Electricity Auctions: Regulatory and Efficiency Issues

Christiano Vieira da Silva
Advisor: Professor John Forrer

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1. Introduction

Electricity restructuring poses major changes for those involved with regulatory issues. This means that new schemes of coordination and rules to guarantee a sufficient level of competition and non-discriminatory open access to all users need to be achieved.

By far one of the most significant challenges faced by those who wish to consolidate an efficient electricity market in Brazil is the design of electricity procurement mechanisms that assures publicity, transparency and access rights.

Electricity markets differ in several aspects, but until recently most of them had already gone through some market oriented restructuring in order to improve economic efficiency. Nearly every deregulated electricity market had adopted at least a wholesale power market. Auctions were the primary instrument chosen to deal with the allocation of property rights over transacted power. A variety of mechanisms were designed to permit such negotiations between buyers and sellers.

Although Brazil has a relative recent experience in designing electricity auctions, it is generally believed that electricity procurement using auctions provides a good framework for achieving allocative efficiency.

This paper aims to contribute to the discussion concerning the efficiency of electricity procurement, considering the fundamental theoretical concepts, the Brazilian legislation, electricity market rules and procedures, and finally the challenges posed to the Brazilian Electricity Sector Industry.

The remainder of this paper proceeds as follows. Section 2 provides a brief introduction to the current Brazilian electricity market. Section 3 introduces the most common aspects of auctions and provides some theoretical background and points out some remarkable findings in the auction literature. Section 4 elaborates more on the auction theory applied

to electric power markets and presents an application of it. Section 5 discusses the electricity power procurement in Brazil. Finally, section 6 and 7 make some recommendations concerning the auction format adopted in Brazil and call for further study on the important subject of electricity procurement.

2. Brazilian Electricity Market

2.1. Electricity Market Fundamentals

The electricity market comprises at least three productive activities: generation, transmission and distribution. There is a continuum of electricity market types that ranges from monopoly to competition. In the former, all productive activities are bundled and performed by a single electricity provider. In the latter, these activities are unbundled and performed by many providers.

When electricity markets were first established they were organized either as a state monopoly or as private monopoly heavily regulated by state. The rationale used to justify such arrangements was the "natural monopoly" features of all segments of the electricity market. It was believed that it would not be possible for more than one company to provide electricity efficiently in the same region. There were gains of scale that would be achieved by the first company entering in the market. Because of these gains, other firms would eventually be driven out of the market. In any case, the economics of natural monopolies, markets and regulation are not enough to understand the complexities of real electricity markets. Many issues of practical implementation should be analyzed through case studies. Also many contributing factors stem from the political scenario specific to each country.

During the 1990s, restructuring and deregulation processes are carried out by governments through the introduction of electricity markets to increase efficiency and reduce prices. Rothwell and Gómez raise the many driving forces to electricity restructuring around the world:

1. New generation technologies, such as combined-cycle gas turbines (CCGT), have reduced the optimal size of an electricity generator.
2. The competitive global economy requires input cost reduction; electricity is a primary input for many industries.
3. The State, as owner and manager of traditional infrastructure industries, cannot respond as quickly as private owners to economic and technological change, prompting privatization.
4. Information technologies and communication systems make possible the exchange of huge volumes of information needed to manage electricity markets. (Rothwell and Gómez, 2003, 3)

The restructuring process encompasses a deep transformation in the structure and organization of electricity companies. Competition was introduced by unbundling generation, transmission and distribution services. Public utilities were privatized in order to promote efficiency. The theory of perfect competition was the rationale behind these changes. In theory, the interaction of many buyers and sellers would yield a market price that is equal to the cost of producing the last unit sold, provided the regulators are able to eliminate or prevent the exercise of market power (i.e., the capability of a firm or a group of firms to set prices consistently above production costs).

Electricity energy has some idiosyncrasies that greatly affect the way the electricity markets are organized. First, electricity cannot be stored in an economical way. Therefore supply needs to equate demand at every second. Second, all electricity consumers are connected to the same grid. For this reason any failure at any point of the grid may negatively affect the entire set of consumers connected to that grid. In economical terms both facts introduce restrictions in the electricity market's design and operation. The former calls for centralized operations, while the latter introduces negative externalities that need to be taken into account in order to promote allocative efficiency.

Despite the restructuring process in course in many electricity markets, it does not mean that regulation is not required anymore. From the standpoint of the regulator, economic

efficiency and secure operations are directly connected to the interests of consumers either in the short-run as in the long run. In fact, regulation continues to be used where competition is not feasible, e.g., in sector which still have characteristics of natural monopolies or in circumstances where externalities have not been internalized, such as high-voltage transmission, distribution and system operation. All those functions are performed under direct regulatory supervision.

2.2. Current model

The Brazilian power market utilizes a hybrid model that relies on long-term bilateral contracts and short-term adjustments done at the market operator (MAE). Any market agent can negotiate a power supply agreement directly with suppliers or choose to buy electricity at the current spot market price.

Bilateral contracts are negotiable agreements on delivery and receipt of power between two traders. These contracts set the terms and conditions of agreements independent of the National System Operator (ONS). The bilateral contract model is very flexible as trading parties specify their desired contract terms. However, its disadvantages stem from the high cost of negotiating and writing contracts, and the risk of the creditworthiness of counterparties

Any customer would be allowed to negotiate a power supply agreement directly with suppliers or choose to accept power at the spot market price. The market operator serves all participants (buyers and sellers) who choose no to sign bilateral contracts.

Market operations are assigned to the ONS, which is responsible for dispatching the system and safeguarding operational reliability, and the Wholesale Energy Market (MAE), which conducted financial clearing operations for the pool. The National Agency of Electric Energy (ANEEL) was created by Law # 9,074/95, enacted in 1995, although the actual decree authorizing the creation of ANEEL was not adopted until 1996.

As a result of the restructuring, what arose was a transition period believed to last as long as ten years, ending in 2006, followed by a fully competitive generation market with many private companies competing, both buyers of existing state assets as well as new entrants. This transition from the old model to the new was bridged through the use of long-term contracts known as "initial contracts".

By the middle of 2001, Brazil faced a significant energy shortage. Whole sectors in the economy were disrupted. It had to implement a rationing plan during jun/2001-feb/2002. Economic growth had decreased by 2% of GDP as a result. The Civil House of the Presidency of the Republic commissioned a report by a group of experts coordinated by Commissioner Jerson Kelman, National Water Agency's director-president, on the causes of the Brazilian energy crisis. The commission report pointed out the postponement of new power plant investments in the period following the restructuring as a major contributing factor to the energy crisis.

A new administration took office with the election of President Lula in late 2002. On July 2003, the Ministry of Mines and Energy released the guidelines for a new regulatory framework in the Brazilian electricity sector. The model was enforced initially by means of a provisional measure that was later converted into law # 10,848/04. This new model introduces stricter regulations and broadens government supervision and control over the sector.

Currently, transition procedures and legal arrangements are being devised at the Ministry of Mines and Energy in order to complement law # 10,848. This will be done by decree and resolutions in the terms of the law. As far as electricity procurement is concerned, law # 10,848 establishes two environments in which energy will be transacted. There will be a free trade environment and a regulated trade environment. Distributors will be required to buy electricity in the latter environment. Electricity will be procured through auction mechanisms, except when it is produced by means of wind and biomass sources, or small hydro plants.

2.2.1. Key market entities

2.2.1.1. ANEEL

ANEEL was established as part of a state reform process to perform the role of the regulatory and inspection body in the electric energy sector. It has an important role in the mediation process between industry players and electric energy consumers. ANEEL is also in charge of granting concession contracts and authorizations.

Its structure comprises two hierarchical levels. The Board of Directors, consisting of a director-general and four directors, deliberates under collegiate rules of procedure. Below this level, there is another that comprises twenty superintendents, whose roles are based upon organizational processes, both technical and administrative.

2.2.1.2. ONS

ONS performs the system operation. It is responsible for the dispatch at the lowest economic cost, but only deals with the physical aspects of operations. It takes charge of unit commitment and transmission control.

ONS has the authority to commit and dispatch some or all system resources and to curtail loads for maintaining the system security. ONS is mainly concerned with maintaining transmission security in the operations of the power market.

2.2.1.3. MAE

MAE is the market operator. It is responsible for the accounting of the agents' transactions in the short-term market and the financial settlements resulting from these transactions. MAE is subordinate to the regulation of ANEEL and must function under the directives of the Market Convention issued by ANEEL on the 1st of March of 2002,

which established Brazilian Electricity Market rules, penalties, operational policies and procedures.

2.2.2. Key market agents

2.2.2.1. Generators

Generating Companies (GENCO) operate and maintain existing generating plants. Despite the privatization efforts during the last decade, federal state owned GENCOs are still responsible for near 80% of generated power in Brazil. Some GENCOs were formed by segregation of electric power generation assets form the existing utilities. GENCOs own generating plants. GENCOs have the opportunities to sell electricity to entities which whom they have negotiated sales contracts. GENCOs may also opt to sell electricity in the spot market from which big customers such as electric distribution companies may purchase electricity to meet their needs. In addition to real power, GENCOs may trade reactive power and operating reserves. GENCOs are not affiliated with ONS or TRANSCOs. A GENCO may offer electric power at several locations that ultimately will be delivered through TRANSCOs and electric distributing companies to customers. There are three generation modalities: public service, independent production, and self production. The independent producer may engage into power purchase agreements in a competitive environment. GENCOs in the public service modality must sell their energy through auctions.

2.2.2.2. Transmission companies

A TRANSCO transmits electricity using a high-voltage, bulk transport system from GENCOs to discos for delivery to customers. It is composed of an integrated network that is shared by all participants and radial connections that join generating units and large customers to the network. The use of TRANSCO assets is under the control of the ONS, although the ownership continues to be held by original owners. TRANSCOs are

regulated to provide non-discriminatory connection and comparable service for cost recovery.

2.2.2.3. Electric distribution companies

Electric distribution companies (EDC) distribute the electricity, through their facilities, to customers in a certain geographical region. EDCs are regulated electric utilities that construct and maintain distribution wires connecting the transmission grid to end-use customers. EDCs are responsible for building and operating their electric systems to maintain a certain degree of reliability and availability. EDCs have the responsibility of responding to distribution network outages and power quality concerns. EDCs are also responsible for maintenance and voltage support as well as ancillary services.

2.2.2.4. Retailers

A retailer buys electric power and other services necessary to provide electricity to its customers and may combine electricity products and services in various packages for sales.

2.2.2.5. Customers

A customer is the end-user of electricity with certain facilities connected to the distribution system, in the case of small customers, and connected to transmission system, in the case of bulk customers. Brazilian regulations characterize two types of consumers. According to Law # 9,074 art 15 and 16, consumers with loads up to 3 MW are considered to be captive consumers and do not have the right to choose their power provider. They obtain electric energy services from a utility or distributor that has legal rights to provide those services in the service territory where they are located. Customers with power demand over 3 MW are no longer obligated to purchase any services from their local utility company. These customers have direct access to generators and

contracts with other providers of power, and choose packages of services with the best overall value that meet their needs.

3. Auction Theory

3.1. Introduction

Auctions are simply organized markets where goods are granted to bidders based on explicit set of rules that determine who wins the auction and the price the winning bidder pays. Auctions have been used since ancient times for the sale of a variety of objects. They can be used either to sell products (e.g. soybeans and steel) or to award contracts to potential suppliers (e.g. for power plant construction projects). Auctions of the second type are called procurement auctions, since a product is being procured rather than sold.

The economic theory of auctions had its beginnings in the 1960s, but early research had little influence on practice. Only after the design and operation of the radio spectrum auctions in the United States (1993-1994), auction theory gained increasing prominence.

Nowadays numerous kinds of commodities ranging from corn and fresh flowers to steel and gold bullion are sold by means of auctions. Long-term securities are sold on weekly auctions conducted by the U.S Treasury in order to finance the borrowing needs of the government.

3.2. Types of Auctions

Auction designers have four basic types of auction formats from which to choose that have been widely analyzed and applied:

- the ascending-bid auction (also called the open, oral, or English auction),
- the descending-bid auction (used in the sale of flowers in the Netherlands and so also called the Dutch auction),

- the first-price sealed-bid auction, and
- the second-price sealed-bid auction (also called the Vickrey auction).

Auctions may be ascending or descending depending on whether the price goes up or down during the auction. The auction may be a first-price or second-price. If the price paid is the last price bidded, then it is a first-price auction. If the price paid is an amount equal to the price of the largest losing bid, than it is a second-price auction. Auctions may also vary according to whether the prices bidded are known to other bidders. If the bid is known only by its bidder, the auction is called a "sealed-bid" auction.

In some auctions, an auctioneer calls out bids and bidders actively indicate their willingness to continue participating, for instance by flashing bidder cards. In other auctions, including those in the electricity market, bidders privately submit their bids to the auctioneer without communicating any information to other bidders about how much they are willing to pay.

These basic categories can be mixed and produce different types of auctions. For instance, we have ascending first-price, descending second-price, sealed-bid first price, etc. It can be proved theoretically that the total revenue generated from any of the four basic auction forms described above would be equivalent under a particular set of assumptions.

A common aspect of all these auctions is that they elicit information, in the form of bids, from potential buyers regarding their willingness to pay and the outcome – that is, who wins what and pays how much – is determined solely on the bases of the received information. An implication of this is that auctions are universal in the sense that they may be use to sell any good. A second important aspect is that they are anonymous, in the sense that the identities of the bidders play no role in determining who wins the object and who pays how much.

3.2.1. Single-unit Auctions

Single unit auctions are characterized by having just one kind of item for sale. In addition to, each bidder can buy at most a single item. The open ascending price or English auctions is perhaps the most common format. On its simplest form, the sale is conducted by an auctioneer who begins by calling out a low price and raises it, typically in small increments, as long as there are at least two interested bidders. The auction stops when there is only one interested bidder. This bidder wins the object and pays the auctioneer an amount equal to the last price bidded.

The so called Dutch auction is the open descending counterpart of the English auction. Here the auctioneer begins by calling out a price high enough so that presumably no bidder is interested in buying the object at that price. This price is gradually lowered until some bidder indicates his interest. The object is sold to the bidder at the given price.

The first-price sealed bid auction is another very common format, particularly in government procurement. Bidders submit bids in sealed envelopes; the object is awarded to the person with the highest bid. The winner pays what he bidded. Finally, there is the second-price sealed bid auction. Its format is very similar to the first-price sealed bid. The only difference stem from the amount paid for the object. The winner is the bidder with the highest bid, but he pays for the object the value of the second highest bid.

3.2.2. Multi-unit Auctions

When multiple objects are to be sold, many options are open to the seller. First, the seller must decide whether to sell the objects separately in multiple auctions or jointly in a single auction. In the former case, the objects are sold one at a time in separate auctions – conducted in a way that the bids in the auction for one of the objects do not directly influence the out come of the auction for another. In the latter case, the objects are sold at

one go in single auction, but no necessarily all to the same bidder, and the bids on the various objects collectively influence the overall allocation.

Second, the seller must choose among a variety of auction formats, and there is a wide range of possibilities to choose from. For instance, if the seller decides to sell the objects one at a time in a sequence of single-object auctions, there is still the question of the particular auction form – first-price, second-price, or some other format – to adopt. Finally, the seller must choose between a uniform or discriminatory price auction. Uniform price auctions promote the law of one price, according to which identical goods should have identical prices. Therefore, the same object is sold at the same price for all the winners. On the contrary, discriminatory auctions lead to different prices for the same object.

The simplest kind of uniform price auctions are sealed-bid auctions. This format is useful when bidders have demand for multiple units. They can submit one or more bids specifying a quantity q and price p for that quantity being purchased. The auctioneer will use this information to establish the bidders' demand curves. Then the auctioneer sets the price so that quantity demanded equates available supply.

Ausubel and Cramton show that these auctions inevitably create incentives for bidders to reduce demand to avoid driving up prices:

> The intuition for bid shading and demand reduction in the uniform-price auction is as follows. When a bidder desires multiple units of the good being auctioned, there is a positive probability that her bid on a second or later unit will be pivotal, thus determining the price that the bidder pays on other units that she wins. Given this, she has an incentive to bid less than her true value on later units in order to reduce the price she will pay on the earlier units. With discrete goods, this intuition suggests that the bidder will bid her true value on her first unit demanded, but strictly less than her true value on all subsequent units. With divisible goods, this intuition suggests that a bidder's submitted demand curve will take on the

> qualitative features of a monopolist's marginal-revenue curve: at zero quantity the demand curve and the bid curve (marginal revenue curve) intersect, but at all positive quantities, the bid curve (marginal revenue curve) lies strictly below the true demand curve. (Ausubel and Cramton 2002, 3)

Another kind of uniform price auction is the simultaneous ascending auction introduced by de Federal Communications Commission (FCC) in 1994 and its clock variants. In the FCC design the bidders call the prices, while in a clock auction the auctioneer calls the price, which is then posted on a digital or analog clock.

The first FCC auction design had the following characteristics:

1. Bids are placed in a series of rounds
2. Bidders are committed to their bids
3. Each round, the auctioneer determines the standing high bid, which is the larger of the previous standing high bid and the highest new bid.
4. At the end of the round, the auctioneer determines a minimum bid for the next round by adding an increment to the standing high bid
5. The auction ends only after a round in which there are no new bids on any license.

Rule 5 is called "closing rule". It has an important role in the arbitrage among substitutes, because a bidder may become interested in bidding on one license only after the another substitute license has risen sufficiently.

Another important rule is the "activity rule", which prevent bidders from waiting until late in the auction to begin bidding seriously. In its simplest form, it states that activity can never increase from round to round, i.e., a bidder that place bid for n units in one round cannot bid for more than n units in the next rounds.

At the end of each round, the bids made by all bidders and their identities are revealed to all bidders and the public.

The FCC's auction design worked reasonably well for spectrum licenses, but it has lead to lengthy auctions. The standard simultaneous ascending auction fails to take advantage of the homogeneity of the items, which is very important in commodities markets like securities and electricity. (see Milgrom 2004, 279)

The clock auction design had the following characteristics:

1. Bids are placed in a series of rounds
2. Bidders place quantity bids
3. In each round, the auctioneer increase prices by one increment for those goods for which demand exceeds supply.
4. The good is awarded at the final price, i.e., when demand is less or equal supply

Despite its simplicity, the clock auction poses some practical challenges. Since the auctioneer increases bids in discrete increments, prices can overshoot. Some refinements need to be made in the auction design to fully account for this possibility. Clock auction are currently use in electricity procurement. We analyze in sections 4 and 5 some practical implementations of the clock auction, both ascendant and descendent versions.

3.3. Efficiency

The main questions that guide auction theory involve a comparison of the performance of different auction formats as economic institutions. These are evaluated on two grounds and the relevance of one or the other criterion depends on the context. From the perspective of the seller, a natural yardstick in comparing different auction forms is the revenue, or the expected selling price that they fetch. From the perspective of society as a whole, however, efficiency – that the object ends up in the hands of the person who values it the most ex post – may be more important.

One of the most desirable outcomes of any auction is that prices be close to the marginal cost of producing the product. Also for this condition to hold it is necessary that sellers do not have unilateral incentives to increase prices. At the same time the more sellers there are the less likely it is that anyone can increase prices above costs without being challenged by a competitor.

When values are interdependent, information necessary to determine the values is dispersed among the bidders. To achieve efficiency, this information must emerge during an auction. Ascending auctions may provide the bidders with such information through the course of bidding. This information may encourage competition by creating a reliable process of price discovery and by allowing efficient aggregations of items.

3.4. Revenue Maximization

It is possible to show that any auction that awards the object to the bidder with the highest private valuation and offers no expected surplus to the bidder with the lowest-feasible private valuation produces equivalent expected revenue, with each bidder making the same expected payment as a function of their private valuations. This remarkable theoretical result is called the "revenue equivalence theorem." (See Vijay, 2003, 29)

The "revenue equivalence theorem" has important policy implications. First, the total costs to society of procuring goods through any of these basic auction formats are likely to be the same regardless of format. Second, buyers' and sellers' bidding strategies will be adjusted as the auction rules change, making those costs independent of the format adopted. Although this reasoning is very appealing, it only applies in cases where the information that shapes buyers' and sellers' valuations of the good is strictly private and to cases where at least some of the information buyers and sellers use in forming their bids is commonly held by all.

Of course, revenues and efficiency are not the only criteria that should guide the choice of an auction format. The common auction forms discussed thus far have the virtue of simplicity – the rules of the auctions are transparent – and this may be an important practical consideration. Another important factor may be the potential for collusion among bidders. Auction formats differ in their susceptibility to such collusion.

3.5. Market Power

Market power in the electric power industry arises in the context of non-competitive practices, especially in the generation sector. Producers exercise market power when they are able to exert a significant influence on the pricing or on the availability of electricity.

Market power can either be exercised intentionally or accidentally, either by one seller or by a group of sellers (collusion). For instance, if a generating company could commit costly generating units when cheaper units are available, it is considered intentional. On the other hand, a transmission constraint that could limit the transfer capability in a certain area is considered to be accidental.

A major concern in the auction literature is how to avoid inefficient outcomes that could derive from collusion. An auction designer faces various trade-offs in terms of efficiency, revenue and simplicity. For instance, the price discovery mechanism that characterizes open auctions and could lead on one hand to efficient outcomes, in contrast may be used by bidders to establish and enforce collusive outcomes.

In an ascending auction, deviations from collusive agreements can be punished during the auction. In a sealed bid auction, deviations cannot be punished in the auction. Nevertheless, punishments can occur outside of the auction. Since collusion is illegal, punishment schemes need to be devised in order to constrain colluders under the rule of law.

Sealed bid auctions have an important advantage over ascending auctions regarding to collusion avoidance. In multi-unit ascending auctions, the bid process can serve not only to impose a collusive arrangement but also to recognize one. In multi-unit ascending auction, bidders can effectively use their bids to bargain a division of the goods.

As bidders can use bid to communicate information and enforce collusive outcomes, it is important to place restrictions on bids, in order to control how much information is revealed to bidders. At one extreme are the FCC spectrum auctions, which to date have revealed all bids and bidder information and have imposed few restrictions on bids. At the other extreme is an auction that just reports high bids and restricts new bids to be exactly one increment higher.

4. Power Auctions

There are several reasons that explain the increasing interest in electricity procurement through auction mechanisms. First, transparency is important to reassuring parties that the procurement process is being conducted fairly. In this sense, all participants and stakeholders can see the basis for the results. Second, fairness is very important to the extent that all participants should be on an equal footing.

Furthermore, a better auction design that minimizes risks encourages participation. As new and smaller players participate, auction is likely to diversify the base of suppliers. High participation leads to vigorous competition, which leads to minimum procurement costs. At the very end, the minimization of procurement costs translates into lower prices for customers

Auction rules are essential to understanding how aggressively parties will bid, who will win, and how cheaply a contract will be procured (or, in a sale auction, how much money the product will sell for).

Until recently most electricity wholesale markets were structured as uniform, first-price auctions. Generation unit owners would submit bids, either simple supply curves which give each unit's willingness to supply electricity as a function of the market price, or multi-part bids, typically specifying start-up and no-load costs and the willingness to supply as a function of the market price.

In England and Wales, the British regulatory authority (Ofgem) introduced major changes in the electricity trading arrangements introduced in 1990. In the middle of the reforms adopted in March 2001, a discriminatory or `pay-your-bid' auction format was implemented. The main reason was the perceived belief by the regulatory authority that uniform auctions could be more susceptible to strategic manipulation by large traders than discriminatory auctions. Likewise, before its breakdown, the California Power Exchange commissioned a report by top auction experts on the advisability of a switch to a discriminatory auction format, due to the increasing incidence of price spikes (see Kahn et al., 2001).

Discriminatory auctions are not generally superior to uniform auctions. Both types of auction are commonly used in financial and other markets, and there is now a voluminous economic literature devoted to their study. (see Vijay, 2002)

As a rule the comparison between these two auction formats is much more complex in multi-unit settings. There is neither theoretical background nor empirical evidence that would allow us to determine whether discriminatory auctions would perform better than uniform auctions in electricity markets.

Rassenti, Smith and Wilson (2003) suggest that discriminatory auctions may reduce volatility (i.e. price spikes), but at the expense of higher average prices. Wolfram (1999), on the other hand, argues in favor of uniform auctions for electricity.

By the same token, other authors have come to contradictory conclusions. Klemperer (2001, 2002) suggests that discriminatory auctions might be less vulnerable to `implicit

collusion', while Federico and Rahman (2003) find theoretical evidence supporting discriminatory auctions, at least for the polar cases of perfect competition and monopoly. Kahn et al. (2001), on the other hand, reject the idea that switching to a discriminatory auction will result in greater competition or lower prices.

While uniform price auctions give some sellers a unilateral incentive to raise prices, discriminatory auctions also can give incentives to submit high bids. These high bids may cause what is known as the "Winner's Curse", the possibility that the winner pays more than the value. It happens only if bidders do not calculate the value of winning correctly and overbid as a result.

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

Concerning production efficiency, a discriminatory auction may incur some losses as each bidder has to guess the auction clearing price. They might sometimes guess too high and not end up selling while more expensive bidders that make better guesses do. If that occurs too often, there will be some degree of inefficiency in the market. Bidders with high marginal costs may win before those with low marginal costs.

4.1. Utility procurement in New Jersey

Since August 1999, customers in New Jersey have been able to choose their electric supplier. Customers who do not opt for a new supplier or who leave a third party supplier are supplied electricity by their local electric utility through **Basic Generation Service** (**BGS**). Regulators determined that BGS electricity supply would be purchased by the New Jersey utilities through an auction process. The first auction was held in February 2002 to supply $3.8 billion of electricity from August 2002 through July 2003. The

second BGS auction process took place beginning February 2, 2004. In this second auction, New Jersey's four Electric Distribution Companies (EDCs) have purchased New Jersey's BGS electricity supply.

The auction process consisted of two concurrent auctions: one called the hourly energy price or HEP auction for larger customers (about 1700 statewide) for 2,600 MW and one, a general auction for smaller commercial and residential customers, for 15,500 MW. The New Jersey Board of Public Utilities (BPU) decided to split these two customer groups because the BPU felt that large customers are better able to adjust usage to hourly market price fluctuations. The group of 1700 larger customers will have an energy rate based on hourly PJM spot market prices while the smaller customer group will have prices that are fixed for different durations.

The general auction will be a descending clock auction via the Internet. Supply bids will be submitted and prices will decrease each round until supply equals just the amount of load needed. Suppliers will bid on tranches equal to approximately 100 MW of load.

The Auction is a simultaneous, multiple round, descending clock auction via the Internet. In this kind of auction, tranches for all the EDCs are put on tender through the same auction. The auction continues in rounds. In each round, the auction manager announces a charge for each EDC. Bidders bid by supplying the number of tranches that they are willing to serve for each EDC at the charges announced by the Auction Manager. Suppliers will bid on tranches equal to approximately 100 MW of load. If the number of tranches bid is greater than number of tranches needed for an EDC, the charge for that EDC is reduced for the next round. In the next round, bidders are given an opportunity to bid again.

Charges decrease throughout the Auction, starting high and being reduced gradually until supply equals just the amount of load needed. Charges drop off by a decrement, i.e., a given percentage of the previous charge. Bidders holding the final bids when the Auction closes are the winners.

Each EDC will seek tranches for the 10-month and the 34- month term. Additionally, each EDC has established load caps which represent the maximum number of tranches available to any one bidder for a given term.

Table 1 below summarizes the load procured in the 2004 BGS-FP Auction

Table 1. BGS-FP Number and MW-Measure of Tranches

		Number of tranches				
EDC	FP Peak Load Share (MW)	Procured in 2003 (2-year term remaining)	Procured in 2004		Size of tranche (%)	MW-measure
			1-year	3-year		
PSE&G	8615.7	29	28	28	1.18	101.36
JCP&L	5089.3	14	12	15	2.27	115.67
ACECO	2109.0	7	8	7	4.55	95.83
RECO	374.8	1	2	1	25	93.70

The New Jersey Power purchase illustrates some of the difficulties of implementing clock auctions. Suppose bidders demand four kinds of power products, labeled A through D. Suppose that, in some round, demand exceeds. Suppose the auctioneer increases prices for products A and B. It is possible for products A and B become unsubscribed and products C and D become oversubscribed instead. A complex set of rules was implemented to avoid creating unsubscribed products due to switching.

5. Brazilian Experience with Electricity Auctions

Although first-price sealed bid auctions are very common in procurement practice in Brazil, the use of other designs, particularly in power market, is recent. The objective was to create a competitive mechanism to allow power producers to sell their output to distributors and retailers. The design implemented should guarantee publicity, transparency and equal access to third-parties.

The auction format adopted in most electricity energy procurement in Brazil is a variant of the so called "ascending clock auction". The clock points out the current price. In each round, the bidders submit the quantity they are willing to buy at the current price. The clock is increased every time the total quantity bid exceeds the quantity available, in other words, an excess of demand still subsists. The bidding process goes on until the quantity bid is less than the quantity supplied. As a result the good is allocated at the prior price, and is rationed for those that reduced their quantity in the last round.

In the next section we describe in detail which auctions were implemented and its purposes.

5.1. Electricity Procurement Auctions

5.1.1. Objective

The electricity procurement auctions were introduced by law #10,604 which states that after January 1, 2003 Electricity Distribution Companies (EDC) could only contract power purchase agreements (PPA) by means of specific designed auctions regulated by ANEEL.

Buyers can be any EDC or electricity retail company (ERC). These auctions are meant to be sponsored by MAE in order to fulfill EDCs needs in terms of energy balances. Due to legal restrictions power distributors should back up to 95% of their markets by buying PPAs or having power from generating units of their own. These restrictions constitute the main motivation for EDCs to participate in these procurement auctions.

According to the Decree # 4,562 of December 31, 2002 only federal and state electricity generating companies, independent power producers, retailers and EDCs could participate in the electricity procurement auctions as sellers.

The auction is coordinated by the market operator (MAE). MAE enrolls buyers and sellers. It also registers the selling products and announces the opening and closing of the auction. According to

An EDC's load is divided into units called tranche, each representing the same amount of load according to ANEEL's Resolution #246/03 which states that there should be two standard energy tranches which, for the purpose of the auction, are called "products".

Products are energy tranches having 0.5 MW each and distinct characteristics according to the place of delivery or to whether it is intended for base load or peak load use. Products should also identify the buyer, submarket, contract duration[1], tranche type (base or flexible) and delivery date.

The number of tranches to be procured at the Auction and the type of each tranche are provided by EDCs according to scheduled presented by MAE.

5.1.2. Auction Format

EDCs will procure their loads through a Simultaneous Descending Clock Auction. The Clock Auction proceeds in a series of rounds. During the bidding phase of each round, each bidder (seller) must indicate the amount of each product the bidder wishes to serve at the charges announced by the Auction Manager. A "bid" is the number of tranches of each EDC load that a bidder wants to serve.

Each EDC should notify MAE concerning the demanded quantity of each product as a round positive number of tranches and their desired reserve prices for the demanded products prior to the beginning of the auction.

[1] Products must have contract duration of 6, 9 or 12months.

They also have to specify at least one and at most at most five reserve prices for each product. For each reserve price there will be an associated demanded quantity. When the **current price** reaches a value less than or equal to the next reserve price of that product, the demanded quantity correspondent to that reserve price will be added to the demanded quantity valid up to that moment.

For each product, the auction manager should specify a price decrease. Each bidder should choose the product and bid the amount of tranches he wants to sell. A bidder can bid more than once for the same product, as long as he has enough collateral to back the operation. The quantity demanded will increase when the current price reaches a value equal or less than the reserve price. The sum of total tranches associated to a reserve price should be equal to the quantity bidded

After the bidding phase of each round, the Auction Manager reduces the charge for the tranches of an EDC by a decrement if the number of tranches bid by all bidders exceeds the quantity of tranches needed by that EDC. The Auction Manager then announces the new charge for each EDC before bidding in the next round opens. The Auction continues and the charges decrease until, for each EDC, the total number of tranches subscribed falls to the point where it equals the number of tranches needed. When the Auction ends, the bidders holding the tranches at the charges of the final round are the winners, which pay the closing price, i.e., the price charged in the final round.

ANEEL is responsible for approving the Auction process and will be overseeing the Auction. The resulting PPAs should also be registered at ANEEL

Table 2 below summarizes the load procured in Auction

Auction #	Buyer	Qty. demanded (MW)	Qty. awarded (MW)	Average Price (R$)
8th	GCS	200	80	33,93
8th	União Comercializadora	15	0	-
7th	Tradener	20	0	-
5th	CLSFC	15	15	47,23
5th	Enertrade	10	0	-
4th	CENF	9	9	51,53[2]
4th	União Comercializadora	40	0	-
1st	CPFL Brasil	25	0	-
1st	União Comercializadora	50	0	-

5.2. Electricity Surplus auctions

5.2.1. Objective

The objective was to allow for generators and independent power producers that had excess energy of the initial contracts[3] and equivalents to sell it to consumers defined in articles 15 and 16 of Law 9,074 of 07/07/95. According to the law, those are the consumers which have load greater than 3 MW and are free to choose their electricity power provider.

[2] Prices were average between different products: base energy and flexible energy.
[3] Initial contracts are long term bilateral contracts with regulated prices and quantities which are reduced at a rate of 25% per annum after 2003. These contracts were devised for the transition period to a competitive environment.

Most initial contracts were established with state owned generating companies. As the initial contracts were reduced, these companies needed to sign other PPA in order to assure their cash flow. Otherwise, the total amount of energy reduced from the contracts would be settled in the spot market.[4]

5.2.2. Auction Format

GENCOs sell their energy through a series of round in a Simultaneous Descending Clock Auction. During the bidding phase of each round, each qualified consumer must indicate the amount of each product she wishes to buy at the charges announced by the Auction Manager. A "bid" is the number of tranches offered by generating companies that a qualified consumer wants to buy.

Each GENCO should notify MAE concerning the supplied quantity of each product as a round positive number of tranches and their desired reserve prices for the supplied products prior to the beginning of the auction.

They also have to specify at least one and at most at most five reserve prices for each product. For each reserve price there will be an associated supplied quantity. When the **current price** reach a value less than or equal to the next reserve price of that product, the supplied quantity correspondent to that reserve price will be subtracted of the supplied quantity valid up to that moment.

For each product, the auction manager should specify a price decrease. Each bidder should choose the product and bid the amount of tranches he wants to buy. A bidder can bid more than once for the same product, as long as he has enough collateral to back the operation. The quantity supplied will decrease when the current price reaches a value

[4] Because in wet years the spot price is likely to be low, the lack of new contracts for the excess energy of the initial contracts would have a great impact over the state owned generating companies cash flow.

equal or less than the reserve price. The sum of total tranches associated to a reserve price should be equal to the quantity bidded.

After the bidding phase of a round, the Auction Manager reduces the charge for the tranches by a decrement if the number of tranches bid by all bidders does exceed the number of tranches supplied by GENCOs. The Auction Manager then announces the new charge for each product before bidding in the next round opens. The Auction continues and the charges decrease until, for each product, the total number of tranches supplied falls to the point where it equals the number of tranches demanded. When the Auction ends, the bidders holding the tranches at the charges of the final round are the winners.

Table 3 below summarizes the load procured in Auction

Contract Duration	Total Supply (MW)	Total Trade (MW)	Total Trade/ Total Supply
6 months	1,114.70	6.40	0.57%
1 year	2,017.00	108.20	5.36%
2 years	2,622.00	797.60	30.42%

5.3. Electricity Power Auctions

5.3.1. Objective

The objective of the first electricity power auctions finished in September 19, 2002 was to deliver to EDC's and electricity retailers energy tranches supplied by federal and state power generators. Private generators were allowed to take part in such auctions, in order to guarantee equal access rights.

MAE was responsible for the implementation and execution of the entire process. The electricity power auctions were introduced by law #10,438 of 2002 which states that

portion of the electric energy traded by generation utilities under federal ownership should be transacted by means of public auctions.

5.3.2. Auction Format

The format used was a Simultaneous Ascending Clock Auction. Federal and regional generating companies were in the seller side. Distributors and retailer were on the bidding side.

In the same way as in the surplus auction, each GENCO should notify MAE about the supplied quantity of tranches for each product. Moreover they should specify their desired reserve prices for the supplied products before the auction starts.

GENCOs may specify from one up to five reserve prices for each product. There will be an associated supplied quantity for each reserve price. When the **current price** reach a value less than or equal to the next reserve price of that product, the supplied quantity correspondent to that reserve price will be added of the supplied quantity valid up to that moment.

For each product, the auction manager should specify a price increase. Each bidder should choose the product and bid the amount of tranches he wants to buy. A bidder can bid more than once for the same product. The quantity supplied will increase when the current price reaches a value equal or greater than the reserve price. The sum of total tranches associated to a reserve price should be equal to the quantity bidded.

During the bidding phase of each round each bidder must indicate the amount of each product she wishes to buy at the charges announced by the Auction Manager. After the bidding phase of a round, the Auction Manager increase the charge for the tranches by an increment if the number of tranches bid by all bidders surpass the number of tranches supplied by GENCOs. The Auction Manager then announces the new charge for each product before bidding in the next round opens. The Auction continues and the charges

tick up until, for each product, the total number of tranches demanded falls to the point where it becomes equal or less than the number of tranches supplied. When the Auction ends, the bidders holding the tranches at the charges of the final round are the winners.

6. Recommendations

The auction design adopted for electricity procurement in Brazil is particularly attractive because it is operationally simple to implement. For instance, buyers only need to bid a single quantity in each round. In addition, it helps to prevent collusion, while generating a single market-clearing price. Aside from that, the possibilities of undesirable bid signaling are extremely reduced, since only the total quantity bid shows up.

However, as shown in (Ausubel and Cramton 1996), this auction design does not produce efficient outcomes. Bidders have an incentive to shade their bids in order to limit price increase.

According to Cramton (Cramton, 1998):

"Large bidders tend to shade more than small bidders, since a particular price effect has a bigger impact on profits for a large bidder. This differential shading leads to an inefficient outcome. Large bidders win too little and small bidders win too much."

A possible solution would be to implement an alternative ascending clock auction proposed by Ausubel (Ausubel, 1997). This design achieves efficiency and it very simple to implement.

Ausubel deem an item as "clinched" when it becomes mathematically impossible for the bidder not to win the item (that is, excess demand would fall to zero before the bidder could reduce its demand to zero). In usual ascending clock auctions all items are sold at the clearing price, whereas in Ausubel auction "clinched" items are sold at the amount on the clock at the time of clinching.

7. Conclusions

This paper has laid out some of the basic features of auction as an effective mechanism capable of producing efficient outcomes in the electricity market and commented on the extent to which the auction formats adopted for the Brazilian Electricity Sector will promote them. Economists have identified two basic characteristics of efficient markets: production should take place at the lowest possible cost and prices should be equal to the marginal cost of production.

In choosing auction formats, a variety of considerations affects efficiency. The goods should be awarded to those who value them the most. Particularly, in the electricity sector, it is important to achieve the right allocation in the first time, due to the high costs involved in the negotiation of power purchase agreements and legal restrictions to reselling.

There are potential possibilities to consider which may warrant additional topics for further study on electric power auctions. Auctions are also being used in the contracting of generation capacity entitlements and ancillary services. Questions about efficiency and market power mitigation also need to be addressed in these applications.

The importance of auction design lies in the fact that, without careful consideration for designs whose rules are complete, consistent, and without ambiguity, energy markets will be less efficient and the objectives of the auction and the best intents of regulators will not be fully realized.

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