RUTCOR RESEARCH REPORT

CONTROL OF MARKET POWER IN ELECTRICITY AUCTIONS

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Abstract. In a number of jurisdictions, deregulation has led to the establishment of auction spot markets for electricity supply. Short run demand for electricity is almost totally inelastic, and in most situations economically significant amounts of electricity cannot be stored. During periods when demand is relatively high, suppliers with what, in other markets, would be regarded as a relatively small percentage of the industry total capacity have and have exercised extreme market power. This paper proposes and discusses a narrowly targeted and automatic remedy that will keep suppliers with the capacity and incentive for exercising such power from any role in setting the market-clearing price.

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1 Introduction

Electricity markets in England, California, New Zealand and several eastern US states have recently been deregulated.[1] In each of these cases, the deregulation has involved setting up day-ahead auction markets and real-time markets for electricity. In some cases, the deregulation was accompanied by divestiture of generating assets by formerly regulated entities. Several of these markets have not worked as well as had been hoped, and are being modified. Unexpectedly high prices are an important problem. The high prices could be the result of one or more of several different causes. First, they could be the result of a shortage of supply, but in some cases, this is clearly not what is going on. (See Wolak and Patrick 1996a, 1996b, Wolfram 1999, Borenstein *et al*. 2000) Second, they could be the result of collusion by the bidders, tacit or explicit.[2] Bidders do seem, on occasion, to be bidding in ways--e.g., several bidders using "hockey-stick" bids[3] in a market-clearing-price auction--that suggest that tacit collusion is, in fact, going on. Third, they could be the result of a rational and unilateral exercise of market power. This short paper argues that this third cause is a potentially serious problem and suggests a rather simple and narrowly targeted fix for it.

In the long run, there is some elasticity of demand for electricity. However, electricity has become a basic utility of daily life and economic activity. Furthermore, it usually cannot be stored economically. The result is that avoiding the immediate loss of a kilowatt-hour of electricity that normally sells for about 10 cents is worth at least $10 for almost all customers in a position to make the choice.[4] Thus, in the short run--a day ahead and especially an hour ahead or a minute ahead--there is essentially no elasticity of demand for electricity. This lack of elasticity means that if the demand for electricity at a given point in time is close enough to the available capacity that a single seller could put the market into deficit, then that single seller can unilaterally raise the price to extraordinarily exorbitant levels. Such suppliers are sometimes called "pivotal." At a moment when a seller is pivotal in this sense, that seller by any reasonable definition has extreme market power. This is true whatever its market share. Hence, market-share-based ways of controlling market power, such as the use of HHI indices, are unlikely to be well suited to the task. This paper proposes an automatic and narrowly targeted way to control this kind of extreme market power.

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[1] For fuller discussions of electricity deregulation in the US and worldwide see, respectively, Joskow 1997 and Gilbert and Kahn 1996.

[2] To be clear, I include within the term tacit collusion any independently arrived at bid by a bidder that is intentionally not in her best interest within the particular auction in question, i.e. not a Nash equilibrium bid for that auction taken in isolation. Rothkopf 1999 points out that there are good reasons to anticipate tacit collusion of this kind in daily electricity auctions involving the same bidders.

[3] "Hockey stick" bids are bids into a market clearing price auction offering most capacity at marginal cost and the rest at much higher prices. If several bidders do this, the market-clearing price is more likely to be high than if any one bidder did it, and, if it is high, all winning bidders will be much better off.

[4] See Ghajar *et al.* 1996 and Wolak and Patrick 1996a. Many customers are not in a position to even consider such a choice since their instantaneous use of electricity is not metered or billed. Others, who do have time sensitive metering and billing may not have technology in place to react on short notice to extreme changes in prices.

2 The Proposal

The basic idea is that at any point of time any seller that controls enough uncommitted generating capacity to put an electrical grid (or any part of it isolated by transmission constraints) into deficit be denied any role in setting the price of electricity. Instead, I propose that that seller's bid be ignored, but that it be required to generate to the extent that its capacity has variable cost less than the system marginal cost. Note that by committing its capacity in advance, the seller can avoid this out come. The denial of a role in setting the price is proposed only for those with both the capability and the economic interest to put the system into deficit. Before discussing the pros and cons of this idea, variants of it, and implementation problems, I would like to develop an example so that the idea is clear.

Suppose that there are 18 generators each with a capacity of 5 and one generator with a capacity of 10. Thus, the total capacity is 100, and the largest generator has only a 10% share of the capacity. Suppose that half of the 18 small generators have a marginal unit cost of 5 and half of them have a marginal unit cost of 10. Suppose that the large generator has a marginal unit cost of 7. If the suppliers act independently and the completely inelastic demand is, say, 75, the price will be 10, the marginal unit cost of the marginal supplier. However, if the inelastic demand is 94, the large generator, by withholding more than 6 units can make the price arbitrarily high. The proposal is that whenever this situation arises, the large generator be required to run. Its capacity would be subtracted from the demand, and the remaining generators would supply 84 units at a price of 10. As discussed below depending upon the variant selected, the large generator would be paid a price in the range between its variable cost of 7 and the market-clearing price of 10 paid to other generators. The large generator may well not like being paid less than the market-clearing price. However, it can avoid this outcome and be paid the market-clearing price for the electricity it sells by disposing of its control of a sufficiently large part of its capacity or of its ability to profit from high prices. In the above example, the large generator could sell 5 units in advance. If it did so, then withholding 7 units of capacity to put the market into deficit would be unprofitable for it. If it did this, it would be generating only 3 units but would be committed to delivering 5 units. Thus, it would be a net buyer of 2 units at the abnormally high price it caused.

3 The Proposal

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4 Dealing With Complications

This idea faces a number of potential complications. I do not think that any of them invalidate it, but each of them needs to be dealt with appropriately.

One complication is the definition of capacity. At times, generating plants fail or are unavailable for service due to preventive maintenance. My proposal for handling this is that for the purposes of administering this proposal that the total nameplate capacity of the *industry* be derated by expected unscheduled maintenance and, during off-peak seasons, for normal preventative maintenance. However, I would not derate an *individual company's* nameplate capacity in this way. If a generating company has a single generator, then this is not a problem since if that generator is unavailable the company will not have power to sell. If, alternatively, the company owns several generators, it will face some disadvantage from this approach. On balance, however, this seems like a simple workable rule that will not seriously disadvantage any company. At worst, it would require particularly large companies to commit slightly more of their capacity in advance.

The appropriate definition of demand has some subtleties. How should we treat reserves in the definition of demand? If calculated correctly, reserves are the larger of two quantities. One of these is the extra capacity required to preserve system reliability in the face of reasonable equipment failure scenarios. For example, the failure of any one transmission line or generator should not threaten the system. The second reserve quantity is an allowance for unexpected demand fluctuation. In my view, all of the first kind of reserve requirement needs to be included with the definition of demand. Any additional reserve requirement above this reliability requirement is more problematical. (It makes sense to cut off supply to some electricity users to preserve system integrity. It doesn't make sense to cut off supply involuntarily to some electricity users to avoid the possibility of having to cut off some users in the future if demand increases.)

An important issue is what happens when supply falls short of demand. In this situation, a system emergency exists, and load will be shed. At this point, the appropriate marginal value of electricity is the value of the shed load. This is a high value. I would have this value estimated (in advance) by the system operator and treated as the system marginal cost when load is being shed. In such a situation, all capacity would be dispatched, and every bidder that supplies its nameplate capacity should be paid this amount. Any bidder supplying a smaller amount should have an affirmative duty to prove that it was not willfully or negligently withholding capacity in order to be paid more than its variable cost on any uncommitted capacity it controlled.

Transmission congestion can complicate the definition of both demand and of capacity. The ideal definitions would compute demand and capacity within zones that are actually, as opposed to potentially, separated by transmission congestion. Where such zones exist and are well understood, this is possible and appropriate. An example can help illustrate what is needed. Consider the linear, three-node network illustrated in Figure 1. In it, Company X has a total capacity of 150, other companies have a total capacity of 470, and overall demand is 400. Thus on a total basis, company X is not pivotal. However, Company X has 50 of the 170 units of capacity at bus C, and due to transmission constraints at least160 units of capacity at bus C is needed to meet the demand at busses B and C. Hence, Company X's 50 units of capacity at bus C is pivotal. Thus, if this capacity is unhedged, it will receive only its marginal cost. However, Company X's 100 units of capacity at bus A is unaffected and would get the market-clearing price calculated with the appropriate network model.

A critical complication is how to deal with power imported from outside of the system. The analysis and example above assumed a closed system. Some separately administered systems, such as California, are far from being closed systems. Even some regional systems would not be completely closed. However, just as a system operator predicts demand, it can predict demand net of imports. Neither prediction will be perfect, but if the system is substantial, the operator ought to be able to predict well enough to make it operate reasonably. Obviously, the predictions would be better and this proposal would work better in a system that is closer to closed. If a system is suffering from the exercise of market power by suppliers outside of its control, then either it must be given power over those with that market power or it must be conceded that a more inclusive system is required for an efficient and fair market.

Another complication is how to decide if a contract signed by a generator is adequate to mitigate market power. Contracts come in a wide variety of forms. One way to deal with this is for the system administrator to approve a variety of standard contacts and conditions. The criteria for approval should be that the contract and conditions clearly remove a company's incentive to withhold capacity. If the use of pre-approved contracts and conditions is too restrictive, the system administrator can use an "IRS-type" system of self-reporting with auditing and penalties. The standard contracts and conditions could still be used by anyone who didn't wish to risk an adverse audit decision. If a new type of appropriate contract becomes popular, the companies could ask the system administrator to approve it with appropriate conditions as a standard type. If a company uses a nonstandard contract, it would have an affirmative duty to prove that it had given up the incentive to withhold power.

It is instructive to extend the example based upon Figure 1 in this context. In that example, if Company X sold in the forward market more than 40 units of power for delivery at bus C, it would avoid being pivotal *provided that it does not own the transmission rights from bus A to bus B.* To see the importance of the italicized condition, suppose that it sells 45 units of capacity at bus C, but owns 20 units of the transmission rights from A to B. Then, by withholding 11 units of capacity it would put the system into deficit at busses B and C. Company X would lose a large amount on the 6 units it would be short, but it would gain back more than three times as much on the 20 units of transmission rights from A to B it controlled. Hence, such a hedge would not be adequate; Company X would still have the incentive to withhold power.

Any reduction in electricity cost due to companies having too much unhedged capacity should be used to reduce the purchase cost for electricity buyers during the relevant period. If this proposal works well, however, companies will usually sell, in advance, enough power to get paid the market clearing price and the amount involved will probably be small compared to the general administrative costs of running the system. In this case, it can be used to reduce the "tax" to the electricity users that is used to cover that cost.

5 Implementation

Implementing this approach requires the system administrator to know quantitatively who controls or has the right to control generation capacity at any given moment. The obvious way to do this is to have an online system in which traders can instantly register with the system operator changes in control or economic interest.[5] In most cases, a single registration could change two different company's ownership status just as registering a deed or transferring an automobile registration creates one interest and ends another. Traders would be required to register trades before auctions results are calculated. Intentional profiting from failure to do so, would be cheating just like tax evasion or criminal anti-trust violations and should be treated accordingly. Mere failure to report without economic consequences would not be cheating, and the consequences of accidental errors could be corrected when they are discovered. Not punishing non-reporting when there are no economic consequences has the implication that if contracting so as not to have absolute market power becomes routine, little will need to be reported.

There would be a one-time cost of creating and checking a computer system for this and for registering initial capacities.

In addition, a way will have to be selected to determine the marginal unit cost of each plant. There are standard costing methods. One approach would be to determine the cost elements for each plant (e.g., therms of natural gas per KWh) on an engineering basis and the current values of these cost elements. Then, an index to these costs could be developed so that estimates of them can be calculated at any time using information on current factor costs. There

[5] Disclosure of this information by the system operator like the disclosure of bid information must be delayed sufficiently to obviate its use in facilitating collusion.

may be better approaches to this problem, but in any case, if the overall system works well, there will be little need to use these cost numbers, so extreme accuracy may not be critical.

For systems in crisis, it is critical that these steps will take time. Thus, such systems may well need more drastic short-term fixes until this system can be agreed upon, implemented and tested.

6 Possible Variations

There are at least two kinds of variations on the scheme just described that have some appeal and should be considered. First of all, the scheme uses as its cut off level of capacity control by a company the amount that will allow that company unilaterally to put the market into deficit. Given that this auction is repeated daily with the same participants, it is reasonable to expect some tacit collusion to develop. (See Rothkopf 1999) This suggests that a more severe cut off level might be appropriate and needed to protect electricity consumers and improve efficiency. The extra amount to tighten the cut off level is subjective, but a standard that required companies not to be within 1% of putting the market into deficit certainly seems reasonable, and might well help combat "hockey-stick" bids.

Another factor that could be varied is the level of payment to bidders who are over the cut off level. In order to avoid a moral hazard problem, the payment needs to be at least the bidder's marginal unit cost. Making the cut off level the market-clearing price figured without the company's bid (10 in the example above) is the highest possible level that does not cause serious problems. However, while there is some room between those two levels, I think that the higher level would be an inferior choice since it would provide little or no incentive for bidders with control of too much capacity to adjust their level of control downwards. It may well be that if the compensation level for bidders over the cut off level is low, such compensation will never need to be paid, but that if it is too high or just high enough, it will be paid regularly. One potentially interesting compromise is to use the average of the unhedged bidder's marginal cost and the system's market-clearing price figured without the company's bid. This compromise has the advantage that it avoids the moral hazard problem that would occur if the estimate of the marginal cost were too low while maintaining a positive incentive for a bidder to be sure that she is adequately hedged.

7 Discussion and Conclusions

Is a system like the one proposed needed? There is some economic theory that suggests that it may be superfluous. See Allaz 1992 and Allaz and Vila 1993 for models that suggest that oligopolists already have incentive to enter into forward contracts. However, whether for institutional reasons, inertia, tacit collusion, or other factors not considered in these papers, there are newly deregulated electricity markets in which inappropriately elevated prices are a problem.[6] While there is certainly a cost of setting up a system such as the one proposed, setting

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[6] See Wolfram 1998 and Wolak and Patrick 1996a and 1996b on the UK electricity market. Krugman 2000 says, "California power companies…clearly have both the means and incentive to [rig electricity prices]." Private

it up should be considered a one-time cost of deregulation. If and when forward contracting that eliminates unilateral market power becomes routine, the cost of running the system should be small. However, not having the system when it is needed risks failure of the deregulation.

The proposed system should lead to most power being contracted for in advance. This is not only desirable for market power mitigation purposes, but it will also aid scheduling. In addition, the forward prices for electricity should reflect the chance that there will, in fact, be a true shortage of generating capacity. As capacity is perceived as becoming tight and that chance increases, the forward prices will rise. These higher prices will reflect expectations about demand rather than about market power. Thus, such prices will supply the best possible market signal for capacity expansion. Furthermore, since these are steadier prices, they will support a lower cost of capital for new capacity.[7]

This approach will have strong political opposition. In particular, those currently exercising market power will be reluctant to give it up. That kind of opposition can be expected, however, for any approach that will limit market power. Hence, if the argument of strong political opposition were taken as decisive, we would have to concede that nothing could be done to curb the exercise of market power. Furthermore, failure to control market power is likely to lead, eventually, to a major political backlash and full-scale reregulation.

Assuming, however, that something will be done to control market power, this approach has a lot to recommend it. It is narrowly focused on situations in which there is undoubtedly extreme market power. It has no effect elsewhere. (Indeed, given its limited scope, it should not be used as an excuse to avoid all other efforts aimed at the control of market power.) It gives companies with momentary extreme market power easy ways to dispose of it without long-term consequences. Its administration, once it is put in place, should not be particularly burdensome. Finally, and somewhat to my surprise, I am not aware of serious alternatives that are narrowly targeted on extreme market power.

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communications I had in New Zealand in 1999 suggest that prices in that country's electricity market are, at times, constrained by political concerns rather than by short-term market forces.

[7] Note, however, that we are not requiring that there be multiyear forward contracts. If they do not run into regulatory or other problems, such long-term contracts between load serving entities and electricity suppliers would provide an ideal basis for capacity expansion. (Whatever their other disadvantages, regulated utilities tend to have low costs of capital. Deregulation has, in some places, made installing generating capacity a task for high-cost venture capital.) Ironically, one potential obstacle for such highly desirable multiyear contracts is "retail choice." If the customers of a regulated distribution company can choose to get their power from other sources, then the distribution company risks being stuck if it signs a long-term contract that turns to have, in retrospect, too high a price, but it cannot profit from good outcome. In principle, customers who are free to chose could themselves contract long term, but transaction costs and enforceability issues make this highly impractical.

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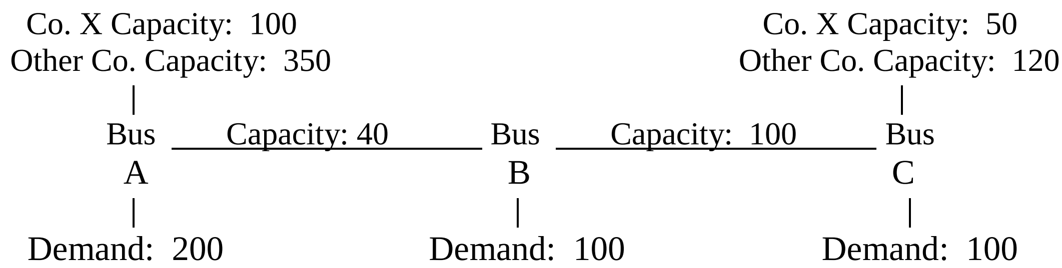

Figure 1. Example Involving a Transmission-Constrained Network. Generating capacities, their ownership, and demand are shown at each bus. Capacity is shown on each line.