Review of Colombian Auctions for Firm Energy[*]

by

David Harbord[+]

&

Marco Pagnozzi[++]

25 November 2008

1. Introduction

In 2006 the Colombian Comisión de Regulación de Energía y Gas (CREG) introduced a new regulatory scheme to ensure the reliability of the long-term supply of electric energy in Colombia. The scheme allocates Firm Energy Obligations (OEFs) to new and existing generating plant in order to guarantee a sufficient long-run supply of firm energy at prices determined in competitive auctions. Firm Energy Obligations commit generating companies to supplying energy to the market at a fixed price during periods of scarcity. The OEFs needed to cover predicted long-run demand are auctioned: a generator which is allocated an OEF in an auction receives a fixed annual 'option fee' for each capacity unit covered by the OEF, and is committed to delivering energy up to a specified quantity when the energy spot price is higher than a pre-determined "Scarcity Price." Generators supplying energy under an OEF are paid the Scarcity Price for

---

* This report was commissioned by the Colombian Comisión de Regulación de Energía y Gas. We thank Javier Diaz, Camilo Torres and Omar Pesca for extremely helpful discussions, as well as the energy company representatives we met with in Bogota. The views expressed here are the authors' alone.

+ Market Analysis Ltd, 66 Observatory Street, Oxford OX2 6EP, UK (e-mail: dharbord@market-analysis.co.uk).

++ Department of Economics, Università di Napoli Federico II, Via Cintia (Monte S. Angelo), 80126 Napoli, Italy (e-mail: pagnozzi@unina.it).

the amounts of energy supplied up to their committed quantities, and receive the spot price on any additional quantities.

The first OEF auctions were held in May and June 2008 and allocated OEFs for periods of up to twenty years beginning in December 2012. As a result some 9,000 GWh per year of OEFs were allocated to new resources, along with 62,860 GWh per year allocated to existing generating plant at an auction-determined "option" price of $13.998/MWh. Existing generating plant will receive the option fee for a single year beginning December 2012, while new resources are guaranteed the fee for up to twenty years.[1] Subsequent auctions will be held whenever the CREG estimates that the demand for energy in future years cannot be covered during scarcity periods by the energy production of existing generation resources and any planned new resources that will enter into operation. To quote the CREG, "*this new scheme aims to ensure the reliability in the supply of energy in the long-run at efficient prices*."

As has been frequently pointed out, most industries do not need a separate capacity market to achieve efficient long-run investments. Rather, a competitive market for the primary good is sufficient. The balance of supply and demand in the spot market determines a market-clearing price, which in turn determines the profitability of capacity in the short run. In the longer run, capacity enters until expected short-run profit is equal to the marginal capacity costs. So why the need for an organized forward market for capacity in the electricity industry?

Some authors point to unique features of electricity as a commodity (e.g. Creti and Fabra 2007).[2] Others emphasize the role of long-term forward or option contracts in mitigating the effects of market power in the spot market, due to the near-contestability of forward markets where price is determined by the cost of new entry (Chao and Wilson 2004).[3] Chao and Wilson (2004), for instance, write:

---

1 Although existing power plants will continue to receive this price in each subsequent year unless another auction is held.

2 A. Creti and N. Fabra (2007) "Supply security and short-run capacity markets for electricity," Energy Economics, Volume 29, Issue 2, March, pp. 259-276.

3 H. Chao and R. Wilson (2004) "Resource Adequacy and Market Power Mitigation via Option Contracts," EPRI, Palo Alto, CA.

"All long-term contracts take advantage of the mutual interests of utilities and suppliers in insuring each other against subsequent price variations. They can also ensure adequate supplies of energy and reserve capacity. Long-term contracting transfers utilities' purchases from spot markets to forward markets where the elasticity of supply is greater. Because the longer time frame enables investments in capacity, forward markets are more contestable and thus prevent incumbents from inflating their bids above the long-run incremental cost of capacity expansion." (p. 4)

Thus:

"Option contracts are negotiated in forward markets that are more contestable than spot markets – because long-term contracting enables financing and construction of new generation assets. And they mitigate market power in spot markets." (p. 17)

Cramton and Stoft (2005) emphasize market failures.[4] In particular, the absence of widespread demand-side participation in electricity spot markets prevents consumers' willingness to pay for capacity, or "the value of lost load", from setting price during periods when supply is scarce. In addition, imperfectly competitive spot markets mean that suppliers have substantial market power, especially during peak demand periods or periods of scarcity.

While the issue of whether competitive electricity markets could provide for efficient capacity investments without regulatory or government intervention remains controversial, and has yet to be studied in sufficient detail,[5] we will assume for the purposes of this project that an organized forward market for firm energy is desirable, both for achieving long-run supply security, and for mitigating

4 P. Cramton and S. Stoft (2005) "A Capacity Market that Makes Sense," Electricity Journal, 18, 43-54, August/September.

5 For opposing views see P. Joskow (2008) "Capacity Payments in Imperfect Electricity Markets: Need and Design," Utilities Policy, 16:1590170; and F. Wolak (2004) "What's Wrong with Capacity Markets?" mimeo, Stanford University. For more formal work on the issue see: N. Fabra, N.H. von der Fehr and M. Frutos (2008) "Investment Incentives and Auction Design in Electricity Markets," CEPR Discussion Paper no. 6626, January; and N.H. von der Fehr and D. Harbord (1998) "Capacity Investment and Competition in Decentralized Electricity Markets," Memorandum No. 5/98, Department of Economics, University of Oslo.

the effects of market power, and hence comment only upon the specifics of the auction design and its implementation.

The purpose of this report is to provide a detailed analysis of the performance of the OEF auctions held in May and June 2008 and to make any recommendations for their improvement that seem desirable. In particular we have been asked to consider:

- the information provided to participants both before and during the auctions;
- any other aspects of the auction designs relevant to auction performance

and to suggest any changes which may result in the improved performance of future auctions.

In summary form, our main conclusions and recommendations are:

1. More consideration should be given to the types of common value uncertainty faced by bidders in the auctions, and whether holding a descending-clock auction (DCA) is justified. The main purpose of a descending-clock auction is "price discovery", i.e. to allow agents to revise their reserve prices in light of the information revealed by the bidding behavior of other agents during the auction. However, all of the auction participants we spoke with reported that their reserve prices did not (<u>and would not</u>) change during the auction. This may be due to the particular types of uncertainty faced by the bidders, as discussed further below. Given this, different auction formats, such as sealed-bid auctions, should be considered.

2. The combination of lumpy capacity bids with the auction information rules (i.e. revealing excess supply to bidders during the DCA) makes it more likely that when one or more large bidders become pivotal, they will end the auction at prices exceeding the competitive market-clearing level. The "lumpiness" of offers tends to reduce the cost of reducing supply in order to obtain a higher price. A re-evaluation of the auction information rules is therefore recommended if further descending-clock auctions are to be held.

3. In the GPPS auction, the quantity offers for different years by some of the

participants resulted in there being no competition, and has likely led to there being an excess supply of firm energy available in the market for a number of years. Some fairly straightforward adjustments to the auction rules will help to prevent this in future, and likely lead to more competitive auctions taking place.

4. It has been recognized in other contexts that, in forward electricity markets, "*the planning period is necessary for vigorous contestability. It is important that the market not favor only the quickest plants to build.*"[6] In the case of Colombia, where large hydro projects require longer planning periods than thermal plant, the DCA attracted primarily thermal plant, while the GPPS auction attracted only hydro projects. This is likely to have reduced competition and efficiency in both auctions. Where possible, future auctions should have longer planning periods, and cover a sufficient number of years, so that all types of plant compete in the same auction.

A number of more detailed issues and recommendations are discussed in Sections 4-6 below. For a summary of all of our recommendations see Section 7.

2. Background

Colombia has a hydro-dominated electricity market. Roughly 77% of its energy and 67% of its capacity comes from hydro resources, with the remainder supplied by thermal generation plants. The Colombian wholesale electricity market – or MEM – consists of three components:

(i) a daily spot market that determines the spot energy price in every hour as well as the dispatch of resources. The spot energy market is a single-zone hourly market with supplier offers submitted one day ahead of dispatch.

(ii) a bilateral contracts market in which generators and electricity suppliers sell and purchase energy at freely-negotiated prices and quantities. This market is fundamentally financial: the purpose of the contracts is to reduce the exposure of both the supplier and the end-user to price volatility in the spot market, while the physical delivery of the energy committed in these

6 P. Cramton (2006) "New England's Forward Capacity Auction," 25 June.

contracts occurs via the spot market.

(iii) a firm energy market to ensure that there will be sufficient energy resources, particularly in exceptionally dry periods. The firm energy market pays generators a Reliability Charge determined by a competitive auction for each MWh of firm energy committed. Generators in turn are obligated to supply energy at a fixed price whenever spot prices exceed a pre-defined "Scarcity Price". Hence, the firm energy market provides price coverage for all prices above the Scarcity Price.[7]

From 1997-2006 generators in Colombia were paid a government-determined Capacity Charge. The Reliability Charge scheme commenced in December 2006 and pays generators an administratively determined price of $13.05/MWh until December 2012.[8] From December 2012, the Reliability Charge will be determined by the clearing price in competitive auctions. One purpose of the new scheme is to ensure that sufficient new generation capacity is constructed to ensure energy reliability from 2012/13 onwards.

The electricity wholesale, or generation, market in Colombia is not perfectly competitive. The largest-four companies provide about two-thirds of both the capacity and energy. Market shares in firm energy are shown in Table 1 below. In addition, 56% of current generation capacity is government owned, and 44% privately owned. Hence an important feature of the auction design for firm energy obligations is the rules devised to control the exercise of market power by existing generating companies.

---

7 The Scarcity Price is established by CREG and updated monthly based on the variation of the Fuel Price Index. In January 2007 it was $120/MWh. The Scarcity Price has a double purpose. On the one hand, it indicates the time when the different generation units or plants will be required to fulfil their firm energy obligations, which happens when the Spot Price exceeds the Scarcity Price; on the other hand, it is the price at which this energy will be paid.

8 In 2007, approximately 55,300 GWh per annum of firm energy was paid the Reliability Charge.

TABLE 1: Existing Generating Companies in Colombia

Generating companies	ENFICC Declared (GWh)			Firm Energy Market share
	Hydro	Thermal	**Total**	
Emgesa	10,419	2,373	12,792	21%
Epm	8,523	3,295	11,818	20%
Gecelca		9,873	9,873	16%
Isagen	5,099	2,327	7,426	12%
Epsa	1,487	1,655	3,142	5%
AES Chivor	2,925		2,925	5%
Gensa	57	2,594	2,651	4%
Termoflores		2,189	2,189	4%
Others		1,533	7,183	12%

3. The OEF Auctions

The firm energy auction is a forward market for firm energy obligations. A firm energy obligation (OEF) commits the generating company to have available pre-specified quantities of energy in periods of scarcity, defined as periods in which the spot price exceeds the Scarcity Price. In such periods generators are paid the Scarcity Price for energy supplied under their OEF, and the spot price for any additional energy supplied. Similarly, generators pay a penalty for failing to supply energy called up under their OEF given by the difference between the spot price and the Scarcity Price.

Two auctions were held in May and June 2008. The first auction ("the descending clock auction"), conducted 4.5 years in advance of the commitment period (the "planning period"), was a descending clock auction for new resources and effectively a sealed-bid auction for existing power plants, since bids for existing plants had to be submitted before the beginning of the auction, and could not be modified afterwards. In this auction, new resources were able to lock in a firm energy price for up to twenty years, beginning in December 2012, while existing resources receive the price set by the auction for a single year only.[10] The reserve price used in the auction was two times "the cost of new entry" (CONE), as established by CREG, and a price floor of one-half CONE was also used, so that CREG was committed to purchase all energy offered at that price.

The second auction ("the GPPS auction") was for new generation projects with longer construction periods, and allocated OEFs for periods of up to twenty years beginning in December 2014. The reserve price in this auction was the "market-clearing" price established in the descending clock auction. If, as turned out to be the case, insufficient supply was offered to cover auction demand, then the reserve price was to be paid; if supply exceeded demand, a sealed-bid auction was to be held.

The auction rules are described in detail in CREG documents and in Cramton and Stoft (2007),[11] so we will not repeat them here. Rather, in Sections 3.1 and 3.2 we briefly summarize the outcomes of the two auctions, and in Sections 4, 5 and 6 we consider various elements of the auction designs which may require further consideration or revision. Section 7 then summarizes our proposals and recommendations.

10 Although existing power plants will continue to receive this price in each subsequent year unless another auction is held which sets a new price.

11 P. Cramton and S. Stoft (2007) "Colombia Firm Energy Market," February.

3.1. The Descending Clock Auction

The descending clock auction occurred on 6 May 2008 and allocated OEFs for the period 1st December 2012 to 30th November 2013 for existing generating units (i.e. one year), and from 1st December 2012 to 30th November 2032 for three new power plants (i.e. twenty years).

TABLE 2: New Power Plants Offered in the DCA

Generating companies	Power Plant	Technology	OEF Offered [GWh]	Market share	Share of new capacity
ISAGEN	Amoyá	Hydro	214	12%	2%
GECELCA	Gecelca 2, 3 & 7	Coal	2,979	16%	34%
POLIOBRAS	Termocol	Fuel Oil	1,678	0%	18%
COSENIT	Termodial1	Petroleum	208	0%	2%
MERILÉCTRICA	Merilectrica-cc	CC-Gas	602	2%	7%
PROELÉCTRICA	Termoandinai	Gas	766	1%	8%
TERMOCANDELARIA	Termocandelaria-cc	CC-Gas	1,449	2%	16%
TERMOTASAJERO	Tasajero2	Coal	1,290	2%	14%

Overall there were seventeen participants, or “bidders”, in the auction. Ten new power plants were initially offered, with a combined capacity of 9,185 GWh per year, while the remaining capacity offered came from existing plants (62,860 GWh per year). Of the new plants offered, only two came from new entrants in the Colombian market – Poliobras and Cosenit – and only Poliobras was successful in selling an OEF.[12] The other two companies which sold OEFs for new power plants were already large players in the Colombian electricity market: Gecelca with 16% of existing capacity and Isagen with 12%. The only participant which offered more than a single new plant was Gecelca with three plants of 1117, 1117 and 745 GWh per year respectively. Table 2 summarizes the breakdown of new capacity offered by existing players and new entrants.

Thus the only bidder which was a large participant in both existing plant and in new resources was Gecelca, with 16% of the existing firm energy market and 34% of the new resources.

Of the 65,869 GWh of firm energy "purchased" in the auction for the first year (December 2012 to November 2013), new power plants accounted for 3,009 GWh per year (i.e. 4.6%) while existing generating units accounted for 62,860 GWh per year (i.e. 95.4%). The new power plants which were allocated OEFs are shown in Table 3 below.

TABLE 3: New Plants Awarded OEFs in the DCA

Generator companies	Power Plant Projects	Technologies	Location	Power	OEF [GWh ano]	Commitment period [years]
ISAGEN	Amoyá	Hydroelectric	Tolima	78 MW	214	20
GECELCA	Gecelca III	Coal	Córdoba	150 MW	1.117	20
POLIOBRAS	Termocol	Liquid fuels	Atlántico	201,6 MW	1.678	20

The auction "clock" started at a reserve price of $26.09/MWh (2xCONE) reducing

12 Our understanding is that none of the new plants offered in the auction that failed to sell a firm energy commitment will be constructed.

14 Of the early withdrawers, only Cosenit was a new entrant. Hence the other companies could have in principle been taking account the effects of their withdrawals on the auction price they would achieve for existing plant, as well as expected revenues in the spot and forward markets. That is, the opportunity cost of offering new capacity to the market includes the expected reduction in revenues from existing plant from multiple sources. However, in each case, the plant withdrawals were either for small plants, or made by bidders with only very modest shares of existing capacity.

to $22/MWh in the first round, and then decreased in $2/MWh decrements in each subsequent round. The first capacity withdrawals occurred in Round 3: Gecelca withdrew one of its larger plants (1117 GWh) at $20/MWh, the round opening price; Cosenit withdrew its 208 GWh plant at $19/MWh; and Termocandelaria withdrew its 1449 GWh plant at $18.025. There was one further capacity withdrawal in Round 4 (Merilectrica - 602 GWh), and two in Round 5 (Proelectrica – 766 GWh; Termotasajero - 1290GWh). Round 5 ended with an excess supply of 907 GWh at a price of $14.00/MWh.

Since Gecelca was the only active bidder with multiple plants in the auction, and the only operator which was a significant player in both types of resources, it may be viewed as unlikely that the plant withdrawals by the other bidders were made for purely strategic reasons. Since the aggregate excess supply at the round closing price was reported to bidders at the end of each round, during the first five rounds each bidder could see that its individual plant was not pivotal, and hence that withdrawal would likely result in it exiting from the auction as an active bidder altogether.[14]

By the beginning of Round 6 two bidders had become pivotal: Gecelca with plants of 1117 and 745 GWh respectively, and Polibras with a single plant of 1678 GWh. Poliobras did not respond to this opportunity to exercise its market power and continued to bid in its unit at the round closing price of $12/MWh. Gecelca, on the other hand, withdrew its smaller plant at a price of $13.999 and its larger plant at a price of $13.998/MWh. This resulted in the auction ending at a closing price of $13.998 (with an excess supply of 163 GWh), and Gecelca's larger plant was allocated an OEF at this price.[15]

One problem is to explain why Gecelca did not withdraw its larger plant at $13.999 thus ending the auction at that price and selling both of its plants, instead of just one. Another is to explain why Gecelca did not aggregate its three plants into a single block. Gecelca's total offered new capacity in the auction was 2,979 GWh. Assuming that all other bidders behavior was unchanged, had Gecelca aggregated the three units, it still would have become pivotal at the end of Round 5 where excess supply would have been 2,024 GWh. Withdrawing the entire

15 Gecelca also sold OEFs on 9,414 GWh of existing capacity at this auction closing price.

capacity at a price of $13.999 would thus have resulted in all of his capacity being sold at that price, and market excess capacity would have been 2,024 GWh.[16]

One possible explanation is that Gecelca was concerned with the overall amount of (excess) capacity in the market since this would affect the profitability of its existing plant as well as any new plant it constructed. Whatever the explanation, it appears that Gecelca saw an opportunity to end the auction at a favorable price and took it. Perhaps it is not surprising that the one example of strategic supply reduction observed in the auction came from the only bidder with a large stake in both existing plant and in new resources.

3.2 The GPPS Auction

The GPPS auction took place on 13 June 2008, and used a reserve price equal to the closing price of the descending clock auction of $13.998/MWh. Total demand was 6,285 GWh, being the sum of the incremental demands specified for each year. Bidders were required to first submit their quantity offers for each of the five years covered by the auction. They were only required to submit price offers in a sealed-bid auction if supply exceeded demand in any of the five years.

Since the incremental supply offered by bidders was less than incremental demand in every year, the reserve price was paid to the six bidders for power plant projects commencing from December 2014 to December 2018 (see Table 4).

It appears that the fact that the auction participants were able to split their offers over five years allowed them to implicitly "coordinate" on a "high-price" equilibrium in which all offers were accepted at the reserve price.[17] This made the protection of the reserve price crucial. However, the auction nevertheless resulted in *de facto* excess supply in the first two years, since the total available supply of firm energy from 2014-2016 exceeds aggregate demand in those years.

---

16 Gecelca explained to us that one of its larger plants – Gecelca 2 – faced higher fuel costs than its other two plants, and hence was withdrawn at a higher price.

17 As we remark again below, we are not suggesting that any explicit coordination of offers took place between the bidders.

TABLE 4: GPPS Auction Results

Generating company	Project	2014/15	2015/16	2016/17	2017/18	2018/19	Totals	ENFICC
		GWh ano	GWh ano	GWh ano	GWh ano	GWh ano	GWh ano	GWh ano
EPSA	Cucuana	49.5	0.5	0.0	0.0	0.0	**50**	**50**
Promotora	Miel II	182.6	1.8	0.0	0.0	0.0	**184.4**	**184.4**
EMGESA	El Quimbo	400	450	500	300	0.0	**1,650**	**1,750**
EPM	Porce IV	0.0	320.6	320.6	320.6	0.0	**961.7**	**1,923**
ISAGEN	Sogamoso	400	400	750.1	750.1	50	**2,350.3**	**3,791**
Hydroelectrica	Pescadero Ituango					1,085	**1,085**	**8,563**
Incremental Supply		1,032	1,174	1,571	1,371	1,135	**6,286**	**16,261**
Incremental Demand		1,779	1,910	1,965	2,013	2,170	**9,836**	
Incremental ENFICC available		5,775	1,923	0.0	0.0	8,563	**16,261**	

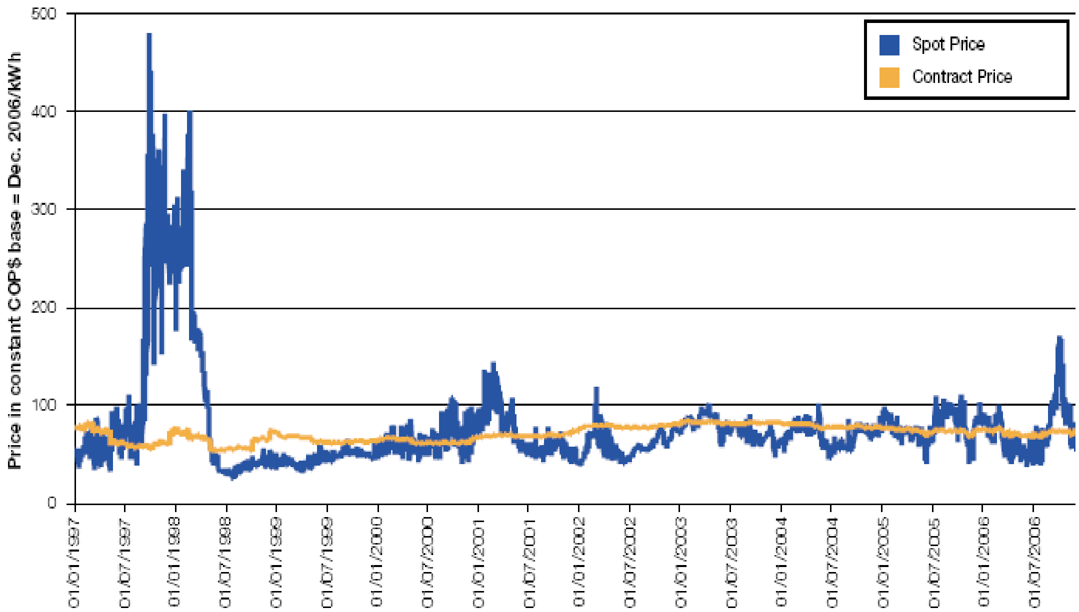
4. The Descending Clock Auction Design

4.1 Descending Clock Auction Information Rules

The 6 May auction was a descending clock auction for new resources, and effectively a sealed-bid auction for existing resources. New power plants were able to submit supply bids during each round of the auction and withdraw supply at whatever prices they chose. Supply curves for existing resources were submitted in advance of the auction, and the ability of operators to express price-sensitivity for existing resources was severely curtailed by rules intended to limit the exercise of market power.[18]

The general rationale for the use of a descending clock auction is “price discovery”. Generators offering to supply firm energy in the auction are effectively bidding to obtain a fixed annual fee in exchange for giving up the opportunity to sell energy at prices which exceed the Scarcity Price during periods when supply is scarce. They are thus substituting a random stream of revenues for a fixed payment. The main source of common value uncertainty would therefore seem to be the number, duration and intensity of high-price periods during which the spot price exceeds the Scarcity Price, which we understand is largely determined by long-term weather and rainfall patterns. The figure below illustrates fluctuations in spot market prices from 1997 to 2006.

18 These rules are described in more detail below.



In order to limit the exercise of market power in the auction, existing resources were required to commit all of their capacity in advance, and given limited opportunities to withdraw supply. Thus, with one exception, existing resources were effectively committed in advance to supplying firm energy at the auction price which was bounded below by ½ CONE.[19]

1. A first observation is that the rules governing the behavior of existing resources – which accounted for more than 87% of the energy offered in the auction – severely curtailed "price discovery" in the sense that existing resources could not respond to any information acquired during the auction, nor could their behavior reveal very much information to other bidders during the auction.[20] The market power mitigation rules effectively meant that the auction was a sealed-bid auction for 87% of the energy offered.

19 Existing resources were also able to submit "opt-out" bids in advance of the auction which allowed them to withdraw supply at prices less than 0.8CONE. See below for a discussion.

20 However, as noted, eight of the ten new power plants offered were offered by existing market players, accounting for 75% of the new capacity offered.

2. A second observation is that the source of common value uncertainty may be such that no bidder had any particularly useful information that could be imparted to other bidders during the auction in any event. The most relevant information would be expected annual rainfall patterns from December 2012 until November 2032. It is unclear that bidders in the auction would have anything other than freely-available historical information on which to base their expectations, and these should not be influenced by bidding behavior during the auction.

Given (1) and (2) above, it may make sense to reconsider the rationale for holding an open, descending-price auction for new resources alone. The limited opportunities for learning provided by the auction, and the arguably limited relevance of whatever information bidders may have had, suggests that bidding behavior was probably little influenced by pure information acquisition during the auction.[21]

The information transmitted to bidders before and during the auction was:

i. the aggregate capacity/energy offered at the reserve price in advance of the auction and technical parameters for new and existing power plants;

ii. the demand curve to be used by CREG in the auction and the value of CONE ($13.045/MWh);

iii. each round's opening and closing price and the aggregate excess supply at the closing price at the end of each round.[22]

The supply bids of the individual bidders were not reported to avoid providing information which could be used to support tacit collusion.

According to Cramton and Stoft (2007, p. 13), one reason for reporting information on excess supply is that it helps bidders decide questions such as whether they could get two 100 MW units accepted or only one, and because of economies of

21 As noted above, the auction participants we spoke with indicated that learning during the auction was not a particularly relevant issue for them.

22 Cramton and Stoft (2007) also recommended reporting supply by resource type at the close of each round. This was because this information is useful to the bidders, as the profitability of a unit generally depends on the distribution of unit types. This recommendation was not adopted.

scale, they will want to bid a different price depending on this answer. This argument is based on the general result that "*knowing more about market conditions improves decision making and efficiency*", so long as bids in the auction reflect actual proprietary information rather than merely strategic behavior. However, bidders of new resources in the auction were able to freely choose the number of units they offered, and how they were aggregated, thus providing them with one means of dealing with issues of economies of scale even with no information on excess supply.[23] And only one bidder in the auction offered more than a single unit of new power plant, so this consideration turned out to be of limited relevance.[24]

Since the auction ended at the first point at which any active bidder became pivotal, and on the basis of bids which were evidently finely-tuned to achieve a particular outcome (see above), it is therefore worthwhile reconsidering the information reported to bidders during the auction in order to limit their ability to manipulate the auction outcome. In particular, reporting aggregate excess supply, along with precise information about the auction demand curve, allows bidders on new resources to see exactly when their capacity becomes pivotal, and thus endows them with an ability to end the auction at prices which do not reflect actual energy costs.

This problem could be dealt with in a number of possible ways:

i. by making the auction a sealed-bid auction for all bidders, rather than just for bidders on existing resources (see the discussion above);

---

23 A version of the "exposure problem" could arise in this auction because a bidder that is offering to supply firm energy with, say, two plants may be awarded the quantity supplied by only one of its plants if (and only if) the bidder withdraws both plants when the auction price is lower than the price it requires to supply firm energy with only one plant, and the auction terminates as a consequence of its withdrawal but only one of its plants is needed to eliminate excess demand. However, it is not clear if, and to what extent, knowing excess supply could help the bidder deal with such a risk. It is also unclear the degree to which economies of scale or scope exist between generating units. If such concerns are significant, however, a natural approach to dealing with the associated "exposure" issues would be to allow more fully combinatorial bids, albeit at the cost of introducing some additional complexity.

24 This bidder (Gecelca) evidently used information on aggregate excess supply to precisely the opposite purpose, i.e. to guarantee that only one of its units was taken at the auction-clearing price.

ii. by not reporting any information on supply or excess supply during the descending clock auction;

iii. by reporting only total (rather than excess) supply during the auction, and not providing bidders with any information on the demand curve;

iv. by introducing a random component in demand, so that reported information on excess supply was sufficiently uncertain to make price manipulation strategies more risky for bidders (Klemperer and Meyer 1987);[25]

v. by allowing the auctioneer to reduce demand after observing the bids submitted in any round (e.g. McAdams 2006).[26]

Each of these rules is designed to prevent new resources from manipulating the auction outcome by being able to identify the precise point at which their supply becomes pivotal. Rules (i) and (ii) do this by depriving bidders of information on the quantities supplied by other bidders, which may worsen price discovery during the auction to the extent that this is valuable. Rules (iii), (iv) and (v) do this by depriving bidders of information on demand, which should have fewer negative implications for price discovery.[27] Indeed, simply reporting total supply in each round or at each price (with no demand information supplied), should allow bidders to ascertain all of the useful information they would otherwise obtain from observing excess supply, but deprive them of the ability to unilaterally end the auction at a high clearing price when they see that their capacity has become pivotal.

Of course, not having information on excess supply will make it much more difficult for bidders to anticipate the closing price of the auction, or to realize when the auction is about to terminate. However, it is not clear if, and to what extent, this

---

25 P. Klemperer and M. Meyer (1987) “Supply Function Equilibria in Oligopoly Under Uncertainty,” Econometrica, 57(6), 1243-1277.

26 D. McAdams (2007) "Adjustable Supply in Uniform Price Auctions: Non-Commitment as a Strategic Tool," Economics Letters, 95(1) 48-53.

27 We note that the CREG did introduce an uncertain factor in the demand curve before the first round of the DCA. Hence one suggestion would be to extend this practice to subsequent rounds of the auction.

information is valuable for bidders in choosing an appropriate bidding strategy.

4.2 Market Power Mitigation Rules

The special rules devised to curb or mitigate the exercise of market power by incumbent generators are an important component of the descending clock auction design. None of these rules were activated during the DCA that occurred in May 2008, however, and are therefore likely to have had at most a limited impact on the auction outcome. The suggestions below are intended to improve the performance of future auctions in which it is possible that these rules will be activated.

4.2.1 "Opt-Out" Bids or Temporal Withdrawals

The significant market shares of the large existing generators creates a risk that they could strategically withhold supply from the firm energy market to unilaterally end the auction at a high clearing price. To reduce the existing generator's ability to exercise market power in this way, two alternative sets of market-power mitigation rules have been considered: those proposed by Cramton and Stoft (2007, pp. 14-15), and the ones actually adopted by GREG. The two sets of rules differ in the way they treat "temporal withdrawals" (or "opt-out bids") by existing operators. As we argue below, they also have different implications for "price discovery" and differing effects on bidders' strategies during the auction and hence on final auction prices.

The Cramton-Stoft Rules

Cramton and Stoft (2007) proposed two rules for capacity withdrawals by existing generating plant:

(i) "opt-out" bids, which allow existing generating units to be withdrawn from the firm energy market for a single year if the auction price is lower than a pre-determined threshold chosen by the operators.

(ii) "retirement bids" which allow existing generating units to be withdrawn permanently from the firm energy market.

Both types of capacity withdrawal bids were to be submitted prior to the auction, so for the purposes of existing plant this is effectively a sealed-bid auction in which supply curves are submitted simultaneously by all participants and cannot be revised during the auction.

Cramton-Stoft suggested that opt-out bids should not be revealed either before or during the auction and hence "*cannot impact the price for existing supply*." Specifically, in order to ensure that the firm energy supplied is sufficient to cover demand, they suggested that:

> *"Accepted opt-out bids are replaced with new resources as follows. First the auction is run ignoring the opt-out bids, and the clearing price is set […] This is the clearing price for all existing resources. Then we replace the accepted opt-out bids by marching up the supply curve revealed in the clock auction until all the opt-out bids are replaced. […] All new resources receive this higher price."*

Retirement bids, on the other hand, are announced as soon they are received and thus effect the auction supply curve and the clearing price paid to all resources.

CREG's Rules

The market-power mitigation rules adopted by CREG distinguished between "temporal withdrawals" (corresponding to opt-out bids) and "definite withdrawals" (corresponding to retirement bids). The retirement bid rules used do not appear to differ from those proposed by Cramton and Stoft. The rules for temporal withdrawals, however, allowed a supplier of existing resources to "*withdraw a power plant temporarily from the auction*," by providing, prior to the auction, a supply function specifying the price at which the plant would be withdrawn, with such "opt-out" prices constrained to be less than 0.8 CONE. Each such temporary capacity withdrawals would then be subtracted from the existing aggregate supply – although the withdrawal itself would not be communicated to other bidders – and the resulting market-clearing price paid to all new resources. On the other hand, the:

> *"Reliability Charge Price paid to existing power plants will be calculated by adding power plants' ENFICC from opt-out bids, to the ENFICC supply.*

The price will be set at the point where the intersection takes place between the demand curve and this adjusted ENFICC supply."

The crucial difference between the CREG rules and the rules proposed by Cramton and Stoft is that, under the CREG rules, the quantity withdrawn by existing operators is subtracted from the aggregate supply during the auction, and this aggregate supply is (implicitly) communicated to bidders during the auction. The auction clearing price is then paid to the new entrants. By contrast, the Cramton-Stoft rules communicate no information about opt-out bids to bidders during the auction.

Both rules are intended to ensure that when an operator reduces supply by withdrawing an existing plant, it cannot thereby affect the price it is paid for the firm energy produced by its other existing plants that are not withdrawn from the auction.[28] Under both rules, the price paid to existing plant is determined by assuming that actual supply includes the quantities withdrawn – i.e., it is determined as if the withdrawals had not taken place.

Fundamentally, the two rules differ in the information they supply to bidders of new resources, and this may affect bidding in one of two ways. First, under the CREG rule, bidders of new resources will learn of the reduction in supply during the auction and this may influence their estimates of the value of selling an OEF (i.e. via "price discovery").[29] Such bidders may therefore decide to withdraw capacity from the auction earlier than they might have if the supply reduction had not been observed. In addition, under the CREG rule, bidders of new resources will be unable to distinguish between withdrawals of existing capacity and withdrawals of new capacity. This distinction may be relevant for bidders.

A numerical example in Annex 1 shows that under the CREG rule, bidding strategies on new resources may be affected by a reduction in the quantity supplied by existing operators. And this in turn may be used strategically by the

---

28 Note, however, that such capacity withdrawals will effect the price paid to new resources, and these are largely owned by existing generating companies. Hence neither rule can completely eliminate incentives for strategic capacity withdrawals of existing plant.

29 Since all bidders are told the demand curve to be used by CREG during the auction they will be able to deduce supply reductions whenever they occur.

owners of existing plant to end the auction at a higher price, and be paid higher prices themselves for existing plants.

The Cramton-Stoft rule, on the other hand, reveals no information on the withdrawal of existing capacity to other bidders during the auction. Hence, only withdrawals of new capacity are observed by all bidders.

At a basic level there is a trade-off between revealing information during the auction and controlling the exercise of market power. If information on withdrawals is considered important to bidders, then the CREG rule may be preferable, although arguably withdrawals of existing capacity should be announced prior to the auction. However, since revealing this information tends to exacerbate opportunities for the strategic exercise of market power by the owners of existing plant, as demonstrated in Annex 1, the bidding behavior will therefore tend to be less informative. Overall, this may lead to a preference for the Cramton-Stoft version of the rule.

Comparison

CREG's rules may endow new entrants with market power at higher prices, inducing them to terminate the auction earlier, and at higher prices than those that would result under Cramton and Stoft's proposed rules.

Specifically, the strategic considerations highlighted by the example in Annex 1 are the following:

i. If new entrants are told the actual residual supply after the withdrawal of an existing operator's plant, they are more likely to become pivotal – and realize it – when the auction price is still relatively high. In this case, they can unilaterally terminate the auction (and be among the winners) by strategically reducing supply. Hence, with CREG's rules the auction is more likely to end at a higher price due to strategic supply reduction by new entrants.

ii. Existing operators, understanding this, can affect the price they are paid under CREG's rules, because they can induce new entrants to terminate the auction at higher prices by strategically reducing supply themselves. And even if the price they are paid is determined by adding their withdrawn

> quantity to the aggregate supply bid during the auction, this price will be higher, in general, if the aggregate supply bid during the auction is shifted upwards (as it is as a consequence of the new entrant's response to the existing operators' supply reduction).

These strategic effects of an existing operator's supply reduction do not arise under the rules proposed by Cramton and Stoft, because those rules do not provide any information to bidders during the auction about the actions of existing operators. Hence they appear better suited to addressing market power.

However, Cramton and Stoft's rules distort the information about aggregate supply conveyed to bidders during the auction. This may reduce the scope for price discovery, reducing the advantages of holding a dynamic auction rather than a sealed-bid one. The basic principle, once again, is that greater transparency favours price discovery – assuming this is relevant – but potentially increases firms' ability to exercise market power.

4.2.2 Rules for Inadequate Supply, Insufficient Competition and Insufficient Offers

Cramton and Stoft (2007) propose two fail-safe mechanisms for the auction that have been adopted by CREG. First, they propose that if the auction fails because of *inadequate supply* of firm energy, i.e. if supply is less than demand at the auction starting price, then new resources should be paid the auction starting price and existing resources paid 1.1 CONE. Second, in case of *insufficient competition* – i.e., if:

> *"(1) existing resources, less retirements, is less than demand at the starting price, and (2) at the starting price, the firm energy bid exceeds the demand but there is less than 4% excess, or a single supplier's new resources are pivotal (i.e., the supplier can unilaterally push the price to 2 CONE by withholding its new projects),"*

Cramton and Stoft propose that the auction is still conducted, but that new resources be paid the auction clearing price, while existing resources be paid the smaller of the clearing price and 1.1 CONE.

In addition, to make sure that enough competition comes from smaller market players, Cramton and Stoft propose that:

> *"Insufficient competition also occurs if at qualification, the quantity of new projects from small players—those with less than 15% maximum firm-energy market share—is less than 50% of the required new firm energy."*

CREG adopted a similar rule for "insufficient offers" that applies if:

> *"**at the end of the auction**, at least 50% from all firm energy obligations backed by new power plants and existing power plants with a planned expansion, is not allocated to firms with firm energy market share less than 15%."*

Both versions of this "insufficient offers" rule may have the effect of inducing firms with large market shares to prefer to allocate new plant to the GPPS auction, rather than to the DCA. In addition, the CREG version of the rule may also induce larger players to reduce supply during the DCA, in order to avoid activating this rule

Arguably, the "market power mitigation rules" described above should be sufficient to guarantee the competitiveness of the auction by preventing the exercise of market power by large players without imposing an additional rule concerned with insufficient offers. However, if this rule is to be retained we recommend that it be applied to the offers made at the beginning of the auction, to avoid distorting bidding behavior during the DCA auction.

4.3 Further Issues

4.3.1 The Strategic Effects of Lumpy Investments

The auction rules treat offers to supply a certain quantity of firm energy produced by a generating plant as a package bid (or a "lumpy investment"): the supplier is either awarded the whole quantity produced by a single plant, or none of it. In other words, CREG cannot accept only a part of the firm energy offered by a supplier's plant. The rationale for this rule is that, because of economies of scale and/or fixed costs, the price a bidder is willing to accept for the whole quantity produced by one of its plants is arguably lower than, say, *k* times the price it is willing to accept for *1/k* of that quantity.

This rule may also affect bidders' strategic behaviour during the auction. Specifically, as our next two examples show:

(i) it can reduce bidders' ability to jointly coordinate (implicitly or explicitly) on an high-price equilibrium;

(ii) it can increase a bidder's incentive to unilaterally reduce supply.

Example 1: Lumpy investments reduce bidders' ability to coordinate on a high-price equilibrium.

Suppose there are 5 bidders, each willing to supply quantity 30. Total demand is 100.

- Without lumpy investments, bidders have the option to terminate the auction at an arbitrarily high price (e.g., 2 CONE), by each reducing supply to, say, 20. By so doing, each bidder is awarded some of the quantity demanded.
- With lumpy investments, it is just not possible for each of the 5 bidders to be awarded some of the quantity demanded. So if bidders want to end the auction at a high price, then one of them has not to be among the winners.

In other words, lumpy investments reduce bidders' ability to coordinate (implicitly or explicitly) to end the auction at a high price by jointly reducing supply and sharing the quantity demanded.

Example 2: Lumpy investments increase the incentive to unilaterally reduce supply.

Suppose a bidder's capacity is 60 and excess supply, at the current auction price, is 50. The bidder is then pivotal and it can unilaterally terminate the auction at the current price. However:

- with lumpy investments, if the bidder drops out it is then awarded its whole supply of 60 (in order to ensure that the whole demand is covered);
- without lumpy investments, if the bidder drops out it risks being awarded only 10 (the minimum quantity that eliminates excess demand).

Therefore, without lumpy investments bidders have a weaker incentive to unilaterally terminate the auction when they become pivotal.

4.3.2 Discrete Price Decrements

The use of discrete price decrements (whereby bidders cannot choose arbitrary prices at which to modify the quantity they supply, but have to choose price that are multiples of a predetermined discrete quantity) can reduce bidders' incentive to strategically reduce supply.

Consider the following example. A bidder has 2 plants, one with capacity 40, the other with capacity 70. Suppose that at price 20 excess supply is 100. If he can choose arbitrary prices, the bidder can withdraw 40 (the smaller plant) at price 19.999 – thus reducing excess supply to 60 – and then 70 (the largest plant) at price 19,998 – thus reducing excess supply to -10. He would then be allocated quantity 70 at price 19,998. This strategy is profitable if the bidder prefers to receive a higher price for his larger plant, at the cost of giving up the chance of also winning with his smaller plant.

With discrete price decrements in multiples of 1 say, the previous strategy is less profitable, since in order to be sure to be allocated quantity 70 the bidder has to reduce the auction price to 18 (by withdrawing 40 at price 19, and 70 at price 18). Notice that if the bidder withdraws both plants at price 19, then he is only allocated 40, since this is enough to eliminate excess demand.

4.3.3 Price Floor

The auction rules constraint to auction price to be higher than ½ CONE, since a lower price would "*increase the volatility of prices and therefore supplier risk.*" the rationale for this constraint is unclear, however, since any bidder not willing to supply firm energy at prices below ½ CONE can simply withdraw its plant at that price. New resources can do this during the descending clock auction, while existing power plants can do this by temporarily withdrawing capacity before the auction.

5. The GPPS Auction Design

The GPPS auction effectively occurs in two stages. In the first stage, bidders submit their quantity offers over five years. If supply exceeds demand in any of the five years, then a sealed-bid auction is held in which each bidder submits a single price bid for its entire offered quantity. Bidders are not informed in which year (or years) there is either excess supply or excess demand.

If a sealed-bid auction takes place, the CREG then uses an "optimisation" procedure to allocate price-quantity offers over time in order to minimise the total cost of purchasing firm energy. This optimisation procedure treats the *total* offer from each plant over the five year' period as being available in the first year the plant is offered, and reallocates this quantity across years accordingly. The result is a firm energy price calculated as the market-clearing price in each of the five years.[30]

In the GPPS auction held in June 2008, the bidders split their offers over the five years in a manner which ensured that there was no excess supply in any year, and hence implicitly "coordinated" on a "high-price" equilibrium in which all offers were accepted at the reserve price.[31] This made the protection of the reserve price crucial, but the auction nevertheless resulted in *de facto* excess supply in the first two years. Therefore, absent this strategic behavior, a sealed-bid auction would likely have taken place, and the auction could then have provided signals concerning the timing of new investments, as well as their price.

In order to avoid this outcome occurring in future, we propose the three following changes to the GPPS auction design:

i. Bidders should submit price and quantity bids simultaneously

In the GPPS auction bidders first submitted quantity offers, and were only required to submit price bids if supply exceeded demand in one or more years. This makes

---

30 Exact market-clearing may not be possible due to the "lumpy" nature of the quantity bids.

31 There is no suggestion here that any explicit coordination of offers took place between the bidders. However, our conversations with auction participants made it plain that a number of the larger bidders clearly saw that by independently splitting their quantity offers over time, they made it more likely that a sealed-bid auction would not occur.

it easier for bidders to coordinate on a high-price equilibrium, because bidders can observe the quantities offered by their competitors before making their price offers. We therefore suggest that bidders should submit their quantity and price offers at the same time. This should make it harder for bidders to coordinate on low quantity offers in each year, since it provides incentives for each bidder to try to be awarded a larger quantity at a price just below the reserve price. Realising this, each participant will wish to offer slightly lower price etc.

ii. The CREG should provide less information on annual incremental demand, for example by providing information on the total five-year demand only

This measure will clearly make it more difficult for bidders to fine-tune their quantity offers so as to minimise the probability of supply exceeding demand in every year.

iii. Bidders should be required to offer in a single year the entire quantity they wish to offer in the auction from any new plant or project

Preventing the spreading of offers over multiple years will make it much more difficult and costly for bidders to limit the quantities offered below the quantity demanded by CREG, and hence prevent an auction occurring.

Proposals (i) and (iii) in combination should allow for more competitive GPPS auctions to take place in future. Proposal (ii) involves the usual trade-offs between providing useful information and facilitating the exercise of market power.

6. Should there be Multiple Auctions?

Sections 4 and 5 above have discussed various possible improvements for the DCA and GPPS auction, respectively. However, as noted by Cramton (2006), for vigorous contestability *"it is important that the market not favor only the quickest plants to build ..."* and this is not best achieved by holding separate auctions for plant with differing construction periods. In particular, the shorter planning period of the DCA meant that it attracted primarily thermal plant,[32] while the GPPS auction

32 The exception was the small hydro plant Amoya, with 214 GWh per annum.

attracted the large hydro projects. However, since most of the new firm energy from both auctions will be supplied over the same time period, i.e. 2012 – 2032, the different planning periods in the two auctions likely restricted the amount of competition in each auction. It would be preferable if new thermal and hydro plant competed in same auction.

A possible solution is to hold a single GPPS-type auctions in future, covering more years, and with longer planning periods, in preference to holding further DCAs followed by GPPS auctions. We recommend that the CREG consider holding combined DCA/GPPS auctions in future. For example, an auction could be held in 2010 for years 2016/17 – 2020/21 so that all types of new plant could participate. The rules suggested above for GPPS auction should be applied, plus the special rules for existing plant from the DCA. Such an auction would yield clearing prices in each year which could be paid to both new and existing plant.

Some advantages of holding single GPPS-type auctions in future are:

- it allows all new plants to compete in the same auction, e.g. large hydro projects and thermal plant;
- a single price is set for all new and existing plant in each year, subject to special rules for existing plant;
- it provides information or signals on the best timing for new projects, e.g. if a project does not win an OEF in the first year it is offered, it can delay construction

A number of issues will need to be resolved, however, before such auction can be implemented. Among these are the following:

- Should the auctions be sealed-bid, or should a descending-clock auction be used for each year? Since the auction has combinatorial features (i.e. lumpy capacity bids), a descending auction is more complex. However, a potential advantage of a descending clock auction, in addition to price discovery, is that it would allow bidders to adjust their quantity offers in light of information revealed in the auction (e.g. which years have excess supply or excess demand), and hence potentially allow for price equalisation across years.

- Should a first-price or second-price (e.g. proxy-type) auction be used? I.e. should each years' price be the market-clearing price, or the lowest rejected offer, suitably defined? It is argued by some auction theorists that the latter approach can simplify bidding behavior and potentially improve auction efficiency.[33]
- What reserve price should be used? For example, 2xCONE as was used in the DCA, or the clearing price from previous auctions, i.e. $13.998/MWh?

It is beyond the scope of this study to address questions such as these in any detail. However, should the CREG decide to proceed with such auctions in future, we recommend that further consideration be given to these issues.

7. Conclusions and Recommendations

We have reviewed the design and performance of the firm energy auctions held in Colombia in May and June 2008. In summary form, our main conclusions and recommendations are as follows:

1. More consideration should be given to the types of common value uncertainty faced by bidders in the auctions, and whether holding a descending-clock auction (DCA) is justified. All auction participants we spoke with reported that their reserve prices did not (<u>and would not</u>) change during the auction. Given this, different auction formats, such as sealed-bid auctions, should be considered.
2. The combination of lumpy capacity bids with the auction information rules (i.e. revealing excess supply to bidders during the DCA) makes it more likely that one or more large bidders will find it profitable to end the auction at prices exceeding the competitive market-clearing level. A re-evaluation of the auction information rules is therefore recommended if further descending-clock auctions are to be held. For instance, we suggest reporting only total (rather than excess) supply during the auction, and

33 See, for instance, L. Ausubel and P. Milgrom (2002) "Ascending Auctions with Package Bidding," Frontiers of Theoretical Economics 1(1); also P. Milgrom (2007) "Package Auctions and Exchanges," Econometrica, Vol. 75, No. 4, 935–965.

providing bidders with less information on the CREG demand curve.

3. In the GPPS auction, the quantity offers for different years by some of the participants resulted in there being no competition, and has likely led to there being an excess supply of firm energy available in the market for a number of years. Some fairly straightforward adjustments to the auction rules will help to prevent this in future, and likely lead to more competitive auctions taking place. Our suggestions for improving the performance of the GPPS auctions have been detailed in Section 5 above.

4. The planning period for the DCA was not long enough to attract large hydro projects. Consequently, the DCA attracted primarily thermal plant, while the GPPS auction attracted only hydro projects. This is likely to have reduced competition and efficiency in both auctions. Where possible, future auctions should have longer planning periods, and cover a sufficient number of years, so that all types of plant compete in the same auction, as described in Section 6 above.

A number of more detailed recommendations are as follows.

For the DCA:

- in the absence of any compelling reasons to be concerned with further enhancing "price discovery", we recommend that the Cramton-Stoft rules for "opt-out" bids (or temporal withdrawals) be adopted in future auctions (see Section 4.2.1);
- the rule on insufficient offers should be modified to be applied to the offers made at the beginning of the auction, or possibly dropped altogether (Section 4.2.2);
- there appear to be valid economic reasons for allowing for "lumpy" capacity offers, so we do not recommend changing this (Section 4.3.1). Our recommendation to deal with the exercise of market power by pivotal bidders is to amend the information provided during the auction, as discussed above;
- price bids should probably be limited to single decimal places, rather than the three decimal places allowed for in the past auctions (Section 4.3.2);

and

- there appears to be no compelling reason for the use of a price floor in the auction, and this should probably be abandoned (Section 4.3.3).

For the GPPS auction:

- bidders should be required to submit price and quantity bids simultaneously;
- less information on annual incremental demand should be provided, for example by providing information on the total five-year demand only; and
- bidders should be required to offer in a single year the entire quantity they wish to offer to the auction from any new plant or project.

Ultimately, we believe that the use of a single auction to accommodate both the longer planning periods required for large hydro projects, and the shorter ones for thermal projects, will result in greater competition and efficiency, and should be given careful consideration by the CREG.

Annex 1: Example of Comparison between CREG and Cramton-Stoft Rules for Temporal Withdrawals

We suppose that demand is 1000 for all prices *p* such that $6 < p < 24$ (i.e. CONE=12 and, for simplicity, demand is inelastic between 2 CONE and ½ CONE) and is flat otherwise. There is one existing operator, with three plants, each with capacity 300. There are two new entrants, each proposing to build one new plant with capacity 250. Therefore, total supply at the beginning of the auction is equal to 1400.

Entrant A's reservation price is equal to 16, and entrant B's is equal to 14. “Truthful” bidding would imply that each entrant drops out of the auction when the price equals its reservation price. However, we assume that each entrant would strategically reduce supply (unilaterally) – i.e., it would withdraw its plant – if it knows that this triggers the end of the auction allowing the entrant to be one of the winners. Arguably, this strategy is consistent with the actual bidders’ behaviour observed in the auction held on May 6.

Suppose that the existing generator withdraws one of its plant at p=20, while the other two plants are never withdrawn. According to the rule proposed by Cramton and Stoft (2007), the withdrawal at p=20 is not communicated to the new entrants and *is not subtracted from the aggregate supply*. Hence, at p=20 the new entrants are told that aggregate supply is still 1400 and that excess supply is 400. At this point, neither entrant can unilaterally terminate the auction by withdrawing its plant.

Entrant A drops out at p=16, reducing excess supply to 150. At this point, entrant B can trigger the end of the auction, so it drops out at p=15 (assuming price decreases in multiples of 1). Hence the auction ends at p=15 with excess supply = -100. The existing operator is paid 15 - the auction closing price - for its two remaining plants. In order to “cover” the whole demand (i.e., eliminate the negative excess supply), each new entrant is allocated quantity 250 at a price of 16, which is the lowest price at which the “real” supply in the auction exceeds demand. Notice that entrant A is eventually declared a winner, even though it dropped out during the auction, expecting not to be allocated any quantity.

By contrast, according to rule adopted by CREG, the withdrawal at price 20 is not communicated to the two entrants but *it is subtracted from the aggregate supply* (and the aggregate supply is communicated to the auction participants in each round). Hence, at price 20 the new entrants know that the actual aggregate supply is 1100 and excess supply =100. Since the new entrants know the “real” excess supply at price 20, they also know that they can unilaterally terminate the auction. Hence, following the withdrawal of the existing capacity, both will immediately drop out at p=19.

So the auction ends at price 19 and each new entrant is allocated quantity 250 at this price. For its 2 remaining plants, the existing operator is also paid 19, which is the price at which the demand function equals the supply function obtained by adding the withdrawn plant to the actual supply bid during the auction (in which case supply is 1400 for $p > 19$ and 900 for $p < 19$).

Hence, both the existing operator and the new entrants end up being paid higher prices under CREG’s rules then under Cramton and Stoft’s rules.[34]

Notice also that, if it anticipates the reaction by the new entrants, the existing operator realizes that it can be paid 19 for 2 plants if it withdraws 1 plant (or indeed, in our example, that it can be paid one bid increment less then the price at which it withdraws any of its plants, for its 2 remaining plants). Therefore, with the rules adopted by CREG, the existing operator can exercise its market power, terminate the auction and set the market clearing price, by strategically withholding capacity.

34 Notice that, even if CREG’s rules would not affect the new entrants’ strategies, the price paid to the incumbent firm may still be different under the two sets of rules. For example, suppose that under CREG’s rules entrant A still bids truthfully and drops out at price 16, as it does under Cramton and Stoft’s rules. At this point the auction ends, since excess supply becomes negative, and the new entrants are paid 16, the market clearing price, as under Cramton and Stoft’s rules. However, in this case the existing operator is paid only 6, which the price at which demand equals the supply function obtained by adding 300 to the actual supply bid during the auction (in which case total supply is 1400 for $p > 16$ and 1150 for $p < 16$).