energy blocks do is provide a way to *assign* load responsibility. The problem with doing it this way is that it adds both complexity and uncertainty. In the energy auction, bidders do not find out whether they are winners or losers until years after the auction. Not only does this add uncertainty, but it further undermines competition. A key element of competition in an auction is being bumped from a winning position to a losing position. This encourages the bumped parties to come back and improve their bids. This element is lost in an energy auction.

A further problem with not knowing whether you are a winner or loser in the energy auction is that it exposes bidders to "attrition risk" in the multi-year context. Consider a full-term bid for 10 blocks at a 5% discount. Such a bid may be profitable only if the bid is at the top of the ranking. At the top of the ranking, the 5% bid will always be a winning bid, and so the bidder will supply in each of the seven years. In this way, early year losses can be made up with later year gains. However, as the 5% bid falls in the ranking, it becomes less likely that the bidder will supply power in the later years. All that is left are the early unprofitable years. When placing a bid, the bidder must be concerned that its profitability will erode due to bidder competition. This attrition risk forces bidders to shade their bids or perhaps not bid at all.

2. Capacity Auction

A variation of the energy auction is a capacity auction, in which the quantity unit is blocks of capacity. For example, there might be 200 blocks, each for 20 MW of capacity. Like in the energy auction, a bid in the capacity auction is translated into a load responsibility on a periodic basis (quarterly or annually). Each period, the Distribution Company estimates the annual peak demand. For example, on March 15, 1999, it estimates that the annual peak load for standard offer service will be 2,000 MW (100 blocks). As before, the bids are sorted from largest discount to smallest discount until the 100th block of capacity is reached. The load responsibility is then assigned among these winning bidders in proportion to their bids. A winning bid for 10 capacity blocks would translate into an obligation to serve $10/100 = 10\%$ of the standard offer load for every hour during the next period (say, April 1999). The capacity auction can be implemented in two ways. In the first, the capacity bid can represent a fixed cap beyond which the bidder will not have to serve. In this case, the utility's estimate of required capacity would need to be inflated to assure that sufficient capacity would be available. Alternatively, the capacity bid is simply a convenient unit of measure and does not actually provide a cap on what the bidder will be asked

⁵ The standard offer load curves will be determined separately by voltage level, then aggregated so that line losses and other costs are allocated appropriately.

to provide. In this second alternative, the winning bidders are entirely responsible for meeting the specified percentage of load, regardless of how much capacity is actually required.

The capacity auction has the advantage that it states the obligation in terms most relevant to the supplier: the required capacity. However, like the energy auction, the capacity auction suffers from the fact that it does not identify auction winners until the beginning of each supply period. Hence, both during the auction and after the auction (until the beginning of the specified supply period), the bidder does not know whether it is a winner or a loser. This undermines competition in the auction and increases uncertainty, since the bidders do not know based on their bids whether they will be called on to serve.

3. Load Responsibility Auction

Our third alternative for the quantity unit provides a simple and elegant fix to this problem. It solves a fundamental shortcoming of the previous two methods of assigning load responsibility: as the auction progresses, there are no clear winners and losers, resulting in reduced incentive to compete. We propose that rather than bid for energy or capacity blocks, let the bidders directly bid for shares of the standard offer service load responsibility. Instead of 134 energy blocks or 200 capacity blocks, there could be 100 shares of load responsibility. A bid for 10 shares corresponds to a 10% share of the load responsibility. With this minor change, bidder uncertainty is dramatically reduced. Bidders then know after each round of bidding which of their bids are winners and which are losers. They then can improve the losing bids if they so desire. Moreover, since they know what they have won (to the extent possible) at the close of the auction, they can base their business decisions on this information, lining up the capacity (through actual generation or market contracts) as required.

There is one sense in which this load-responsibility auction may increase uncertainty relative to a capacity auction. In particular, in the capacity auction, the bidder knows that a bid for 10 blocks will ultimately translate into either a losing bid or a winning bid in which case the bidder serves a load with a peak very close to the estimated peak of $10 \times 20 \text{ MW} = 200 \text{ MW}$. However, up until just before the start of the period the bidder does not know whether it will be serving at all! In contrast, in the load-responsibility auction, a bidder knows immediately whether its bid for 10 shares of the load is a winning bid. Then between the end of the auction and the beginning of the period (up to seven years), the winner is able to revise its estimate of what a 10% share of the load means and take the steps to best serve that load.

A second important advantage is that the Distribution Company can get out of the forecasting business. The need to do monthly or quarterly updates vanishes. Not only do these forecasts postpone the resolution of major uncertainty, but they introduce unnecessary conflicts of interest. If an affiliate of the Distribution Company participates in the auction and the relationship is not severed after the auction, then there may be incentives to make "strategic forecasts" based on the market prices and where the affiliate ends up on the aggregate supply curve. Furthermore, the uncertainty in the load is precisely what the Distribution Company is attempting to transfer along with the standard offer service obligation.

Under option 3, our recommended approach, we auction 100 shares of load responsibility for each year. A bid consists of three components: the year, the number of shares, and the discount (in percent). A winner is obligated to serve the percentage of the standard offer service load in the specified year at a discount from the stipulated prices, in accordance with their bid. A bidder can submit as many bids as it likes, subject to its eligibility as initially determined by its deposit. This structure accomplishes two things. First, it gives the bidders the flexibility to tailor their bids for standard offer service to their particular situation over the seven-year transition period. Second, it immediately resolves the uncertainty about who the winners and losers are in the auction. This stimulates competition. Moreover, it greatly improves efficiency and reliability by giving the bidders the information they need to plan for the supply of standard offer service.

B. Use a Bid Deposit to Assure that the Bidders Are Serious

A bid deposit is an essential requirement of participation. It is an upfront payment that can be applied to penalties in the event a winner fails to execute the contract. The deposit assures that the bidders are serious and thereby guarantees the integrity of the bidding process. The maximum quantity of shares that a bidder can bid on is determined from the bidder's bid deposit. The bid deposit is forfeited in the event a winning bidder fails to execute the contract for load responsibility at the conclusion of the auction. A bid deposit of \$x is required per share of eligibility. The appropriate value of x depends on the amount of the standard offer load. A reasonable value would be about \$0.001/kWh of estimated delivered energy. The weighted-sum of shares of the bidder's bids cannot exceed its eligibility. The eligibility weights vary by year as follows, which is based on a linear attrition from standard offer service:

Year	1	2	3	4	5	6	7
Calendar Year	1998	1999	2000	2001	2002	2003	2004
Weight	1.00	0.86	0.71	0.57	0.43	0.29	0.14

Hence, to get one share of eligibility in year 7 requires only one seventh of the deposit required to get a share of eligibility in year 1. This reflects the fact that the load in year 7 will be less than the load in year 1, because of attrition from standard offer service. The weights above are **not** a prediction of likely attrition from standard offer service, only a recognition that the standard offer load will decline over time, and standard offer service will not be offered to Massachusetts customers after seven years. Attrition must be estimated by the bidders.

C. Use a Simultaneous Ascending Auction Design

There are three basic features of a simultaneous ascending auction. First, all the goods are on the auction block at the same time. In the case of the standard offer service auction, this means that all shares of load responsibility for all years are bid on simultaneously. Second, bids are accepted for any or all items in a sequence of rounds. And third, the auction does not end until a round goes by in which no improved bids are received on any of the items. This auction design is the natural extension of the traditional English auction of a single good to the case where the auctioneer is selling many interrelated goods. The advantage of a simultaneous ascending auction is that it provides a robust process of price discovery. Bidders can initially bid conservatively, and then raise their bids in response to market forces.

Compared with a sealed-bid auction, this design reduces bidder uncertainty. The bids from prior rounds reveal information, which the bidders can take into account in future rounds. Being able to condition on more information reduces the winner's curse, and thereby allows bidders to bid more aggressively.⁶

In addition to reducing uncertainty, the design encourages competition by reducing participation costs. Moreover, it generates market prices for electricity in each of the transition years. Finally, it is an open and transparent process. Bidders, consumers, and regulators can track the competitive process and confirm that the rules are being followed and that no bidders have an unfair advantage. At the end of the auction, the auction winners are winners solely because no one else was willing to offer larger discounts.

⁶ The winner's curse is the tendency for naïve auction winners to lose money, because they fail to take account of the information contained in winning a competitive auction. To avoid the winner's curse, smart bidders shade their bids. The amount of shading depends in part on the amount of uncertainty the bidders face. See Milgrom, Paul R. and Robert J. Weber (1982), "A Theory of Auctions and Competitive Bidding," *Econometrica*, 50, 1089-1122.

The simultaneous ascending auction has now been thoroughly tested in auctions worldwide. It was first used in the FCC spectrum auctions for wireless communications. These auctions have been an enormous success, raising over \$23 billion in revenues in the first three years.⁷

The reason for conducting two ascending auctions (full-term and single-year) is to give priority to bidding in the early years, while allowing some flexibility to bid different prices and quantities in separate years. To promote participation in the auction across all years, encouraging bidding in early years is of primary importance. This is true because the bidding in early years, where the stipulated wholesale prices are lower, may have weak competition otherwise. The full-term auction gives bidders a seven-year contract in which potential losses in early years can be offset by potential gains in later years. Hence, a supplier may be willing to bid in the full-term auction, even if it is unwilling to bid on the early years in the single-year auction. Nevertheless, allowing bidders the flexibility to bid separate discounts for individual years is also a consideration to improve the overall efficiency of the auction outcome. The combination of a full-term and single-year auction is proposed as a way to balance the two principal design objectives.

In the full-term auction, only one discount is bid, rather than a separate discount for each year. The reason is that in the full-term auction, all that matters from an economic viewpoint is the total (across all years) that the winner bids for a specified share of the load. Hence, a single discount across all years gives the bidder all the economic flexibility it needs. For any bid with different discounts in different years, there is an economically equivalent bid with a fixed discount in all years. Allowing different discounts in each year would add complexity in the process, as some method for scoring the bids across years is required. Any scoring method is prone to undesirable gaming by the bidders.

D. Use Pay-Your-Bid Pricing⁸

A primary goal of the auction is to determine competitive supply prices for standard offer service. Pay-your-bid pricing in an ascending bid auction best accomplishes this goal. Pay-your-bid pricing works as follows. With each round of bidding the bids are ranked in descending order of discount, and then ascending order of time-stamp, to form the aggregate supply schedule. For example, Figure 1 shows the supply schedule for a particular year based on the following table of bids:

Bidder	Bid	Discount	Time-stamp	Cumulative		Status
				Shares	Shares	
3	A	5.0%	10/19/97 12:35:42	20	20	Winning
1	B	4.8%	10/19/97 12:14:25	15	35	Winning
2	C	4.7%	10/19/97 12:51:45	25	60	Winning
4	D	4.3%	10/19/97 12:21:52	20	80	Winning
4	E	4.0%	10/19/97 12:02:47	30	110	Rationed
2	F	4.0%	10/19/97 13:12:45	40	150	Losing
1	G	3.5%	10/19/97 12:47:20	15	165	Losing
3	H	3.2%	10/19/97 10:14:06	20	185	Losing
1	I	3.2%	10/19/97 10:36:42	15	200	Losing

Starting with the largest discount, bids are designated as winning bids until the cumulative shares reaches 100. All other bids are designated losing bids. The winning bid with the smallest discount (bid E) defines the clearing discount d^* . After the final round of bidding, all winning bids are awarded at the

⁷ See Cramton, Peter (1997), "The FCC Spectrum Auctions: An Early Assessment," *Journal of Economics and Management Strategy*, forthcoming, 6.

⁸ In this context, the bidders actually provide service at the discounts bid, or are "paid" their bid. In this section we maintain the terminology "pay-your-bid" for consistency with the auction literature.

discounts bid – that is, the winning bidders receive the share of the load they bid for at the discounts bid. The example in Figure 1 illustrates two details. First, ties are broken by the time-stamp of the bid. Bids E and F are tied in discount (4%); however, bid E has an earlier time-stamp and thus has higher priority. Second, in the event the marginal bid crosses beyond the 100-share point, then the bid is only partially filled and is designated as a rationed bid. For example, bid E, the marginal bid, extends the cumulative shares to 110; hence, the bid is reduced by 10 (20 of the 30 shares are won). At most one bid is rationed.

One might think that it might make sense for the winners to pay the market-clearing discount, rather than the actual discounts bid. This approach, known as uniform pricing, has the advantage that every bidder pays the same discount. In the context of an ascending-bid auction, pay-your-bid pricing has the main advantage of uniform pricing, since the auction will end with near-uniform prices, yet it minimizes the risk of collusive outcomes.⁹ This risk is of particular concern if competition in the auction is weak.

E. Use an Activity Rule Based on Revealed Preference

A basic element of the simultaneous ascending auction is the activity rule, which promotes sincere bidding. The activity rule we propose is adapted from the design for the California Power Exchange's day-ahead auction.¹⁰ The rule is based on the principle of revealed preference: a bidder's refusal to improve a previous clearing price is presumptive evidence that it is unwilling to serve standard offer load at a discount greater than or equal to the clearing discount. This principle is represented here by the Exclusion Rule, which freezes a bid that fails to improve the previous clearing price.

1. The Role of Activity Rules

Activity rules are needed to ensure that price discovery is reliable. The issue is very simple: without activity rules no supplier has any incentive to make serious bids until the final round; and without serious bids, the tentative clearing prices in early rounds are unreliable predictors of the final clearing prices. Indeed, any large bidder has the opposite incentive: it withholds information about its own final bids in the early rounds, preferring instead to rely on others to provide such information contributing to price discovery. Activity rules are imposed in order to force all bidders to reveal early some credible signal about the bids they will tender in the final round.

In designing activity rules, the guiding principle is that they should be the least restrictive rules that suffice to assure reliable price discovery. Ideally, they impose no limit on the efficiency attainable at the close of the auction. In particular, they should impose no significant restrictions or disadvantages on suppliers who elect to bid their actual valuation. The only effect of the activity rules is to suppress gaming, or render it ineffective, by imposing constraints on revisions of bids during the iterative process. These constraints create increasingly strong incentives for cost-based bids.

Activity rules can be designed using the principle of "revealed preference." By interpreting previous bids as reliable indicators of what is feasible and economical for the supplier, constraints can be imposed on subsequent bids. As the auction progresses, these constraints narrow the supplier's allowed strategies, until in the final round there is little room for bids that differ significantly from costs. Realistically, costs must be interpreted here as opportunity costs rather than actual running costs, since each supplier also has opportunities to trade in other markets.

⁹ See Wilson, Robert (1979), "Auction of Shares," *Quarterly Journal of Economics*, 94, 675-689; Back, Kerry and Jaime F. Zender (1993), "Auctions of Divisible Goods: On the Rationale for the Treasury Experiment," *Review of Financial Studies*, 6, 733-764.

¹⁰ Wilson, Robert (1997), "Activity Rules for the Power Exchange," Report to the California Trust for Power Industry Restructuring, March 14.

As a practical matter the activity rules must be easily understood by bidders, and simple to implement. The activity rules should be applied automatically by the auction software: the portion of any submitted bid schedule that violates the rules is discarded without any “negotiation” with the bidder.

Activity rules are generally of two kinds. One kind pertains to the opening and closing of the auction, and the other pertains to the ways in which tenders can be revised. We first describe the activity rules for the revision of tenders.

2. *An Illustration of the Proposed Activity Rules*

In every round, each bidder tenders a bid schedule, which is a bundle of bids or steps. Each step consists of a discount for a specified quantity of shares of the load responsibility in a particular year. The table below gives the four bid schedules from our prior example. Bidder 1’s bid schedule has three steps: a 4.8% discount for 15 shares, a 3.5% discount for 15 shares and a 3.2% discount for 15 shares. At the conclusion of each round, steps are designated as winning or losing, depending on whether the discount is above or below the clearing discount. Steps at the clearing discount are ordered by the time-stamp (earliest first) and are designated winning, so long as the cumulative shares is less than or equal to 100. The next step is rationed, unless the cumulative winning shares is exactly 100, in which case there is no rationed step. The rationed step (step E in our example) is split into two parts: a winning step (EW), which increases the cumulative total to exactly 100, and a losing step (EL). All remaining steps at the clearing price (step F) are designated losing. The aggregate bid schedule is reported to bidders at the end of each round.

Bidder	Bid	Discount	Time-stamp	Shares	Cumulative		Status
					Shares	Shares	
1	B	4.8%	10/19/97 12:14:25	15	35	35	Winning
1	G	3.5%	10/19/97 12:47:20	15	165	165	Losing
1	I	3.2%	10/19/97 10:36:42	15	200	200	Frozen
2	C	4.7%	10/19/97 12:51:45	25	60	60	Winning
2	F	4.0%	10/19/97 13:12:45	40	150	150	Losing
3	A	5.0%	10/19/97 12:35:42	20	20	20	Winning
3	H	3.2%	10/19/97 10:14:06	20	185	185	Frozen
4	D	4.3%	10/19/97 12:21:52	20	80	80	Winning
4	E	4.0%	10/19/97 12:02:47	30	110	110	Rationed
Bid E is split as follows:							
4	EW	4.0%	10/19/97 12:02:47	20	100	100	Winning
4	EL	4.0%	10/19/97 12:02:47	10	110	110	Losing

The revision rule has four parts. In each round after the first, for each step of the bid schedule:

1. The discount cannot be decreased.
2. A step can be split into two or more steps with total shares equal to the original step.
3. The discount can be increased only if the new discount is more than the clearing discount in the previous round by at least the minimum bid increment. We say in this case that the new discount “improves” the previous clearing discount.

4. Steps designated as losing in the prior round that do not improve the previous clearing discount are frozen and can never be improved.

Part 1 is a fundamental requirement for a competitive auction. Part 2 gives bidders the flexibility to improve a portion of a step. Part 3's requirement that a discount change improves the clearing discount eliminates extraneous revisions. A minimum increment averts stalling the auction.

Part 4 is the key provision. To see how this works, suppose in our example that the clearing price in the prior round was 3.5% and that the minimum bid increment is 0.5%. Then since steps H and I were losing steps in the prior round and they were not improved, they are frozen. This means that they cannot be improved in any subsequent round. All other steps were either winning steps in the prior round or improved this round.

The motivation for Part 4 is as follows. In the current round, Bidder 3 failed to improve its losing step H. This is taken as *de facto* evidence that it is unwilling to improve the step with a 4% bid (0.5% above the prior clearing discount). Hence, the step is frozen and will be a losing step unless a winner fails to sign the contract, since Part 1 assures that discounts can only increase.

The effect of Part 4 is to freeze any part of a supplier's bid schedule for which there is presumptive evidence that its cost exceeds the clearing discount. Part 3 prevents a supplier from employing a strategy of withholding supply until the final round.

Activity rules of this form produce a characteristic process of competition among suppliers. After each round the bids are divided into those that are winners, because their bid discounts are more than the clearing discount, and those that are losers, because their bid discounts are less than the clearing discount (or they are rationed). In the next round, each losing bid must improve the previous clearing discount or lose that step of the schedule. Thus, if the supplier is willing to bid a higher discount than the clearing discount, then the incentive to raise the bid discount is quite strong, since this is the supplier's last opportunity. However, when the bid is improved, it displaces some previous winning bid, which now becomes a losing bid, and that supplier now faces a similar problem. The resulting process resembles a tug-of-war among the marginal suppliers to determine which ones' bids will be accepted at the clearing discount. This battle is resolved when the clearing discount is driven up to the point where some contenders prefer to let their bids be frozen. The characteristic pattern is that in each round there are many bids near the previous clearing discount; but if the suppliers must be rationed, then those with losing bids and lower costs find it advantageous to raise their discounts. This feature is not present in the auctions that have been considered to date for assigning standard offer service.

3. *A Proposed Implementation*

This subsection describes a complete set of procedural rules. These rules are intended to implement the main ideas elaborated in the prior subsection. They apply to both the full-term and single-year auctions described above, except as noted.

Before the auction, a schedule is established for the first round, along with a preliminary schedule for subsequent rounds. The schedule designates begin and end time for submitting or modifying bids. At the conclusion of each round, the schedule for the next round is established.

Before each round, the auctioneer also determines a minimum bid increment. The minimum bid increment can be modified by the auctioneer during the auction, in order to promote competition and to account for the level of competition evidenced in prior rounds. The minimum bid increment would be adjusted in response to bid activity. With greater activity, high bid increments can be used. For example, if there were bids on 101 shares in the full-term auction with all bids near 0%, then having a 1% increment would be too high. In this case, the auctioneer, after observing the total shares bid would likely

reduce the minimum increment to .25%. Bidders may be unwilling to improve bids by 1%, but they might be willing to improve bids by .25%.

The following activity rules apply separately for each step on the bid schedule. Each step is a binding bid that remains in force until it is improved. An improved step replaces the prior step. Except for those improved, all steps continue in force for the next round. At the close of the auction, those steps with discounts below the clearing discount are rejected, with ties at the clearing discount resolved by the Rationing Rule. The remaining steps are accepted, and each becomes automatically a binding contract for the bid share at the discount bid. This contract is an obligation for serving the specified share of the standard offer load under the terms of a pre-defined power supply contract. If a winner fails to sign the power supply contract, then the lost supply will be filled with frozen bids in the order they appear on the supply schedule.

Eligibility Rule: The Eligibility Rule specifies the deposit required for a desired level of eligibility. The bid deposit, due by the final qualification date, determines a bidder's maximum eligibility. A deposit of \$x per share of eligibility is required. Shares are weighted by year as follows:

Year	1	2	3	4	5	6	7
Calendar Year	1998	1999	2000	2001	2002	2003	2004
Weight	1.00	0.86	0.71	0.57	0.43	0.29	0.14

Opening Rule: The opening rule requires that all new bids must be received early in the auction. In the full-term auction, all new bids must be received in the initial round. That is, the bid quantity associated with any step cannot be increased after the first round. In the single-year auction, all new bids must be received in the first four rounds. This gives the bidders the flexibility to balance their activity across the years in response to the bids of the others. For example, during the fourth round, a bidder may place most of its new bids on year 2, because of a shortage of bids in that year. However, once bids are placed, the bidders cannot shift bids across years. This is to prevent a bidder from placing a large bid for year 1, say, and then shifting it to year 7 near the end of the auction, causing a large disturbance to prices.

A new step in the bid schedule can be submitted only in the first round in the full-term auction, and in the first four rounds in the single-year auction.

In the single-year auction, a bidder must hold bids totaling at least 25% of eligibility (in terms of bid deposits, or equivalently, weighted shares of load responsibility) in the first round, 50% in the second round, 75% in the third round, and 100% in the fourth round. Failure to maintain these activity levels results in a corresponding reduction in eligibility. For example, if a bidder has eligibility to bid on 100 shares, but only bids on 20 in the first round, then its eligibility is reduced 5 shares (25 – 20).

It should be expected that there will be little price discovery in the first several rounds of the single-year auction. Until the end of round 4, there may be no losing bids (i.e., no excess supply) and so no pressure to improve bids. This period of little price activity is intended to give the bidders an opportunity to observe and respond to the quantity activity in yearly markets during the first four rounds. With this information, bidders can make better decisions about where to allocate their remaining eligibility.

In each later round the only bids allowed are improvements of ones submitted in the first round of the full-term auction or the first four rounds of the single-year auction. This rule ensures that the maximum supply in each yearly market is revealed by the fifth round. This rule is essential for effective price discovery; otherwise a bidder could wait until the final round to submit its first bids.

Next we describe the Sorting, Rationing, Exclusion, and Revision rules.

Sorting Rule: All steps are automatically carried over to the current round. The steps are sorted in decreasing order by discount, and then in increasing order by time-stamp (equivalent bids are taken on a

first-come first-served basis). Steps are designated as winners, until the cumulative shares exceed 100. (If the total shares bid is less than or equal to 100, then all steps are designated as winners; no steps are rationed or frozen.) The next step is rationed as follows:

Rationing Rule: The first step with cumulative shares greater than 100 is split into two steps: a winning step with shares so that cumulative shares is exactly 100 and a losing step for the remaining shares of the step. All later steps are losing steps.

This rationing rule has worked well in experiments. It leads to the fastest convergence, because it minimizes the splitting of steps. The alternative, proportionate rationing, which is used in Treasury auctions, splits all the steps at the clearing discount.

In each round after the first:

Exclusion Rule: A losing step from the prior round is frozen after the current round if its discount is not improved (i.e. its discount is not raised above the previous round's clearing discount by the minimum bid increment). Frozen steps can never be improved. However, frozen steps remain binding bids. In the event a winning bidder fails to sign the contract at the end of the auction, the lost supply will be filled by frozen steps in the order they appear on the aggregate schedule.

The Exclusion Rule is based on the inference that refusal to improve the previous clearing discount signals that the improved discount would not be profitable. The restriction that frozen steps cannot be improved is essential to reliable price discovery. Otherwise, a supplier could wait until the last round to improve steps, and in the meantime other bidders would be getting no information about higher discounts the supplier might be willing to bid. Thus, each discount that is below the clearing discount in one round must be revised in the next round lest it thereafter be frozen.

Revision Rule: A step can be divided into two or more steps with total shares equal to the initial step. A step can be revised only by improving the previous clearing discount. That is, the bid for the revised step must top the previous clearing discount by at least the specified minimum bid increment.

Thus, a losing step for 25 shares can be revised by breaking it into two steps, say for 10 and 15 shares. Then, the bidder can improve the previous clearing discount on just one of the steps. In this case, the second step is frozen. Alternatively, the bidder can improve both steps at different discounts, in which case neither step is frozen.

The clearing discount is computed using all steps on the current bid schedules. It is important to realize that the bid increment is an important design parameter that can substantially affect the rate of convergence of the iterative process. Typically, the clearing discount moves by about a bid increment from one round to the next.

Closing Rule: The full-term auction ends when a round goes by without any improvements. In the single-year auction, all the yearly markets stay open until a round goes by with no improvements in any market. Hence, all markets close simultaneously.

Both theory and experiments show that the markets converge naturally.

F. The Ascending-Clock Implementation

An ascending-clock auction can be used to further simplify the implementation. The purpose of this section is to point out the differences between the ascending-clock and the bid-schedule approaches, and to assess the strengths and weaknesses of each method. The issues are nearly identical in both the full-term and single-year auctions. We focus on the full-term auction, which has just a single clock.

There are two important advantages of the ascending-clock design: simplicity and a rapid rate of convergence.

Simplicity stems from the fact that each bidder in each round submits just a single number. The bidder is asked what quantity do you want at the specified discount? The question is made even easier, since it is asked repeatedly with the only change being a slightly higher discount. At the end of each round, a single number effectively summarizes the bidding: the total quantity bid. In contrast, with bid schedules, each bidder is submitting a modification of a bid schedule, which may include many price-quantity pairs. The bidding in a round is summarized by the aggregate bid schedule, which consists of dozens if not hundreds of price-quantity pairs. Bidders have more flexibility with the bid schedules, but flexibility is not always a good thing. For example, there is a greater possibility of making an error in bid submission.

The second major advantage of an ascending-clock design is the rapid rate of convergence. Specifically, the auction progresses by one bid increment with every round. The same cannot be said with bid schedules. The pace of the auction is apt to slow considerably toward the end of the auction when the number of "losing" shares that must be improved is small. To take an extreme example, suppose that there is just one losing share in a round and the "winning" shares are all close to the clearing discount. Then with conservative bidding, just a single share is improved. In the worst case, it could take one hundred rounds to just increase by one bid increment. Typically, this worst case will not be realized, since even with conservative bidding the number of rounds to increase by an increment should not exceed the number of unfrozen bids. However, the general point is valid. As the number of losing shares declines, the number of rounds required to improve bids by an increment increases.

Taken together, greater simplicity and more rapid convergence mean that a much smaller bid increment can be used with the ascending clock. The time required between rounds is directly related to the complexity of the decisions that the bidders are making. With bid schedules there is more information to review and more information to enter with each round. Hence, fewer rounds can be conducted in a given time period. Moreover, toward the end of the auction, less is accomplished with each round, so the auctioneer cannot use a small increment without risking an overly lengthy auction. Hence, the auctioneer can use a much smaller increment with the ascending clock. Indeed, the use of a small increment further simplifies the bidding by reducing the effect of gaming, which means that even more rounds can be conducted in a given time period. This is the advantage of the ascending clock design.

The bid-schedule approach has one main advantage. The distinction between winners and losers is perfectly clear after every round. The losers know exactly what they must do to become tentative winners. The losers – and only the losers – must improve their losing bids by at least one bid increment above the clearing discount. This clarity does not come without cost. It is precisely the fact that only the losers must raise their bids that leads to the potentially slow convergence as the auction winds down. In contrast, with an ascending clock, all bidders that want to guarantee their ability to win their full quantity must bid the full quantity at the higher increment. Any quantity reduction runs the risk that it will not be filled. Early on this risk is so great that a quantity reduction is essentially equivalent to not raising a losing bid. It is highly likely that that quantity will be lost. However, later in the auction the distinction is blurred. It becomes increasingly likely that the auction will end with the next round, which means that the quantity reduction may be filled.

Another feature of the bid-schedule approach is the added flexibility of bidding any discount above the clearing discount. Experience in other high-stake auctions, like the FCC spectrum auctions, suggests that bidders only occasionally take advantage of this flexibility (and sometimes unintentionally make large errors). The vast majority of the time the bidders simply raise by the minimum required. Assuming this is the case here, then the two implementations are effectively identical when the quantity of losing bids is large. However, late in the auction, the incentives for raising are stronger with bid schedules to the extent that the bidders believe the next round will be the last round. Nonetheless, the outcomes from both auctions should be nearly identical, both in terms of the allocation of shares and the discounts bid.

We conclude that both implementations should work well. We slightly favor the ascending-clock approach. The ability to use much smaller bid increments, because of the simplicity and rapid convergence of an ascending clock, reduces gaming and should improve performance.

IV. The NEES Design

In this section, we summarize the NEES design, focusing on features that we view central to the design.¹¹

NEES proposes to hold an energy auction as described earlier. Hence, the quantity dimension of bids is 150 GWh blocks of delivered energy. NEES intends to use a sequence of four auctions or “tiers” to determine the supply schedule for each year. In each of these auctions, both full-term and single-year bids will be accepted, in separate ascending auctions as described below. The first auction is for the first 40 blocks on the supply schedule. The second, third and fourth auctions are for the next 50, 50 and 38 blocks respectively.

A. The Full-Term and Single-Year Auctions

A full-term bid is for the entire seven-year transition period. Hence, a bid for 10 blocks at 5% is, in effect, a bid for 10 blocks at 5% in each of the seven years. Full-term bids can specify a different discount in each of the seven years.

Single-year bids are year specific. A bidder can bid a specified discount for any number of blocks up to its maximum eligibility as determined by its bid deposit. The single-year auction gives the bidder the flexibility to bid different amounts (in both price and quantity) in each of the seven years. Bidders may desire this flexibility if they anticipate their capacities will change over the years or if they believe the appropriate discount varies across years.

The mechanics of each auction are similar to (and modeled after) the FCC’s successful spectrum auctions. All seven years are on the block simultaneously. In each round, a bidder can submit either full-term or single-year bids up to its maximum eligibility. Bids in subsequent rounds must be either new bids (for additional quantity) or improvements of prior bids. All improvements must top the bidder’s prior bid by some minimum, the “minimum bid increment.”

In addition to a minimum increment, there is an activity rule, designed to keep the auction moving at a reasonable pace. The activity rule requires that a bidder’s activity in a round be at least as great as a specified percentage of its current eligibility. A bid counts as activity if it is an improvement over the bidder’s prior bid or it is the largest discount for the particular year. If a bidder fails to satisfy the activity rule more than once, the bidder loses its ability to submit any new or improved bids. The rules specify four stages of bidding with the following activity requirements and minimum bid increments in each stage. The minimum starting bid is 0%.

Stage	Activity Requirement	Minimum Bid Increment (Full-Term)	Minimum Bid Increment (Single-Year)
1	25%	0.50%	2%
2	50%	0.25%	1%
3	75%	0.25%	1%
4	100%	0.25%	1%

¹¹ The NEES design is specified in Exhibit 1 to its draft auction invitation, dated August 1997, and titled “Final Auction Rules.”

Stage transitions are at the discretion of NEES. After each round, the revised supply schedules are posted for each year, identifying bids through a unique bid number known only to the bidder, so that each bidder can see where it stands in the tentative supply schedule for each year.

B. Combining Full-Term and Single-Year Bids

The final, but critical, component to the auction rules is how full-term and single-year bids are combined to form a single, final supply schedule. First, the single-year schedules are used to form complete (seven-year) “strips” for each block of energy. Two sample blocks are shown below.

Year:	1	2	3	4	5	6	7
Block 54	3%	5%	8%	12%	15%	18%	20%
Block 55	2%	5%	8%	10%	15%	18%	17%

It remains to consolidate each seven-year strip (both single-year and full-term) into a single discount that can be used to rank the strips. NEES does this aggregation by taking the *minimum* discount for each strip. These minimums are referred to as ranking discounts. Hence, in the example, Block 54 has a ranking discount of 3% and Block 55 has a ranking discount of 2%. Similarly, ranking discounts are determined for full-term bids based on the minimum of the discounts for any year comprising the bid. The single-year schedule is then combined with the full-term schedule in the traditional way by merging (i.e., adding) the supply schedules in the quantity dimension. This forms a single aggregate supply schedule, which is then used as described in the beginning of this section to assign the load responsibility.

Finally, we must specify what each bidder is paid for energy supplied. Bidders are paid the stipulated price less the discount they bid. If Block 54 from the single-year auction is a winning strip, then the year 4 bidder would receive the stipulated price discounted by its bid discount of 12% for all energy delivered.

V. A Discussion of the NEES Design

We believe that the NEES auction design could be improved. In this section, we present some potential problems along with our suggestions for improvements. The reasons for including a discussion of the NEES design are twofold. First, since the NEES design was the first to be proposed, it is the model against which others are measured. If other utilities choose to pursue alternative plans these plans will need to be justified in terms of their technical merits vis-à-vis the NEES auction design. The second reason is to articulate the benefits of the design recommended earlier in the paper, with attention to the features that represent significant differences from the NEES design for promoting participation and competition. The following sections describe aspects of the NEES design that could be improved.

A. Lack of Demand Constraint

As noted in the Section 3, auctioning the load responsibility in terms of energy or capacity units delays the assignment of load responsibility and reduces competition in the auction, since there are no clear winners and loser as the auction progresses, only an emerging supply curve. This is because the bidders will not know whether they will be required to serve, but only (approximately) the amount of energy or capacity if called upon. To be sure, there is uncertainty in an auction in which the quantity dimension is percent of hourly load, as recommended in Section 3. Specifically, the bidder does not know for certain how much energy *or* capacity it will need (in auctioning energy or capacity blocks, only one of these dimensions can be bounded). However, we believe that (1) bidders will prefer the uncertainty of the “percent of load responsibility” auction, since they will know at the conclusion of the auction whether they have contracted to serve, and will take steps to provide or contract for the necessary generation capacity; and (2) the load responsibility auction will increase substantially the amount of

competition in the auction. As evidence of the preferences of bidders for more certainty in whether they will be called on to serve, we note that the original NEES design was for an auction of the required number of energy blocks to meet the expected standard offer service requirement. The rules have been amended to conduct the auction in four “tiers” in an apparent attempt to help bidders with the uncertainty about whether they will serve. This approach introduces additional potential for inefficient outcomes, specifically, discounts may not be monotonically decreasing as one moves “down” the supply curve, i.e. higher discounts may be bid in lower tiers.

B. Combining The Full-Term and Single-Year Bids

Another issue is the way in which the full-term and single-year bids are combined. Using the minimum discount across the seven years to rank a strip introduces unnecessary uncertainty for the bidders in the single-year auction. Because the schedule of stipulated prices increases steadily from year 1 (3.2 cents) to year 7 (5.1 cents), many suppliers that find the pricing in the later years to be attractive will be reluctant to bid large discounts in the early years. As a result, we can expect the discount in year 1 to be the smallest, and it will be the year 1 bidding that determines the ranking discount (the ensuing discussion presumes this, although the problem is the same regardless of where the minimum occurs). Thus, the bids in all other years are *irrelevant* to the ranking; these bids do, however, determine what the bidder gets paid for electricity delivered. Notice that the yearly bids after year 1 may be much larger than the year 1 discounts. For example, a full-term bid of 2.1% in each of the seven years¹² beats the Block 55 strip, which has a ranking discount of 2%. Yet the Block 55 strip results in lower energy prices in all other years.

The difficulty is that using the minimum to determine the ranking discount puts all the weight on year 1 and no weight on the other years. The end result is that bidders interested in supplying standard offer service in later years cannot directly influence where they end up on the supply curve through their bids, creating unnecessary uncertainty, which can serve to discourage competition. One solution is to use nonzero weights in each year. A standard and universally accepted approach for weighting in a multi-year decision problem is time discounting. Under this approach, early years are given more weight than later years, which are discounted at a constant discount rate. In most problems, the discount rate represents the time value of money. A dollar today is worth more than a dollar tomorrow. However, in this context, there is an additional source of discounting: attrition from standard offer service. Price discounts in year 1 are worth more in aggregate to consumers, since the savings is earlier *and* the savings is received by a greater number of consumers (once a consumer moves off of standard offer they cannot return to it).¹³ Hence, appropriate weights account for both the time value of money and the attrition from standard offer service.¹⁴

¹² A rational bidder would not bid different discounts in the full-term auction, as the minimum is all that is used for ranking purposes. In effect, by bidding anything greater than its minimum bid for any year, a bidder is giving the discount away with no benefit. The only possible benefit of bidding different discounts in different years in the full-term auction would be to break ties in the combined ranking with the single-term auction, but it is better for the bidder to avoid ties when selecting its bid in the year with the minimum discount.

¹³ An exception is made in year 1. In year 1, some consumers can switch back to standard offer service provided the switch occurs within 120 days.

¹⁴ For example, suppose that there is a 10% discount rate due to the time value of money, and that in each year one-seventh of the consumers move off of standard offer service. Then the appropriate price factors and weights are given below.

Year	1	2	3	4	5	6	7	
Stipulated Price	3.20	3.50	3.80	3.80	4.20	4.70	5.10	
Price Factor	3.20	2.73	2.24	1.63	1.23	0.83	0.41	
Weight (sum=1)	0.26	0.22	0.18	0.13	0.10	0.07	0.03	
Sample Strips								<i>Ranking Discount</i> Minimum Discounting Rule Rule

One might argue that an advantage of the minimum rule is that it does not involve the choice of an arbitrary discount rate. However, the minimum rule is implicitly using an arbitrary discount rate of infinity (no weight on years after year 1). Hence, the choice between the minimum rule and the discounting rule depends on whether one believes a finite discount rate is more appropriate than a discount rate of infinity. The reason for the minimum rule is to encourage bidding in the early years. However, this is accomplished more appropriately by the discounting rule, since consumer interests after year 1 should not be ignored. Nonetheless, in this context neither rule is especially effective at encouraging bidding in the early years. The reason is the well-known free-rider problem.¹⁵

One way to avoid the problems associated with combining the full-term and single-year auctions is to conduct them in sequence, as described earlier in the paper. Given the objectives of encouraging bids that span the entire transition period and retaining flexibility for suppliers to bid different quantities and discounts in different years, holding the auctions in sequence is recommended. In this way, full-term bids are given priority explicitly, thus accomplishing the end result of combining the auctions through rankings, without imposing unnecessary uncertainty on single-year bidders. The design proposed earlier in the paper facilitates this solution by clearly defining winners and losers in the auction. Thus, after the full-term auction, the remaining shares of load responsibility are known, and the single-year auction is held for exactly this quantity. In each round, single-year bidders can easily determine where they stand for each of the years, and then improve losing bids in years they would like to win.

C. Other Issues Affecting Participation

Compared to the issues discussed above, those presented in this section may appear minor. However, in auction design, it is important to get the details right. Bidders making decisions with millions of dollars at stake will spend a great deal of resources looking for ways to game the rules to their advantage. Unlike a negotiation, which can be postponed in light of problems, postponing an auction is difficult, since the timing involves many parties. Moreover, many auction mistakes are irreversible.

1. Timing

The critical timing events for the bidders are the final rules date, the qualification date, the auction date, and the timing of all payments. To encourage participation, it is important that there be ample time between the final rules date and the qualification date. Until the rules are set it is not realistic to think that all bidders can do the work necessary to qualify. Prudent investors are unlikely to commit resources until the auction rules are known and ambiguities are resolved. In a recent FCC spectrum auction for wireless communication services, revenues were far below expectations largely because Congress dictated an auction schedule that was too fast. The FCC was able to give the bidders just a few weeks between the

Block 54	3%	5%	8%	12%	15%	18%	20%	3.0%	8.3%
Block 55	2%	5%	8%	10%	15%	18%	17%	2.0%	7.7%

The price factor in year n is simply $p_n \cdot [1 - (n-1)/7] / (1+i)^{n-1}$ where p_n is the stipulated price in year n and i is the discount rate of 10% for the time value of money. The weights are the price factors normalized so that the weights sum to 1. These weights put nearly eight times as much weight on year 1 as year 7. Of course, if it is believed that attrition will occur at more (less) than one-seventh per year, then the weight on earlier years should increase (decrease) accordingly. The last two rows of the table show what the ranking discount would be in our example under the two alternative rules. The ranking discounts under the discounting rule are substantially larger and reflect the actual bids. These are the rankings that should be used if the goal is to maximize the net present value of consumers' savings from discounts.

¹⁵ If bidding in year 1 were a losing proposition, then each bidder would prefer the other bidders to step in and raise their bids in year 1. In this way the bidder avoids the year 1 losses, yet is more likely to be called into action in the later years, because of the year 1 bidding of the other bidders. Using the minimum bid as the ranking discount, bidders underbid in year 1, since they do not take into account the benefits such bidding has on the others. The only real solution to this free-rider problem is to directly subsidize the bids in the early years, but this is simply undoing the intent of the stipulated price settlement.

final rules and the qualification date. As a result, the bidders did not have sufficient time to line up the money needed to participate.

The time between the qualification date and the auction date should be as short as possible. This allows entry into the auction up to the last moment. The electricity industry is in the midst of a massive restructuring. It is not realistic to think that in this setting all bidders can make commitments to participate months before the auction date. In the NEES auction, the qualification date was May 30, 1997 for an auction originally scheduled to begin on September 15, 1997. On May 30th all bidders had to submit complete qualification documents to NEES. The qualification date should be much closer to the auction date. Two to four weeks should be all that is needed to check qualifications. Deposits and final qualification should occur one to two weeks before the auction. Certainly, this rapid turnaround puts a burden on the auctioneer, but it is a burden that can be rewarded by increased participation.

2. *Bid Increments*

NEES uses a constant minimum bid increment (the minimum increase to an existing discount to stipulated prices), across the seven years. This is not appropriate if the auctioneer expects larger discounts in the later years. The size of the minimum bid increment should reflect the expected final bids. Also the bid increments should be adjusted during the auction in response to the total bids in the year.

3. *Activity Rule*

The goal of the activity rule is to encourage reliable price discovery. It is intended to prevent bidders from adopting a snake-in-the-grass strategy – simply waiting while the others reveal valuable information before stepping in with large bids at the last minute. The activity rule should speed the auction along by encouraging sincere bidding, and minimize the possibility for creating distortions in the bidding.

NEES borrowed the type of activity rule used in the highly successful FCC spectrum auction design. Unfortunately, that rule is not transferable to the context of the NEES design. An essential element of the FCC rule is that after each round of bidding there are tentative winners and losers. Bidders are required to have a level of activity that is consistent with their eligibility or they lose eligibility. Activity is defined as being a standing high bidder (a tentative winner) or placing a valid new bid (which moves the bidder from a losing to a winning position).

With the NEES definition of what is being auctioned, winners and losers cannot be identified until years after the auction. This creates a difficulty in applying the FCC rule. The NEES approach is to use the lowest point on the supply schedule (i.e. the highest discount) as the high bid. This high bid counts as activity, but a sufficient percentage of all other bids for each bidder must be improved by the minimum increment for the bidder to maintain the flexibility to improve bids later. Note that the bidder with the largest discount only gets activity credit for the largest bid. This bidder may well have to improve some of its other bids to satisfy the activity rule. Also, as currently structured, some bidders can upset the strategies of other sincere bidders.¹⁶

4. *Eligibility*

Lastly, the eligibility and security requirements could have adverse effects on the auction participation and coverage. This stems from the fact that a block of 150 GWh is weighed equally for

¹⁶ Consider Bidder A bidding on 5 blocks in year 1. Suppose Bidder A can profitably offer a discount of up to 6%. It submits an initial bid of 3% on 5 blocks, hoping to make a reasonable profit. Another bidder, Bidder B, submits the minimum bid of 2% on 49 blocks and a bid of 20% on 1 block. In round 2, Bidder A, since it is not the high bidder, is forced to raise its 3% bid to 5% (assuming the minimum bid increment is 2%) or lose flexibility. Bidder A may well gamble that its expected profits are higher by sticking at 3%. Once Bidder A's flexibility is lost, Bidder B then steps in with a bid of 3.0001% (after the minimum bid increment has dropped to 1%) on its remaining eligible blocks.

determining eligibility and security requirements for every block regardless of whether it is in year 1 or year 7. Despite the fact that in year 7 there are likely to be few customers remaining on standard offer service due to attrition, and therefore fewer “winning” blocks, eligibility and security requirements are the same for each 150 GWh block bid anywhere on the supply curve for any year. While the relative bid eligibility and security of \$1,000/GWh and \$10,000/Gwh, respectively, seem about right, the fact that NEES requires the same amount in early years as later years discourages bidding in later years when the uncertainty of whether the bidders will serve is higher. This raises the cost of participating in the later years of the auction unnecessarily, since the bid deposits and security need only reflect the auctioneer’s true cost of default.

VI. Conclusion

We have proposed a simple auction to determine market prices for standard offer service. The design is a sequence of two ascending auctions, a full-term auction followed immediately by a simultaneous single-year auction. The full-term auction encourages coverage of all years, whereas the single-year auction gives the bidders flexibility to adjust their bids within each year. The approach promotes competition and reduces uncertainty by revealing essential information during the bidding process. Specifically, bidders know which bids are tentative winning bids and which are not at the end of each round of bidding. The process ends naturally when no bidder is willing to improve its bid in any year. In this way, market prices are found that are both fair and efficient. Standard offer service is assigned to those suppliers who offer the best prices. Consumers benefit from this competition, since it leads to the lowest supply prices. In addition, consumers retain the option of moving off of standard offer service when presented with a better offer at any point during the transition period.

To promote sincere bidding, activity rules are included in the design. The essential element is a requirement that a losing bid from the prior round must be revised to improve the prior clearing price by at least one bid increment, or the bid is frozen and can never be improved. The rule is based on the principle of revealed preference: a bidder’s refusal to improve a previous clearing price is presumptive evidence that it is unwilling to bid a higher discount.

The auction can also be implemented using an ascending-clock design. Under this approach, a clock indicates the current discount and bidders are asked the quantity of shares they desire at the specified discount. The clock is increased until the quantity of shares bid falls below the amount available. The activity rule is simply that a bidder can never increase its shares at higher discounts. This implementation is similar to the first approach using bid schedules. However, it has the additional advantages of simplicity and rapid convergence. As a result, smaller bid increments can be used, which may reduce gaming and improve performance.

We describe an alternative auction design proposed by NEES. We find that there are certain areas where the NEES design introduces unnecessary uncertainty for bidders. This uncertainty can serve to discourage participation and renders the auction more vulnerable to inefficient outcomes.

Standard offer service is but one application of the principles of auction design. Indeed, these principles can be applied to many of the critical steps in the move to a competitive electricity industry. These applications include (1) the divestiture of generation assets, (2) the pricing and exchange of electricity in day-ahead and hour-ahead power pools, and (3) the pricing of ancillary services and transmission congestion. In each case, the goal is to determine an efficient allocation of resources and establish market prices. A well-designed auction creates a price discovery process to best meet this goal.