PILOT AUCTION FACILITY FOR METHANE AND CLIMATE CHANGE MITIGATION: RELEVANT ENVIRONMENTAL AUCTIONS

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14 July 2014

POWER AUCTIONS

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1. Introduction

The proposed Pilot Auction Facility for Methane and Climate Change Mitigation (PAF) is a new and innovative way to encourage environmental projects in the developing world. When designing any auction, it is often helpful to identify and review previous auctions in the same sector.

Auctions have been used in environmental settings for many years. In 1993, the US EPA ran the first auction for SO_2 allowances. Since then auctions have been a popular way of allocating allowances for various cap and trade programs. Unlike free allocations, these auctions provide a competitive way to allocate credits and do not have the appearance of rewarding polluters.

While almost all of these auctions occurred in the developed world and were for products that are fairly different from the put options that the PAF is considering for auction, there are important lessons that can be learned about how the methane abatement program may work in practice. The past auctions provide insights into the demand for environmental assets and help to identify pitfalls that the PAF can avoid. At the same time, it is important to recognize that the environmental sector has tended not to have been the most sophisticated adopter of auction methodologies, and so one should not over-rely on the sector's experience.

2. Carbon Auctions

The most common applications of auctions to the environmental setting have been for carbon allowances. While many carbon allowances were initially “grandfathered” (allocated for free based on previous emissions history), most of the major markets are gradually switching over to allocating these allowances through auctions. (Cramton and Kerr, 2002, identify many advantages of using an auction.) The first auction reviewed in this section was a one-off auction designed specifically to procure emission reductions, similar in spirit to the PAF. The remaining auctions reviewed in this section are periodic auctions for the sale of carbon allowances.

2.1. UK Emission Trading Scheme Auction

In March 2002, the UK government ran the world’s first auction for greenhouse gas emissions reductions, and also launched the world’s first economy-wide trading scheme to meet its Kyoto protocol target. Organizations bid reductions in greenhouse gas emissions that they were prepared to make in return for payments from the government, and 34 bidders representing close to 200 separate organizations (mostly large companies, but including universities, etc.) shared £215 million ($305 million) to reduce annual emissions by more than 4 million tons of CO_2, a substantial contribution to the reductions the UK needs to make to meet its Kyoto Protocol Commitment. Trading in these emission reductions in the Emissions Trading Scheme (ETS) began a month later. The auction was also innovative in being run over the internet—thought to be a first for the UK government.

This reverse auction (for procuring reductions) used a descending clock auction format with intra-round bidding. In this format, bidders name the price and the size of quantity reductions, as the price falls in a sequence of rounds. As such, a continuous aggregate supply curve is revealed in the auction to the point where it crosses with the aggregate demand curve, which is formed from the budget limit of £215 million. All quantity bid at prices below the clearing price was paid the clearing price. The quantity bid at the clearing price was rationed pro-rata to achieve the budget limit.

The auction rules included the possibility to reduce the budget after the first round of bidding as a safeguard in the event of insufficient competition. The UK government decided not to exercise this option.

2.2. Carbon Markets

One of the largest markets for environmental assets is the market for carbon allowances. In these markets, the government sets a limit on the amount of emissions that firms can produce in a given period. Firms are allocated carbon credits, which they can then trade with other firms. At the end of the period, firms need to give the government carbon credits equal to their total emissions. Many of these markets initially granted free allocations, giving allowances to firms based on historical emissions levels, and have gradually switched to using auctions to allocate allowances. While overall, these auctions have not performed particularly well, this is mostly due to features of the market that are unrelated to the auction design.

2.2.1. European Union

The EU runs sealed-bid uniform-price auctions. While in Phase 1 and 2 (2005-2012) of the EU's emission trading scheme, the vast majority of allowances were allocated through free allocation, in Phase 3 the EU has begun dramatically increasing the share of allowances that are allocated through auctions. The EU currently auctions over 40% of all carbon allowances and hopes to increase this share significantly by 2020. While most countries use a common platform to run these auctions, Germany, Poland and the UK use their own platforms for their carbon auctions.

2.2.1.1. The German Platform

EU Allowances (EUAs) are auctioned weekly on the German Platform. In the first quarter of 2014, each auction had a supply of 4.6 million EUAs. All the auctions on the German platform use the sealed-bid uniform-price format. Starting in March, the supply was reduced to about 2.35 million EUAs per auction. 22% of the total volume of auctioned EUAs was auctioned on the German platform.

2.2.1.2. The UK Platform

The UK was the first EU member state to hold auctions, and auctioned 10% of allowances in phase 2. In phase 3, 50% of allowances are being auctioned. All of these auctions use the sealed-bid uniform-price format. The UK currently runs auctions every other week. About 4.6 million EUAs were sold in each auction in the beginning of 2014, before the supply was reduced to 2.5 million in March.

2.2.2. RGGI

The Regional Greenhouse Gas Initiative (RGGI) is a cooperative effort among the States of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont to cap and reduce power sector carbon dioxide emissions, and is the first mandatory, market-based CO_2 emissions reduction program in the United States. RGGI was one of the earliest adopters of auctions as a way to allocate carbon credits. Since 2009, RGGI has run 24 sealed-bid uniform-price auctions, which account for almost all of the carbon credits of the participating states.

2.2.3. California

The State of California started running auctions to allocate carbon credits in November 2012. Prior to this, almost all of their allowances were allocated for free based on previous emissions requirements. There have been seven sealed-bid uniform-price auctions for carbon credits so far in California.

2.2.4. Quebec

The Province of Quebec has run three sealed-bid uniform-price auctions for carbon credits. This market is in the process of linking with the market in California, meaning that carbon credits purchased in Quebec will be valid for California's emission requirements and vice-versa.

2.2.5. Proposed Australian Auctions

The Australian Clean Energy Regulator planned to embark on an ambitious program of carbon emission reductions. The intention had been to use a fixed-price carbon pricing mechanism for the initial three years of the program, and then to transition to auctions. Unlike the US and EU programs, the Australian regulator published plans to utilize an ascending clock auction. The regulator planned to conduct eight auctions each year (three auctions for vintages one, two and three years in the future, and five auctions for current vintages). The emission reduction plans have been put on hold because of a change in government.

2.3. Auction Format

All of these carbon auctions have used either sealed-bid uniform-price auctions or dynamic clock auctions. In the sealed-bid forward auction format, each bidder submits one bid which can be interpreted as a demand curve; each bid consists of a set of quantity-price pairs indicating how many allowances the bidder is willing to buy at each price. The auctioneer constructs the aggregate demand curve and determines the market-clearing price. Bidders win the quantities that they demanded at the market-clearing price, and they are charged the market-clearing price. In the RGGI auctions, if the clearing price is too high, RGGI can add additional carbon credits from the Cost Containment Reserve (CCR) to the supply in order to lower the clearing price below a price set by RGGI.

In the ascending clock forward auction format, the auction consists of a series of rounds. In each round, the auctioneer announces a price and bidders respond with quantities. The auctioneer increases the price in successive rounds until demand equals supply. As in the sealed-bid format, bidders win the quantities that they demanded at the market-clearing price, and they are charged the market-clearing price.

In most of these auctions, *current vintages* (credits for the current compliance period) are auctioned together with future vintages, and bidders are able to bid on both. The demand for future vintages is generally much lower than the demand for current vintages. For instance, in two RGGI auctions (auctions 13 and 14), the demand for future vintages was zero.

2.4. Experimental Work

Before beginning its auctions, RGGI ran an experiment comparing sealed-bid and clock auctions (Holt *et al.* 2007). These experiments were run at the University of Virginia. The participants were undergraduate students. The students were asked to buy and trade allowances; at the end of the auction, they were paid (in dollars) depending on their performance. In these experiments, the ascending-clock format experienced greater collusion and did not yield any greater price discovery than the sealed-bid format. Because of this result, RGGI decided to use the sealed-bid uniform-price auction format.

The RGGI experiments made a number of non-standard design choices that we believe produced these results. First, in the standard ascending clock auctions used for electricity and spectrum, aggregate demand information is revealed to bidders after each round. However, in the RGGI experiments, no information was revealed to bidders after each round (other than that the auction had not yet closed). By holding back demand information, the experiments undermined the main purpose of using a clock auction—and the potential for enhanced price discovery during the clock auction was severely hindered. Second, bidders were allowed to chat with each other during the auction through use of an Instant Messaging system that was provided to them by the auctioneer. Since auctioneers generally discourage, rather than facilitate collusion (and bid-rigging is, for example, illegal under US law), this does not accurately correspond to collusion in a real auction environment and may have contributed to the slightly poorer performance of the dynamic auction formats. For these reasons, we do not find these results particularly persuasive. Indeed, there are other published experimental papers (for instance Porter *et al.*, 2009) which show that clock auctions tend to outperform sealed-bid formats.

Australia also conducted experiments to determine the most appropriate auction format. While the sealed-bid and clock formats performed similarly in terms of efficiency, revenues and bidder profits, the final price in the ascending clock auction (with aggregate demand revealed after each round) proved to be less volatile than in the sealed-bid auction. In addition, the Australian experiments did not find any improvement in efficiency from auctioning multiple vintages simultaneously. Partly on the basis of these results, Australia decided to use a sequence of ascending clock auctions, one vintage at a time.

2.5. Auction Results

2.5.1. European Union

The EU has run a large number of carbon auctions for allowances in the EU-ETS. Starting in phase 2 (2008–2012) many member states ran auctions, and there has been a significant push in phase 3 (2013–2022) to increase the proportion of allowances that are being sold through auctions, rather than grandfathered. Unlike the other markets discussed here, the EU runs multiple auctions in the same month. For instance, in March 2014, they ran 13 auctions to raise revenue for 24 member states. In recent auctions, the clearing price tended to be €5 – €7, that is, very close to the price of carbon on the secondary market. Almost all recent auctions cleared within €0.07 of the secondary market price. This price, which is significantly lower than the early prices for European Union Allowances (EUAs), reflects the weak carbon market and the large supply of credits that are available. The early auctions also cleared close to the market price, which at that time was significantly higher.

2.5.1.1. German Platform

In the first quarter of 2014, 4,600,000 EUAs were sold in each auction, and 50,704,000 EUAs were sold in total, at an average price of about €5.91. The auctions generally ended at prices near the market price, fluctuating between 77 and 99 percent of the market price. About 20 bidders participated in this auction, and on average 13 bidders were successful (won something).

2.5.1.2. UK Platform

Recent auctions in the UK tend to clear at the market price of EUAs. In 2014, the clearing price was between €6.80 and €4.88. There are generally between 15 and 20 bidders participating in each auction, and 10-12 bidders usually win EUAs.

2.5.2. RGGI

While the initial set of RGGI auctions did reasonably well, by September of 2010 they began terminating at the reserve price and not allocating the entire supply. In Auction 13 for instance, only about 7 million of the 42 million 2009–2011 allowances put up for auction were sold, and none of the 1 million 2012–2014 allowances were sold. This auction cleared at the reserve price of $1.89 and raised $14,150,430, which is significantly lower than the amount raised in previous auctions. Auctions 9–19 (Sept. 2010–March 2013) all cleared at roughly the reserve price, and many of them ended with a significant number of credits left unsupplied. The demand for future vintages dried up even sooner: starting in September of 2009 the auctions for future vintages were finishing at their reserve price and not allocating the entire supply. After readjusting the supply in 2013, the auction performance has improved dramatically, indicating that many of these problems were due to the supply being too high relative to the unexpectedly low demand.

2.5.3. California

California sets its reserve price significantly higher than RGGI's reserve price (at about $10). These auctions tend to end at or just a bit above the reserve price, and for the most part have allocated all of the supply of current vintages. Demand for future vintages tends to be much lower than demand for current vintages, even relative to the lower supply of future vintages. Overall, California's markets seem to have worked better than the other markets discussed here. The price of carbon has been relatively stable, and the auctions that undersell do not undersell by very much.

2.5.4. Quebec

There have been three auctions for carbon credits run by the government of Quebec. All of these auctions have ended at the reserve price, which is around $11. The first auction, run in December 2013, ended with over half the supply unallocated. The performance of these auctions will probably improve after the Quebec market is linked with California.

2.6. Carbon Trading

An important aspect, both of the allowances in these carbon markets and of the options that the PAF is proposing to sell, is their tradability. Similar to many of the issues in these carbon auctions, many of the problems in these carbon markets are due to the supply being too high.

The European Union's carbon market has been extremely volatile. Demand for the Kyoto credits (CERs and ERUs) is very low at the moment, as is demand for European Union Allowances. The CER price for instance, was about €0.14 in June of 2014. Lower demand than was projected and high supply due to unambitious caps set by the participating nations has led to the low price in this market.

The American markets seem to have stabilized to some extent. The California market has performed relatively well. The price has been relatively flat at around $12. RGGI had a difficult start: the cap was set substantially too high, given the recession and the increased use of natural gas. But the market now seems to be recovering. In fact demand was high enough in the most recent auction that allowances from the CCR were added for the first time. In 2013, the cap was lowered, seeming to help the market recover.

2.7. Lessons Learned

The main problem in these auctions seems to have been that the supply of allowances is set too high relative to the demand, which is not an auction design issue. This causes the auction to terminate at the reserve price. This is a concern, since then most of the advantages of an auction are lost. There is no competitive price discovery process; instead the clearing price is basically set by the regulator.

Fortunately, this problem can be avoided by setting the initial supply at a sufficiently low quantity. This is much easier in our context than in the carbon allowances context, since there is no fixed quantity of options that must be allocated at any moment in time. It is much easier in our context to reduce the supply close to the time of the auction if demand does not materialize.

Setting an appropriate starting price is also important to make sure that the entire supply gets allocated and to allow for some degree of price discovery. The difference between the initial premium and strike price should overestimate the costs of these methane offset projects a bit.

By bundling options for earlier and later periods together, the risk is reduced of leaving the later period's product unallocated. However, there is still the risk that the options for later time periods will not be exercised and will not lead to emission reductions.

We believe that the sealed-bid format is not particularly desirable for these auctions. Since there is no dynamic learning during the auction, it does not lead to much price discovery. This makes the auction format more difficult, especially in the first round, when bidders do not have a good sense of how much the options are worth. Cramton (2007) and Betz et al. (2010) discuss in more detail why a clock auction would be a superior format in this environment.

On the other hand, the existence of an active secondary market reduces the need to use the auctions for price discovery. With a sufficiently active secondary market, we would expect any of these auction formats to end at roughly the market price. In fact, the main purpose of many of these auctions seems to be to give governments a low-transaction-cost way to sell credits at the existing market price (Commission of European Communities, 2010). In the early auctions, after big changes had occurred in the market (for instance, after the cap had been lowered by RGGI), an auction that allows for good price discovery is important. The relatively high fluctuations of the clearing price (prices from auctions 19–24 fluctuated between $2.50 and the ceiling of $4) following the cap being lowered in 2013 is evidence that the sealed-bid format is not providing the best price discovery. Since the PAF is proposing to auction a new type of asset, a good auction format is important for facilitating early price discovery.

3. Other Auctions

3.1. Renewable Energy Auctions

In the context of renewable energy, auctions have been used to fund solar energy projects and to sell offshore wind rights.

3.1.1. New Jersey SREC Financing Program

These New Jersey auctions are intended to select the cheapest solar projects and provide a funding guarantee for solar projects in order to reduce concerns about the volatility of the secondary market for solar credits. Since 2009, New Jersey has been providing funding for the installation of solar-electric generation systems through Solar Renewable Energy Certificates (SREC). This was an attempt to correct a previous program which had failed to provide any price guarantees for SRECs (see Hart 2010 for details).

In every auction, each bidder/project implementer submits a bid for how much he/she is willing to sell SRECs to the state. The auctioneer then awards long-term contracts to the set of bidders who offered the lowest prices. This program aims to provide assurances that firms undertaking new solar projects will be able to collect reasonable revenues from the projects. These are pay as bid auctions. The average price per SREC is about $225.56.

These auctions seem to have allowed the market to recover; this is promising for the PAF, which operates on a similar principle. The auctions have grown in popularity. While in 2010, the bids received were approximately for as many contracts as the supply in the auction, by 2012 New Jersey was received almost 4 times more bids than the available supply. The pay as bid format leads to relatively high dispersion among final prices, with some bidders receiving prices that are about $100 below the average.

3.1.2. Jawaharlal Nehru National Solar Mission

To stimulate the solar energy market, India launched the Jawaharlal Nehru National Solar Mission (JNN Solar Mission) in 2010. Similarly to the New Jersey program, bidders submit proposals for projects, and the lowest cost projects that generate the requested amount of power are selected. The selected projects are offered long term power purchase agreements and feed in tariffs. The auction uses caps on the size of projects with the goal of opening the market to smaller firms. However, some firms won a large percentage of the contracts by forming shell companies or fake projects (Ghosh et al. 2012). This is evidence of the danger of strong preferential treatment in a setting where the auctioneer does not know whether certain bidders/companies are associated with other bidders/companies that participate in the auction. In such a setting, while it may be desirable to provide preferential treatment, the advantage from being a preferred bidder should not be strong enough to encourage the larger bidders to find a way to appear as preferred bidders (e.g., by forming shell companies or fake projects).

3.1.3. Wind Power Auctions for the Bureau of Ocean Energy Management (BOEM)

Power Auctions LLC designed and ran two auctions for offshore wind rights on behalf of BOEM and the Department of Energy. These auctions were ascending clock auctions, one for a single product (a tract off the coast of Virginia) and the other for multiple products (tracts off the coast of Massachusetts and Rhode Island). Bidders were charged the second highest price[1]. Both these auctions performed very well. While there were only a few bidders (3 in the auction for multiple tracts and 2 in the auction for a single tract), the auctions had many rounds (4 for the single unit and 10 for the multiple unit auction) and ended with fairly high prices. Going in to the auction, no one had a great sense of what these tracts should have been priced at, and we believe that the auction enabled a lot of price discovery.

3.2. SO_2

In 1993, the EPA began auctioning a small number of allowances for SO_2 emissions, which are one of the leading causes of acid rain (Ellerman, 2000). These auctions are two-sided auctions: firms with extra allowances submit prices at which they are willing to sell, while firms needing allowances submit prices at which they are willing to buy. Then, the highest buyer is matched with the lowest seller; the second highest buyer is matched with the second lowest seller, etc. Each buyer then pays its bid to the seller.

This auction has a number of serious incentive issues. The presence of active sellers, as well as buyers, makes this fundamentally different from the standard pay-as-bid auction. There are strong incentives for sellers to understate their price to try to get matched with the highest value buyer, since that buyer will pay them the most. The buyers have incentives to understate their demands in order to try to guess the market-clearing price. Bidding strategies in this auction format can be very complex, since the bids that bidders want to submit do not relate that much to their own internal valuations, but instead relate quite a bit to the anticipated bids of other bidders in the auction. Initial bids did end up seeming too low, but the peculiarity of this auction format ended up being largely irrelevant, since most trade occurred on the private market.

3.2.1. Experiments

Cason and Plott (1996) compare this auction to a uniform-price call auction (a two-sided version of a uniform-price sealed-bid auction) in the laboratory[2] and find that the uniform-price format outperforms the two-sided pay-as-bid format with respect to most relevant criteria.

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[1] In an auction for multiple products, the second price is the smallest price that the winning bidder can pay so that no other combination of bidders would have won those products. While there are theoretical reasons that favor this pricing rule, we do not recommend it for the PAF, because of the additional complexity it would create. Another disadvantage of the second price pricing rule in the PAF application is that it could result in different prices for different bidders.

[2] These experiments were done at the University of Southern California. The participants/subjects were junior and senior undergraduates. Each subject was paid between $14 and $50, with a mean of $33.

Specifically, the uniform-price format is more efficient, provides better price information, responds to changes in market conditions better and induces more truthful revelation. This provides further evidence for the unsuitability of the EPA's SO_2 design in this (or any) context.

3.2.2. Private Market

As mentioned before, the peculiarity of this auction was quickly corrected by the flexible private market that the EPA's regulations had established. By 1997, almost all trade occurred on the private market (about 98%), and the relatively small volume in the auctions cleared roughly at the market price, suggesting that almost all of the price discovery was now done by the private market and not by the auction (Ellerman *et al*., 2000). This suggests that a robust private market will eventually mitigate some of the bad design choices made in an auction. However, this does not imply that the market would not have benefitted from a well-designed auction, which perhaps would have allowed the market to settle on the "correct" price much sooner.

3.2.3. Implications

This is evidence of the importance of choosing auction formats that are simple and encourage truthful bidding. The strange format of this auction created strong incentives for bidders to concoct complicated bidding strategies, instead of bidding sincerely. This leads to an inefficient outcome and reduces price discovery, running counter to the main motivations for running an auction like this.

3.3. NOx

In 2004, as part of Virginia's emission reduction plan, the State of Virginia ran an auction for nitrogen oxide (NOx) allowances. This auction was a clock auction that sold 3,710 allowances for over $10.5 million. This auction cleared about 5 – 7% above the market price, which was believed to be an indication that the market price was too low.

3.3.1. Experiments

Experimental tests (Porter *et al.*, 2009) compared the clock and the sealed-bid formats in this environment. These tests suggested that a clock auction would raise between 84.9% and 94.2% of the total revenue share for the state, while a sealed-bid auction would collect only 65.2%. These results suggest that a clock auction may be the right design for these environments. The results are very different from the RGGI experiments' comparison of the two formats, probably due at least in part to the more standard design of the clock auction tested here.

4. Summary and Conclusions

Previous auctions for environmental assets have made a few mistakes that have led to undersell and to relatively low revenues. Large supply compared to low demand, high reserve prices and the sealed-bid format all lead to the poor performance of auctions for carbon credits.

Table 1 – Summary of Environmental Auctions

Organization	Type of asset	Format	Pricing	Summary
DEFRA (UK)	Emission reduction incentives (UK ETS)	Descending clock	Uniform-price	Spent entire allotted budget of £215 million on purchasing emission reductions.
RGGI (US)	Carbon Allowances	Sealed-Bid	Uniform-price	Have allocated most allowances through auctions since the beginning. Prices have been low and many auctions have ended with significant undersell.
European Union	Carbon Allowances	Sealed-Bid	Uniform-price	Recently began running many auctions. There is an active secondary market; and these auctions have cleared at the market price.
California (US)	Carbon Allowances	Sealed-Bid	Uniform-price	Ran 7 auctions, all of which cleared at about the current market price (about $12).
Quebec (Canada)	Carbon Allowances	Sealed-Bid	Uniform	Ran 3 auctions. Significant undersell, especially in the first auction.
Clean Air Regulator (Australia)	Carbon Allowances	Ascending clock	Uniform-price	Government fell; no auctions.
EPA (US)	SO_2 Allowances	Double Auction	Pay-as-bid	Prices varied wildly in early auctions, and in general seemed to be too low. The secondary market was

				eventually able to compensate for this.
Virginia (US)	NOx	Ascending clock	Uniform-price (equal to final clock price)	Ran a reasonably successful clock auction. Clearing price was a bit above the market price.
India	Solar and other renewable energy sources	Sealed Bid	Pay-as-bid	Reasonably competitive auction. Caps on quantity won proved to be somewhat ineffective as large bidders were able to win quantities that exceeded the limits
New Jersey	Solar Energy	Sealed Bid	Pay-as-bid	Auctions have performed well with participation increasing dramatically over the course of the program
BOEM	Wind Power	Ascending Clock	Second Price	Prices were high and the auction seemed to be reasonably competitive.

Many of the problems with auctions for carbon allowances have simply been due to the supply being too large. This may not be a problem for the pay-for-performance auction facility of the World Bank, since the asset being auctioned is different. In fact, a reasonably large supply is important in the PAF's auctions, in order to ensure participation, but should not be so large that supply exceeds demand at the reserve price.

We suspect that guaranteeing a sufficiently high strike price and low starting price will be enough for the pay-for-performance facility to mitigate many of the problems that carbon markets have experienced. Provided that there is sufficient participation in the auction, It seems likely that an auction ending at the reserve price with significant undersell can be avoided.

The EPA's SO_2 auctions support the strong desirability of an auction format with a simple bidding strategy. A complex auction format can have unintended consequences on bidders incentives, which can lead to an inefficient final allocation and hinder price discovery.

Many of the issues with previous environmental auctions can be avoided here. A standard auction design coupled with a reasonable strike price/premium for the asset should be enough to mitigate most of these problems.

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