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The authors of this article were brought together by the California Power Exchange to provide expert opinion on the narrow issue of uniform vs. pay-as-bid auction structure. While significant events in California have overtaken the initial purpose of the panel, it is the authors' belief that the logic and conclusions hold widely where there is consideration of use of pay-as-bid structures in electricity markets. The authors acknowledge the support of Doug Zona and Natalie Efland at Cornerstone Research, New York, in preparing the report and this article.

Uniform Pricing or Pay-as-Bid Pricing: A Dilemma for California and Beyond

Any belief that a shift from uniform to as-bid pricing would provide power purchasers substantial relief from soaring prices is simply mistaken. The immediate consequence of its introduction would be a radical change in bidding behavior that would introduce new inefficiencies, weaken competition in new generation, and impede expansion in capacity.

Alfred E. Kahn, Peter C. Cramton, Robert H. Porter, and Richard D. Tabors

In November 2000, the California Power Exchange appointed a panel to investigate “whether the current rules for determining the market price in the California Power Exchange Day-Ahead market results in a fair and efficient price for electricity in California.” More specifically, the authors of this article were called upon to express an opinion on whether the successful sellers of power in that market should all receive the uniform, market-clearing price (as they were under the Power

Exchange rules) or, instead, their several bid prices—that is, the prices at which each offered its energy blocks. Those approaches typically are referred to as “uniform pricing” and “pay-as-bid,” respectively.

The timing of the commission proved to be ironic. Inspired by what was almost universally perceived as the progressively unsatisfactory behavior of the several associated deregulated California energy markets—characterized by frequent price spikes in both sum-

mer 2000 and winter 2000–01—the performance of these markets so deteriorated, exhibiting such extreme price spikes both on and off peak, as to raise fundamental questions about the structural design of the deregulated industry, if not about deregulation itself. In these dramatically altered circumstances, the suggested remedy we were called upon to evaluate has virtually disappeared from view.

We were neither commissioned nor had the opportunity to reach settled conclusions about other possible remedies, palliative or fundamental, for these unsatisfactory developments; or to apportion responsibility between the structure of the deregulated market and other, external circumstances—such as high natural gas prices, unexpectedly rapid growth in demand, lower-than-expected availability of hydro power, extremes of summer and winter weather throughout the West, plant shutdowns for maintenance and emission constraints—that would in any event have had painful consequences. This article focuses only on answering the narrower but nevertheless important question posed to us.

In sum, our response is that the expectation behind the proposal to shift from uniform to as-bid pricing—that the shift would provide purchasers of electric power substantial relief from the soaring prices of electric power such as they have recently experienced—is simply mistaken. The immediate consequence of the introduction of as-bid pricing would be a radical

change in bidding behavior that would

- Forestall any anticipated savings;
- Introduce unmeasurable inefficiencies in the dispatch of power and impose new costs on generating companies, which would inevitably tend to increase rather than decrease average prices;
- Tend to weaken the competition in generation that is the best safeguard against exertions of

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monopoly power, such as may have contributed to the sharp price increases at times of peak demand; and

- Impede—again to an unmeasurable extent—the expansion of capacity that, along with intensified demand-side response, is the only fundamental remedy for the recent poor performance of these markets.

The following sections, first examine the likely effect of a change from uniform price to pay-as-bid on bidding behavior and market performance in a competitive environment. We then consider its likely consequences in an

environment in which, as several studies have concluded, some generators possess, and have exercised, substantial monopoly power at times when demand presses hard on supply. We do so, first, in terms of the relative susceptibilities of the two auction systems to exertions of that power, and second, the likely effect of the proposed change on the fundamental remedy—the erosion of that power by competitive entry and expansions of capacity. Finally, even though, as has been already pointed out, we are not in a position to recommend other, more promising remedies, we feel obliged, in view of our negative appraisal of this particular proposed reform, at least to mention other possible ones, among those already being widely considered, that seem likely to be more effective.

I. Pay-As-Bid vs. Uniform Price in a Price-Taking (Competitive) Environment

In this section, we examine the merits and drawbacks of these two bidding systems on the assumption—on which deregulation itself was predicated—that the wholesale electricity market is or can be effectively competitive. We recognize, of course, that the argument for moving to pay-as-bid is typically predicated on the belief that the recent extreme price spikes have reflected the exercise of monopoly power, but reserve our assessment of the issue in that context for the next section.

Under the present uniform-

pricing rules, suppliers in an effectively competitive market have every reason to bid approximately their marginal opportunity costs for energy¹ in each of the blocks of power that they offer. They know that if any of those bids is rejected because there are lower bids sufficient to satisfy the demand, they will be better off, because they will not have committed themselves to sales at prices that fail to cover their avoidable costs. More important, they know also that on their accepted bids they will receive the full benefit of whatever price above that level is necessary to equate demand and supply in the market, regardless of the level of their own bids, permitting them to pocket the difference between their avoidable costs and the market-clearing price as a necessary contribution toward recovery of their fixed charges and profits.

Just as with the economic dispatch of power practiced by power pools—dispatching power, that is to say, in merit order of generators from lowest to the highest marginal cost output necessary to meet demand—the consequence is that power is supplied at the minimum cost at each point in time. (As for the behavior of costs over time, the theory of deregulation is, of course, that the pressures of competition will force generators to minimize their costs in order to maximize the profits they can earn from the competitively determined market clearing prices.) So long as competition is effective (which condition, to repeat, we recognize is unlikely to be fully satisfied today), any generator that with-

holds power in hope, by so doing, of raising the market-clearing price and so earning monopoly profits, will find itself displaced by competitors bidding their own, lower, marginal costs. The only consequence for withholding power would therefore be a sacrifice of the difference between the competitive, market clearing price and its incremental cost of producing the output it has withheld.

The naïve expectation of advo-

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cates of a shift to pay-as-bid is, of course, that since all the infra-marginal bids—the ones below the highest marginal cost output necessary for the sum total of accepted bids to satisfy market demand—will under uniform pricing receive *more* than their bid prices, the change in the rules would simply wipe out those markups; that the average price purchasers will have to pay under pay-as-bid will incorporate no markup above marginal costs at all. For example, if the successful bids for a particular hour were of equal blocks of output with incremental costs, successively, of \$30, \$40, and \$50 per

MWh, the market clearing price of \$50 will, under the uniform price system, bestow on the successful bidders markups above marginal costs of \$20, \$10, and zero, respectively, and pay-as-bid will reduce those markups all to zero and the average price to \$40.

The critical assumption is that after the market rules are changed, generators will bid just as they had before. The one absolute certainty, however, is that they will not. Knowing that unless they changed their bidding practice under the new system they would receive only their avoidable costs on all their successful bids—yielding them no contribution to their fixed or common costs, let alone profits—they obviously will universally change their practice immediately, bidding instead at what they *expect* will turn out to be the market-clearing price—\$50 in the foregoing simple example.

To the extent that the several bidders were able perfectly to predict the market-clearing price, in short, the savings from the change in the rules for consumers would prove to be zero. The *only* difference between the average prices actually realized under the two systems would, therefore, be the extent—and only the extent—to which their predictions proved to be mistaken.²

Setting aside for later consideration the possibility that pay-as-bid pricing might be more effective in curbing exertions of monopoly power, if there is no reason to expect that prices will be consistently higher or lower under pay-as-bid, what other effects would

the change be expected to have? The main ones seem to us to be the following:

1. Pay-as-bid introduces some inevitable reduction in efficiency as generators find themselves forced to depart from bidding their marginal costs if they are to receive any compensation for their fixed costs or contribution to profits. With all bids exceeding the marginal costs of all blocks of power, by amounts that depend upon the varying estimates of the several bidders of what will prove to be the marginal, market-clearing bid, the perfect, total cost-minimizing merit order dispatch will, inevitably, no longer be assured: Some lower-marginal cost bids will be rejected—because their bidders have overestimated the market-clearing price—in favor of other, higher-marginal-cost power offered with more conservative markups. Because so very much is at stake in terms of the bidders recovering their total costs or any profit, and because the constantly changing demand and supply conditions that will determine the market clearing price are in important measure unpredictable and the ability of the several sellers to predict them likely to differ substantially, their several bids will vary correspondingly in the markups above marginal cost that they incorporate. The consequent inefficiencies stemming from departures from merit order dispatch of their plants are likely to be large.

Inefficiencies will not be a consequence of forecasting errors only, if bidders differ substantially and

consistently in their relative marginal costs. In such circumstances, occasional inefficient outcomes would be the consequence of rational strategic bidding.³ For example, if there are two bidders, one of which is known to have lower costs than the other on average, the bidder likely to have higher costs will rationally bid with a smaller markup over its operating costs, than the bidder with lower costs. The latter will feel free to incorpo-

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rate a larger markup in its bids, because it knows its rival is relatively unlikely to underbid it. The consequence will be that the disadvantaged bidder will be called on to supply too often, because it will have submitted a lower bid in some instances in which it has higher costs than its rival.

Moreover, the larger the number of competing bidders on the supply side, the greater the resultant inefficiencies will be. Suppliers with a large complement of generating stations would continue to draw upon their several plants in the correct rank order, on the basis of their respective marginal costs.

The greater the number of separate generating companies, in contrast, the greater will be the number of instances in which output will be drawn from a higher-marginal-cost generator in preference to a lower-cost one, because the owner of the former had bid on the basis of a more conservative prediction of what the market-clearing price would turn out to be. Consumers end up bearing the costs of such inefficiencies.

2. Another inefficiency inescapably introduced by moving to pay-as-bid would be the cost of forecasting market prices that it would impose on all participants. Under the uniform, market-clearing price system, sellers have every motivation to bid their marginal costs, which are of course readily available to them. The change in the method of remunerating them would introduce large uncertainties into their calculations and the correspondingly large costs of attempting to forecast what the market-clearing price or prices would turn out to be. These costs, too, would ultimately be borne by consumers.

3. Finally, and in a sense worst of all, it is likely to discourage competition—to which consequence we now turn.

II. The Effect of the Proposed Change on the Exercise and Dissipation of Market Power

Once we move from the assumption that generation markets are effectively competitive to the more realistic one that they are, at best, only imperfectly so, it becomes

necessary to try to decide, first, whether uniform price or pay-as-bid is likely to be more conducive to the exercise of such market power as some of them may possess and to the dissipation of that power over time.

A. Small Bidders are Disadvantaged under Pay-as-Bid

Under the uniform price rule, competitors prosper or fail on the basis of their relative generating efficiencies alone. Under pay-as-bid, their profitability depends heavily also on successful forecasting. From the standpoint of making generation markets more effectively competitive, even more troublesome than the effect of pay-as-bid in creating uncertainties and imposing the costs of forecasting would be the differential relative burdens on small and large firms. There are large economies of scale in the efforts to gather the requisite information and make such forecasts on a continuing, hour-by-hour and day-by-day basis. The small firm would have to mount essentially the same kind of effort as a large one, at a much higher cost per unit of output. Not only will the uncertainties introduced by pay-as-bid tend to discourage the investment in additional generating facilities that is one major part of the essential long-term remedy of the industry's present poor performance, it will have an especially discouraging effect on investment by small firms, the economic feasibility of which was an essential premise of deregulation itself.

There is a particularly ironic aspect of the relationship of these two alternative pricing methods on the prospects of smaller generators challenging the larger incumbents. One powerful impetus behind the proposed shift is the perception—which we will proceed to describe—that the uniform pricing system is susceptible to gaming by large bidders, withholding their supplies in times of



anticipated shortage in order to lever up the uniform price they receive on all their accepted bids. But under uniform price, smaller competitors likewise benefit from any such exertions of monopoly power: They, too, automatically receive any monopolistically elevated prices. We do not wish to make too much of the point, since we will conclude that the proposed reform, in itself, would not substantially alter that situation. To the extent that it does have such an effect, however, it will almost certainly be disproportionately at the expense of smaller competitors, who do not have the ability to

game the system themselves in that way or have direct knowledge of the games large bidders may be planning to play, and therefore to reflect in their bids the anticipated leverage effect of such tactics on price. Under uniform price, no such forecasting is necessary: The monopolistically leveraged price automatically goes to all competitors alike.

To the extent, then, that the present markets are insufficiently competitive and the success of deregulation depends—as indeed it does most fundamentally—on making them more competitive, the proposed shift to pay-as-bid is *almost certain* to be counterproductive.

B. The Relative Susceptibility of Uniform Price and Pay-as-Bid to Monopolistic Gaming

A substantial number of responsible studies have concluded that the extreme price spikes in recent years, at times when demand would in any event have pressed hard on available capacity, were magnified by some large generators “gaming” the system: knowing in advance that supplies were going to be short at those times, withholding some capacity in the expectation that it would increase prices.⁴ For a generator to benefit from such a strategy several conditions must hold. First, demand must, in the aggregate, be inelastic. Second, the generator must control a mix of capacity such that withholding a unit from the market will lever up the market clearing price received by its other, successfully bidding units suffi-

ciently to more than compensate for the sacrificed net revenue on its withheld capacity. Observe that such a practice would not require a high degree of industry-wide concentration, given the very thin margins of excess capacity at the times of peak demand and the extreme inelasticity of demand in the short run. In these circumstances, it takes only a modest amount of withholding relative to the size of both the entire market and the total capacity of the game-playing generator—whether by simply not bidding some fraction of one's operable capacity or deliberately bidding it at a price markedly above its incremental cost—to produce a higher clearing price.⁵

This kind of perceived behavior has lent plausibility to the proposal to substitute pay-as-bid for uniform market-clearing prices. It is only the prospect, under the present system, of receiving on all their sales the benefit of the increase in market price caused by withholding some portion of their capacity that large generators can expect to profit from that practice. The reasoning is that under pay-as-bid, in contrast, such generators would have to bid the estimated monopolistically elevated price on all their proffered sales in order to reap those gains, at the immensely increased risk⁶ that some or all of those higher bids will prove to have been excessive and therefore be rejected. The consequent loss would be the entire difference between their actual marginal costs and the ultimate market price. The proposed

change in the pricing method would, by this reasoning, therefore dramatically alter the balance of risks and potential gains.⁷

Just as the naïve expectation that a shift to pay-as-bid will produce a dramatic reduction in the average prices consumers pay ignores the certainty that generators will radically alter their bidding practices to frustrate achievement of that result, the expectation that it



would discourage monopolistic withholding fails to take into account the ways in which bidders will respond by changing their bidding behavior correspondingly. If and to the extent that monopolistic withholding has occurred in the past, bidders would henceforward, under pay-as-bid, attempt to predict the consequent behavior of the market prices in their several bids and, to the extent they succeed, the anticipated benefits of the change for consumers will prove to have been illusory.

We are somewhat skeptical also of the claims that pay-as-bid pric-

ing will diminish the ability of the parties to collude tacitly to increase prices.⁸ A bidding process that is repeated daily is precisely the kind of game that lends itself to such collusion; changing the pricing rule would not alter that. Indeed, recent experiments conducted at Cornell University, the University of Arizona, and CalTech all suggest that experimental subjects learn how to collude tacitly under either pricing rule.

There is, however, one important difference between the two. The large generator, knowing that it is or will be withholding and when and by how much, is likely to be in a much better position than the small one to anticipate the results and incorporate those anticipations in all its bids. In this respect, once again, the shift to pay-as-bid will discourage the increased competition that is a critical part of the long-run remedy.

Another possibly important difference that argues against moving to pay-as-bid is the greater transparency of bidding behavior under uniform pricing than under pay-as-bid facilitates attempts to detect collusion or quasi-collusion. As we have already emphasized, if the market were competitive all bidders would have every incentive under uniform pricing to bid their true marginal costs. Since at least marginal generating costs are easily measured, to a first-order approximation, it should be feasible to ascertain whether bid prices had exceeded those levels, and from this to infer that collusive or quasi-collusive bidding had

occurred. Under pay-as-bid, in contrast, every seller would be forced to bid above its marginal cost even if the market were perfectly competitive, so there would be no direct way for observers to identify exercises of market power from the bid data.

III. The Proposed Change in Confrontation with the Fundamental Causes of the Unsatisfactory Performance So Far and Other Possible Remedies

The roots of the unsatisfactory behavior of California markets since deregulation run far deeper than its particular method of remunerating bidders in power exchange (PX) markets. Assessment of the required palliatives or remedies is correspondingly more complex.

The fundamental causes are, clearly, the inadequacy of generating capacity in the face of unexpectedly sharp increases in demand throughout the West, intensely aggravated by the many other adverse developments on both supply and demand sides to which we have already alluded. These would have produced sharp, painful increases in wholesale prices, both on average and particularly at times of peak demand, regardless of the method used for determining the compensation of bidding suppliers.

The proposed change in the bidding rules that we have been asked to evaluate would in our judgment have at most only a

slight effect in mitigating these problems and, if anything, introduce new uncertainties that would, on balance, discourage the expansion of capacity (particularly of smaller independents) that is one essential part of the fundamental remedy.

In rejecting this proposal as likely to be ineffective at best and, more likely, counterproductive, we by no means imply that



other proposed actions—both palliative and more fundamentally corrective—are not worthy of consideration; on the contrary. As pointed out in our introduction, however, we refrain from attempting to assess these various possibilities not merely because that was not part of our assigned task, but, more definitively, because we have not had the opportunity even to attempt to reach an informed consensus about them. At the same time, we have formulated some at least provisional opinions about some of these alternative approaches that we describe below.

A. Direct Interventions to Combat Strategic Withholding of Supplies

We concur in the suggestions of some of our witnesses that some agency should have the authority (1) to investigate incidents in which large generators may have engaged in strategic withholding of supplies in times of peak demand, with the effect of sharply increasing market-clearing prices; (2) to issue orders prohibiting such practices; and (3) to impose penalties. If withholdings such as these were unilateral, it seems unlikely they could be attacked under the Federal antitrust laws; but organized exchanges do typically establish and enforce rules such as these, designed to ensure that they be free of manipulation. These are the functions that the Independent System Operator (ISO) and the PX in California (their Market Surveillance and Market Monitoring Committees, respectively) assumed by undertaking to identify and correct market problems, whether the result of design flaws or inadequate competition. This is critical when elasticity on the demand side of the market is at best immature and at worst nil. Without the ability of demand to respond to variable prices, those prices will be set entirely by the supply side and by a small number of players.⁹

B. Long-Term Contracting

The legislation deregulating the industry in California specifically required the three California investor-owned utilities (IOUs), until such

time as they sold off their generation, to offer all of their energy for sale through the Cal PX and ISO, thereby in effect receiving the market clearing price. Until such time as they had recovered all of their agreed-upon stranded costs, the local distribution companies were required also to purchase all of their energy through the Cal PX and to sell to their customers at a regulated rate intended to give all customers immediate benefits of deregulation. This effectively prevented them from entering into forward contracts with generating companies for energy, evidently in the belief that only in this way could emergence of an effectively functioning wholesale market be assured.¹⁰ For these and various other reasons, virtually all energy for retail sale in the state of California has been purchased and sold in the spot market,¹¹ instead of a large portion being hedged through forward purchases.

Several parties, including, provisionally, FERC, have specifically urged that the two remaining IOUs be permitted to enter into forward contracts with generators.¹² Indeed, the Market Surveillance Committee recommends they be *required* to do so.

The availability of unrestricted long-term contracting offers some promise of improving market performance, since it provides a wider variety of options to both buyers and sellers. Its effect on average prices in the short run would probably be modest, since forward contracts do not by themselves alter the immediate balance of supply and demand that, along with a

possible monopolistic behavior, has been responsible for the price spikes of the past months. Those underlying price-inflating factors are likely to be reflected at least partially in the terms of any long-term contracts into which generators would be willing to enter. Nonetheless, long-term contracting with generators would

- Limit the consequences of exercises of market power in



the day-ahead and real-time markets;¹³

- Permit voluntary sharing between generators and their customers of the risks of extreme market fluctuations, which would in itself be of value to consumers at large;

- Even more important, contribute to the ultimate solution of California's problems, so far as the supply side is concerned, by offering generators, both existing and potential, assurances that could encourage them to make the long-term commitments involved in expanding capacity; and in particular

- Help smaller entrants raise the necessary capital and by so doing enhance the competitiveness of wholesale markets.

As we understand it, the prohibition or active discouragement of contracting outside the ISO and PX had two purposes. The first, to which we have already alluded, was to encourage the emergence of a competitive wholesale market that would separate the operation of the transmission system (the ISO) from the effectuation of purchases and sales of electricity. The expectation was also that requiring the vertically integrated IOUs to sell their generation through the PX and purchase their energy at the market clearing prices in that exchange (and, in real time, the ISO) would limit their ability to exercise market power. Ironically, the restriction has apparently conferred some market power on the now-independent generators and exposed the IOUs and their customers to disastrous financial consequences.

The second purpose of the Legislature and consumer advocates was to protect smaller customers from "cream-skimming": The fear was that if the competitive market were opened first to large customers, with whom generators could enter into long-term contracts, they would reap all the benefits of competition, using their purchasing power to sew up supplies at favorable rates, at the expense of the smaller customers, who would be permitted to enter the market only later. The error here was the apparently underlying perception that competition

is a zero-sum game—that if buyer A benefits by taking advantage of it, it will be at the expense of buyers B through Z.

An important way in which competition works in the real world, however, is by large buyers exerting their purchasing power to obtain favorable prices. That is not a zero-sum game: Those favorable rates are not typically obtained at the expense of smaller buyers, but help break down monopoly and collusive pricing structures, to the benefit of customers generally.

C. Promoting Customer Price Response

A critical deficiency in the California market, which we have already emphasized, is the unresponsiveness of demand to even radically changing prices. The decision to require the IOUs to freeze their retail prices (subject to a guaranteed reduction) until they had recovered their stranded costs precluded any such response.

Demand-side responsiveness to price is essential to the operation of a restructured market—the promotion of increased efficiency in the use of electricity, in the long term, and a much more elastic response to short-term peak prices. We have had neither the commission nor the opportunity to make more concrete recommendations for promoting these goals. We cannot refrain, however, from emphasizing how essential it is, if consumers are to modify their purchasing habits in response to extreme fluctuations in price and by so doing to moderate those fluctuations, that they be offered

inducements by their suppliers to permit their use of power to be curtailed and/or confront retail prices that vary with the correspondingly extreme fluctuations at the wholesale level.

IV. Conclusion

The design of electric industry deregulation in California has clearly proved to be fatally flawed. The expectation behind the proposal to shift from uniform to as-bid pricing—that it would provide purchasers of electric power substantial relief from soaring prices, such as they have recently experienced—is simply mistaken. In our view, it would do consumers more harm than good. ■

Endnotes:

1. In most cases, the marginal opportunity cost is just the incremental cost of generating additional energy. For hydro power, however, it has little to do with physical operating costs, consisting rather of the revenue or value sacrificed by using or selling it today rather than later, or in one place in California rather

than elsewhere, both of which depend in turn on how full the reservoirs are and expectations about future prices. Even for fossil and nuclear plants, the marginal opportunity cost may differ from incremental operating costs to the extent there are opportunities to sell the energy in other markets in and out of California.

2. The U.S. Treasury conducted an experiment, in which it employed both uniform pricing and pay-as-bid mechanisms in the sale of Treasury bills. It found mixed results, and could not conclude that the average winning bid prices of the two mechanisms differed significantly. See, for example, Christine M. Archibald and Paul F. Malvey, *Uniform-Price Auctions: Update of the Treasury Experience*, working paper, U.S. Treasury, 1998; and Gregory Belzer and Vincent Reinhart, *Some Evidence on Bid Sharing and the Use of Information in the U.S. Treasury's Auction Experiment*, working paper, Board of Governors of the Federal Reserve System, 1996.

3. See, for example, Eric Maskin and John Riley, *Asymmetric Auctions*, REV. ECON. STUDIES, July 2000, at 413–438.

4. See, for example, Paul Joskow and Edward Kahn, *A Quantitative Analysis of Pricing Behavior In California's Wholesale Electricity Market During Summer 2000*, National Bureau of Economic Research (NBER), Cambridge, MA, Working Paper No. 8157, March 2001; Robert



A critical deficiency is the unresponsiveness of demand to even radically changing prices.

Nordhaus, Carl Shapiro, and Frank A. Wolak, *An Analysis of the June 2000 Price Spikes in the California ISO's Energy and Ancillary Services Markets*, Sept. 6, 2000; and Severin Borenstein, James Bushnell, and Frank Wolak, *Diagnosing Market Power in California's Restructured Wholesale Electricity Market*, NBER Working Paper No. 7868, Sept. 2000.

5. It might appear that the effect of such exertions of market power would be indistinguishable from the effect of a rising peak demand in a situation of inadequate capacity even under pure or perfect competition: Firms with no market power would likewise be expected to withhold capacity in expectation of soaring competitive prices. That would indeed be expected in any other industry, in which supplies withheld today can be sold tomorrow at prices increased by such withholding. It would not be true, however, in the case of electric power. Power (except hydro) that is not offered in the market today cannot be stored and offered tomorrow. The small generator who withholds in this way simply loses the sales it could have made today. Only a generator with aggregate capacity greater than the anticipated shortage could profit by sacrificing some portion of the sales it is physically capable of making in the expectation of gaining more from the consequent increase in the difference between the newly elevated market price and its own marginal costs on the sales that it continues to make.

On the other hand, the fact that prices at such times may exceed the marginal operating costs of the least efficient generator in use—the usual indicator of monopolistic withholding of output—does not in itself prove that such withholding has occurred: When demand reaches the absolute physical limit of capacity—i.e., supply becomes totally unresponsive to price—the competitive price will rise to whatever level necessary to reduce the quantities demanded to that fixed supply.

6. This risk is not great at peak times, when there is little aggregate excess capacity. It is much greater off-peak.

7. See, for example, Giulio Federico and David Rahman, *Bidding in an Electricity Pay-as-Bid Auction*, occasional paper,

Nuffield College, Oxford, U.K., and University of California at Los Angeles, for submission to California Power Exchange Blue Ribbon Panel, Nov. 2000.

8. Natalia Fabra, *Uniform Pricing Facilitates Collusion: The Case of Electricity Markets*, occasional paper, European Univ. Institute, for submission to California Power Exchange Blue Ribbon Panel, Oct. 2000; and Carlos Vazquez, Michel Rivier, and Ignacio J. Perez-Arriaga, *On the Use of Pay-as-Bid Auctions in California: Some Criticisms and an Alternative Proposal*, IIT Working Paper IIT-00-077A, Nov. 2000.

9. This may appear to be an odd kind of



deregulation. The essential premise of deregulation is, however, that competition will effectively protect consumers from monopoly. If the inadequacy of capacity, in confrontation with an extremely inelastic demand, has created opportunities for the exertion of such power, it would be blindly ideological simply to refuse to proceed against such manipulations, while taking pains not to interfere with the longer-term corrective of additions to capacity and more effective efforts to curtail demand and make it more elastic.

10. The IOUs were able to purchase via forward contracts through the CalPX—but only through the PX—after it first made block forward contracts available in July 1999. Although there are regulatory limits on the amount of forward positions that each IOU may take, they have not reached those limits in availing themselves of this opportunity. They may have been discouraged from doing

so by their past experience with forward purchases in California, in both gas and electric, under which regulators forced them to absorb any losses stemming from the contract prices exceeding wholesale market prices while not being permitted to reap the benefits when the contractual prices were lower. In any event, what the IOUs are vociferously seeking is the ability to negotiate contracts directly with generators.

11. We consider both the day-ahead and real-time markets to be spot markets. Energy contracted more than one day in advance is traded in forward markets.

12. "An essential remedy is the elimination of rules that prevent market participants from managing their risks. Moving significant amounts of wholesale transactions into forward markets will (1) reduce reliance on spot markets, thereby directly reducing both the likelihood and the adverse economic consequences of pricing volatility; (2) eliminate the adverse reliability impacts that the ISO faces each day as its obligation to operate a real-time balance market has become transformed into operating the major commodity exchange at the last minute; (3) increase the likelihood of new generation entry because the uncertain revenue stream from spot markets will not attract the necessary capital investments; and (4) limit the ability of sellers to exercise market power in spot markets." Federal Energy Regulatory Commission, Order Proposing Remedies for California Wholesale Electric Markets, Docket No. EL00-95-000, Washington, DC, Nov. 1, 2000, at 21.

13. The MSC contended additionally that the ability and/or incentive of generators to exercise market power in spot markets is increased by the absence of a significant amount of forward contracting. See, for example, Robert Nordhaus, Frank A. Wolak, and Carl Shapiro, *Analysis of "Order Proposing Remedies for California Wholesale Electric Markets (issued November 1, 2000)"*, Market Surveillance Committee of the California Independent System Operator, Dec. 1, 2000, at 27–28, <ftp://zia.stanford.edu/pub/papers/MSDCDEC01.pdf> or <http://www.caiso.com/docs/2000/12/01/2000120116120227219.pdf> (July 6, 2001).