Nodal and Zonal Congestion Management and the Exercise of Market Power: Further Comment

Scott M. Harvey and William W. Hogan[1]

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On January 27, 2000 the California Independent System Operator (CAISO) filed comments at the Federal Energy Regulatory Commission including a further analysis of the implications of zonal and nodal pricing in electric networks given an exercise of market power. The CAISO statement included an attachment addressing policies regarding alternative pricing models and the exercise of market power.[2] The CAISO response in part supports and in part attempts to rebut the conclusions of Harvey and Hogan (HH) that

> "Local market power presents a complication for the analysis of policy in electricity markets. The issue is complex and dependent on the context of particular facts. However, in the choice between market pricing models based on nodal pricing that recognizes different prices at every location, and zonal pricing that creates administrative aggregations to reallocate costs, there is a nearly dominant answer. The result may appear counterintuitive, but nodal pricing is preferred for efficiency reasons and to mitigate market power. Confusion on this principle may arise from a failure to distinguish between the beneficial effects of real expansion of the transmission grid to allow competition over a larger region, and the detrimental effects of cost averaging and reallocation through the administrative creation of large zones in the face of real transmission

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[1] William W. Hogan is the Lucius N. Littauer Professor of Public Policy and Administration, John F. Kennedy School of Government, Harvard University and a Director of the Law and Economics Consulting Group in Navigant Consulting, Inc. Scott M. Harvey is a Managing Director of Navigant Consulting, Inc. This paper draws on work for the Harvard Electricity Policy Group and the Harvard-Japan Project on Energy and the Environment. The authors are or have been consultants on electric market reform and transmission issues for American National Power, British National Grid Company, Calpine Corporation, Commonwealth Edison Company, Constellation Power Source, General Electric Capital, GPU Inc. (and the Supporting Companies of PJM), GPU PowerNet Pty Ltd., Duquesne Light Company, Electricity Corporation of New Zealand, National Independent Energy Producers, New England Independent System Operator, New England Power Company, New York Independent System Operator, New York Power Pool, New York Utilities Collaborative, Niagara Mohawk Corporation, Ontario Independent Electricity Market Operator, PJM Office of Interconnection, San Diego Gas & Electric Corporation, Sempra Energy, TransÉnergie, Transpower of New Zealand, Westbrook Power, Williams Energy Group, and Wisconsin Electric Power Company. The views presented here are not necessarily attributable to any of those mentioned, and any remaining errors are solely the responsibility of the authors. (Related papers can be found on the web at http://ksgwww.harvard.edu/people/whogan).

[2] California Independent System Operator Corporation, Department of Market Analysis, "Response to 'Nodal and Zonal Congestion Management and the Exercise of Market Power,' " in "Answer of the California Independent System Operator Corporation to Motions to Intervene and Response Comments," Federal Energy Regulatory Commission, Docket No. ER00-703-000, January 27, 2000, pp. 16-20.

> congestion. In the latter case, zonal aggregation subsidizes the monopolist and increases the profits that can be extracted through the exercise of market power. By contrast, nodal pricing supports the market and expands the range of tools available to help mitigate market power."[3]

Importantly, the CAISO response supports a major point of the HH analysis. In particular, the CAISO does not refute the many examples developed in HH in which nodal pricing is no worse than and often better than zonal pricing in mitigating the effects of market power. Previously, the decision rules of the CAISO have implied that zonal pricing was always superior to nodal pricing and the mere existence of market power was a prima facie obstacle to further disaggregation of zones. Now, at a minimum, the CAISO response would support a view that the conclusion could be different in different circumstances, and nodal pricing, with its other inherent advantages, would be a pricing model worthy of consideration even in the presence of market power.

Furthermore, the CAISO and HH agree that "both the zonal and nodal market designs are vulnerable to locational market power and must incorporate specific provisions for mitigating the ability of market participants to exercise market power."[4] And that "locational market power is created by the physical constraints in the transmission system, not by the zonal or nodal congestion management market design."[5] However, the CAISO and HH disagree on whether there are any realistic circumstances under which zonal pricing would be superior to nodal pricing when faced with the exercise of market power, with the CAISO arguing that the story is mixed and HH arguing that nodal pricing is generally the superior approach.

The CAISO response builds on two points. First, that the HH analysis depends on a series of examples or case studies and "[t]he obvious problem with the Harvey-Hogan argument is that a case study cannot establish a result in all instances, or even all instances of practical relevance."[6] Second, the CAISO states that the "purpose of the present Response is to provide an example, in the spirit of the Harvey-Hogan cased study, in which the opposite result obtains, i.e., the zonal market design does the better job of mitigating market power impacts."[7]

On both points, the CAISO is incorrect. As for the first point, the CAISO response is not accurate. The HH paper does contain many examples, intended to "illustrate" the argument and explain the seemingly counterintuitive advantages of nodal pricing. However, the HH paper is clear that the argument goes well beyond the illustrative examples and identifies that "in an appendix, we take up the problem of

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[3] Scott M. Harvey and William W. Hogan, "Nodal and Zonal Congestion Management and the Exercise of Market Power," January 10, 2000.

[4] CAISO response, p. 16.

[5] CAISO response, p. 16.

[6] CAISO response, p. 16.

[7] CAISO response, p. 16.

characterizing the market outcomes in the presence of local market power."[8] This appendix identifies general conditions under which the asserted monopoly price and profit conclusions hold, and identifies the unusual conditions that would be required for any exceptions. The HH analysis is clarified by the examples, but does not depend solely on the examples. However, for some reason, the CAISO makes no mention of the appendix, which is an integral part of the HH paper.

As for the contrary example offered by the CAISO, it is worth discussing at further length because it is very helpful in developing the argument and clarifying the issues at hand. The CAISO example is extreme and unusual. For instance, the generator exercising market power has a very small share of the relevant market,[9] but this could be accepted as device to emphasize an analytical point rather than an attempt to suggest that the CAISO example is illustrative of "instances of practical relevance." It is the analytical point that is important, and the analysis clearly reveals what may stand behind the CAISO's preference for zonal pricing.

In particular, the CAISO's main analytical point could be an unintentional mistake, which would reveal why we come to different conclusions about the preference for nodal over zonal pricing approaches. Or the main analytical point may reveal an intentional policy agenda that we would view as mistaken in the same way, and doomed to failure. This too would explain why we arrive at different general preferences for pricing models in the presence of market power.

As developed in detail below, the example in the CAISO response depends fundamentally on competitive suppliers willingly participating in a discriminatory pricing scheme that has the competitive suppliers bidding and receiving less than the market clearing price. Without this assumption, the details of the example turn on their head and provide further support for the HH preference for nodal pricing. This assumption, therefore, is critical to the argument.

As a mistake, the CAISO assumption may flow from a shorthand commonplace that competitive suppliers should always bid their marginal cost. This argument is correct in the case of a second price auction with everyone paid the market clearing price. Further, it is also used often as a workable approximation in analyses of a first price non-discriminatory auction where everyone is paid the market clearing price.

To be precise, an optimal choice in the standard competitive model, with everyone paid market clearing price, is for the competitive supplier to bid its opportunity cost, which is usually taken to be the marginal production cost. This distinction becomes important in the zonal pricing model because this congestion management system inherently introduces a pricing rule that deviates from the market clearing principle, and

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[8] HH, p. 7.

[9] The HHI in the relevant market would be less than 400 for most conventional market definitions. This is well below the usual Department Justice threshold of 1000 for a presumptive finding of no market power.

introduces the practice of paying at least some suppliers what they bid. This difference in the rules distinguishes zonal pricing from the standard competitive model and inherently changes the incentives facing the competitive supplier. Under this alternative pricing rule, the optimal bid of a competitive supplier is no longer its marginal production cost. In effect, the competitive supplier faces an incentive to bid the expected market clearing price if this is above its marginal production costs. In the CAISO setting of perfect information and no uncertainty, the optimal strategy is to bid the market clearing price.

In the CAISO example, the profitability of this bidding strategy would be revealed either by direct analysis, or the competitive supplier would discover this through simple experimentation. The competitive suppliers in the CAISO example could raise their individual bids up to the market clearing price, and no matter what the bids of the other competitive suppliers, all their output would be taken. Hence, the profitability of this optimal competitive bidding strategy does not depend in any way on collusion or supply withholding. Bidding the market clearing price is the equilibrium competitive strategy under the zonal pricing rule.

Once the CAISO example is corrected to reflect the rational strategy of the competitive suppliers, we see the reverse conclusions from the example. With competitive suppliers following an optimal bidding strategy, the CAISO example adds to the list of examples in HH where nodal pricing provides a preferred approach.

Alternatively, it is also possible that the CAISO's main point arises from an error in assessing the impact of vertical integration on the costs borne by load. The CAISO prefaces its example with a reference to the possibility that a competitive generator might overall be a net buyer, having more load than generation located within the market. This possibility would not change validity of the HH analysis, however, because the net buyer would still have to pay the market clearing price for power purchased from net sellers. The CAISO's calculation of net cost to load does not, however, account for the effect of vertical integration. [10] In essence, the price applied to power transferred internally does not affect the net cost to load because the competitive supplier that is a net buyer overall is paying the price to itself. Whether a competitive supplier that is a net buyer sells its output to itself at higher or lower prices does not matter to the net buyer's overall cost of meeting load. What does matter to the net buyer's overall cost of meeting load is the price it pays for the power it purchases from others. In a competitive market the net buyer will be forced to pay the market clearing price for any power it purchases in the market.[11] If this is recognized, the CAISO's example is again turned around and reveals that zonal pricing leads to higher costs borne by load.

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[10] The calculations in the CAISO example do not apply to a competitive supplier that is a net buyer, because the calculated cost of meeting load does not account for the payments the load would be making to itself for the portion of output that was self-supplied. As seen below, accounting for such payments would also entirely change the outcome of the CAISO example, even if the competitive supplier that is a net buyer were to bid its output into the market at an arbitrarily low price.

[11] A large net buyer might have an incentive to artificially depress the market clearing price but it would accomplish this by bidding high cost production into the market at an artificially low price. Such a buyer could not reduce the cost of its net purchases by altering its bidding strategy for infra-marginal production.

If the assumed bidding strategy assumed in the CAISO example is not an unintended mistake, then it reflects an agenda to apply price discrimination among generators. For the same reasons summarized above, it is not likely that the generators would willingly submit to such price discrimination, and the CAISO strategy is likely to fail. Furthermore, if there is some mechanism for the CAISO to sustain such a discriminatory pricing scheme, then the logic would apply well beyond the case of market power. Were the CAISO able to so discriminate, then the zonal pricing system would do so between low and high cost generators just as well. Such discrimination is unlikely to be successful in the long-run (i.e. after market participants recognize that it is occuring and take it into account in their bids) and even less likely to be desirable in a competitive open access market. However, if this price discrimination does reflect the CAISO's intent, then the relationship between price discrimination and the bidding strategy of competitive generators discussed above may account for the CAISO's complaints in a wide variety of forums and contexts that some generators do not bid their costs in the California market.

Moreover, it is important to recognize that such a policy of price discrimination against low cost generators in constrained regions by the CAISO, if effective, would have an extremely negative impact on the profitability of new generation investments within transmission constrained regions. The inevitable outcome of such a price discrimination policy would be that low cost generation would not be built on a market basis within the transmission constrained regions. This outcome would force the CAISO to enter into RMR type contracts for all new generation capacity sited within transmission constrained regions, completely supplanting the competitive generation market, and entailing substantial extra-market payments to the new generation owners.

In short, the CAISO example is fundamentally a compelling illustration of the importance of the market pricing rules. The CAISO attempt to price discriminate among generators is flawed. Competitive suppliers will not cooperate with policies that are not profit maximizing and transfer wealth to consumers. We would expect to find that competitive generators in California would not bid their costs into a market designed to discriminate against them, and thereby would defeat the price discrimination while also reducing the overall efficiency of the market.[12]

California consumers, at least in aggregate, would be best served by an efficient competitive market. Similarly, we believe that generators will in aggregate be best served by an efficient market. Rather than seeking to benefit California consumers at the expense of generators through a continuing sequence of programs designed to maintain

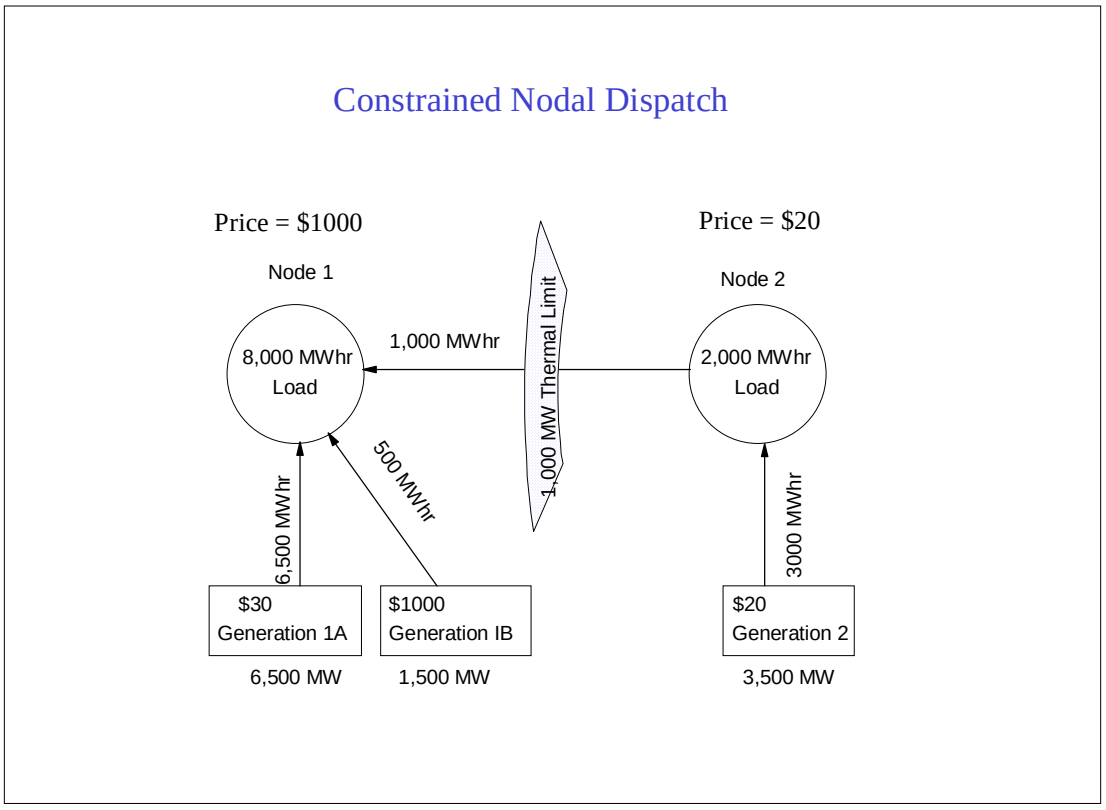
[12] The CAISO makes an argument that if loads in effect controlled the generators then they would have an incentive to bid low to manipulate the market price. ("Generator 1A … has no incentive to raise prices." CAISO pp. 17) Of course, this violates the competitive assumption by making the "competitive" suppliers strategic bidders and suggesting collusion among the competitive bidders. An analysis of offsetting market power on the part of buyers would be interesting, but it is not consistent with the stated competitive framework.

price discrimination and zonal aggregation, the California ISO should simply seek to coordinate a competitive and efficient generation market with nodal pricing.

The CAISO Example

The CAISO advances an example which they claim shows that "a nodal design without adequate market power mitigation in place can yield a more costly outcome than a zonal design." The example operates under conditions where the assumed monopoly bid price is implicitly constrained by a price ceiling, and the monopoly profits are the same under nodal pricing and zonal pricing. Furthermore, the dispatch is unaffected. Hence, the only difference is in the costs to the loads. The CAISO purports to show that the cost to load is higher under nodal pricing. When corrected to incorporate rational competitive suppliers, the opposite result obtains, and costs to load are higher under zonal pricing. Hence, the CAISO example is in fact consistent with the conclusion from HH.

The CAISO example is as shown in the figure.



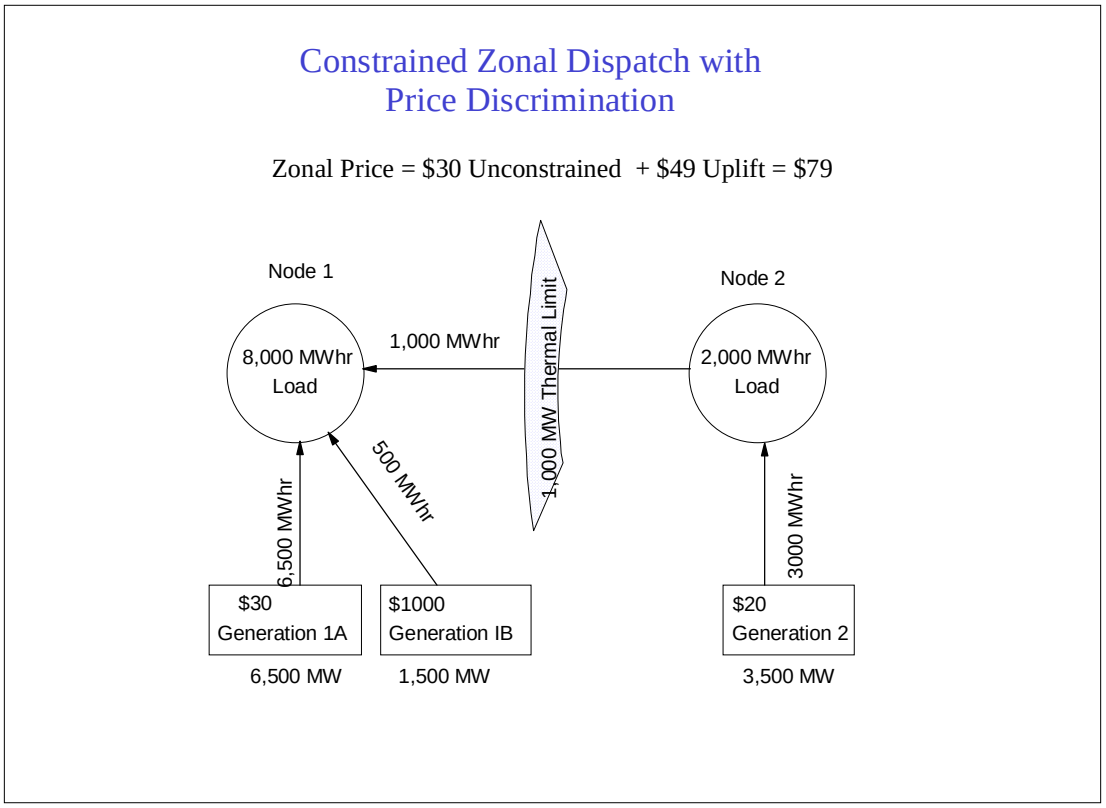
The generators at node 2 are assumed to be competitive suppliers. The generators at node 1 in group A are also assumed to be competitive suppliers. However, the generators at node 1 in group B are assumed to be strategic players who have the same $30 marginal costs as those of 1A but choose to bid $1000 in order to withhold supply and exercise market power. Under the efficient nodal pricing system, with these bids and the constrained economic dispatch, we obtain prices of $1000 at node 1 and $20 at node

2. All loads and all suppliers at each node face the same price at that node. There is no price discrimination for similarly situated market participants. The corresponding quantities are as shown in the figure. The transmission congestion rent of $980 dollars for the 1000 MWhrs moving from node 2 to node 1 is assumed captured by the load. Straight computation gives the total cost to load.

Nodal Total Cost to Load:

8,000MWh * $1000 + 2000MWh * $20 - $980,000 = $7,060,000.

The result for the zonal pricing is somewhat more complicated. The analysis according to the CAISO is shown in the accompanying figure for a successful attempt to price discriminate.



The critical element of the CAISO reasoning is that under zonal pricing, in circumstances in which Generator B is able to exercise market power and raise the market clearing price at Node 1 to $1000, and knowing that they would be paid their bid, competitive price taking suppliers at Node 1 "would bid their cost". In this case, the unconstrained price for the market would be $30. Of course the unconstrained solution would use none of production of generator 1B, and would involve moving 1500 MWhrs from generator 2 to node 1. Since this would be physically impossible, the zonal redispatch to manage congestion would be the same as before. The CAISO assumes the suppliers at generator 1A would still be paid $30, as would the generators at node 2.

However, the generators at node 2 would be compensated for their lost profit from the unconstrained dispatch, a constrained off payment that would be $10 for the 500 MWhr they were forced to reduce. Similarly, the generator with market power at 1B would be paid $1000 for the 500 MWhrs it would have to produce, which is the unconstrained market price of $30 plus a $970 constrained on payment. The resulting uplift would be

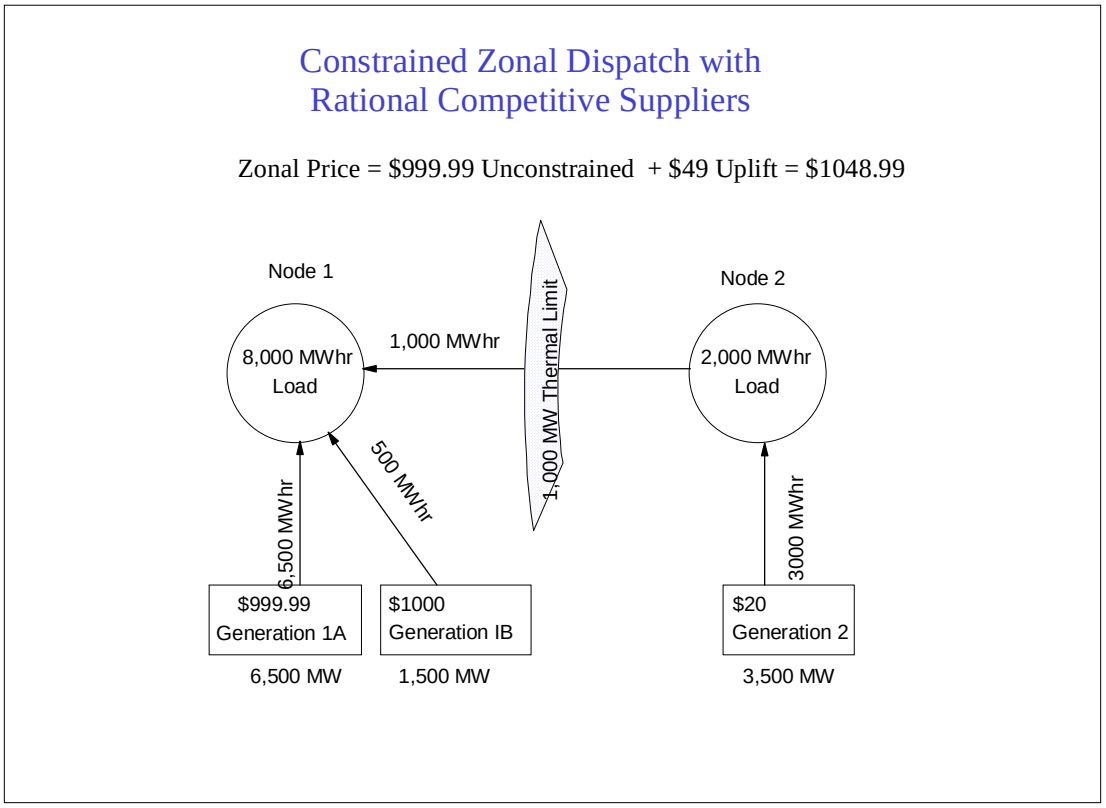
Uplift = ($10*500 + $970*500)/10,000=$49.

Hence, the total price under the CAISO analysis is $79 for a total cost of:

Zonal Discriminatory Total Cost to Load:

10,000MWh * $79 = $790,000.

Thus the CAISO concludes that under zonal pricing the load would see a lower total cost than under nodal pricing. However, this CAISO hypothetical violates the basic principle that the competitive suppliers are assumed to be price takers who maximize their profits. The competitive suppliers could bid their cost and be paid $30/MWh. But if they were rational they would recognize that they could also bid just under the market clearing price, and be paid $999.99/MWh. In an unregulated competitive market, even perfectly competitive firms at Node 1 would bid so as to defeat the price discrimination and be paid the market clearing price. If the competitive firms at Node 1 bid the market clearing price, then the CAISO example illustrates the potential for the cost to load to be higher under zonal pricing than under nodal pricing.



Now the unconstrained price would be $999.99. This would produce the same unconstrained dispatch, which for the same reasons would be physically impossible. The final dispatch would be as before, with constrained on payments of $0.01 for the 500 MWhrs from generator 1B and constrained off payments of $979.99 for the 500 MWhrs of generation that must be backed off from generator 2. Hence the uplift would be the same,

Uplift = ($.01*500 + $979.99*500)/10,000=$49.

However, now the observed zonal price would be $999.99 + $49 = $1048.99, and the total cost to load would be

Zonal Total Cost to Load with Rational Competitive Suppliers:

10,000MWh * $1048.99 = $10,489,900.

With rational bidding by the competitive suppliers, and without successful price discrimination, the total cost to load is higher under the zonal model.

It should be noted that this result does not depend on the coincidental equality between the total demand and the supply at 1A and 2. Suppose that there were 6750 MW of competitive generation at 1A and 3750 MW at Node 2 The competitive generation at

Node 1 would still have an incentive to bid $999.99, and costs to consumers would rise further due to even higher redispatch costs.

(6250MWh + 3750MWh) * $999.99 = hypothetical dispatch cost

+ 250MWh * $999.99 + 500MWh * $1000 – 750MWh * $20 = Uplift

Total zonal cost = $10, 734,898

As mentioned above, the CAISO also refers in its example to the possibility that the generators located at 1A are actually net buyers, rather than pure sellers. Regardless of the "practical relevance" of this assumption, the CAISO's numerical example does not correctly account for the impact of zonal and nodal pricing on loads that are also generators. In essence, the transfer price for the internally provided energy does not affect the net cost of power to loads, only the price paid for purchased power and the cost of generation enters into the cost calculation for a vertically integrated load. The impact of vertical integration on the case posited by the CAISO can be illustrated by assuming that the 6500MWh of generation at 1A is owned by the loads. Under this assumption, the net costs borne by load under zonal pricing is $780,000, while the net costs borne by loads under nodal pricing would be only $755,000. The higher cost of zonal pricing would arise from the artificially high price paid to the competitive generation located at node 2.

The net cost borne by the vertically integrated load under zonal pricing would have three components: zonal payments for energy; generation margins, and zonal uplift costs. These components are shown below:

Zonal payments: (6500MWh + 3500MWh)* $30

Generation margin: 6500 * ($30 - $30)

Uplift Costs: 500MWh * $1000 – 500MWh * 20[13]

The total cost borne by load under zonal pricing is:

$300,000 + 0 + $480,000 = $ 780,000

The net cost borne by vertically integrated load under nodal pricing would also have three components: nodal energy payments; generation margins, and congestion rent credits. These components are shown below:

Nodal payments: 8000MWh* $1000 + 2000MWh * 20

[13] Another way of describing this would be to note that the load buys 3500MWh from others at $30/Mwh, self-generates 6500MWh at a cost of $30/MWh and pays uplift of $480,000 to the generators located at 1B and 2.

Generation margin: 6500 * ($1000 - $30)

Congestion rents: $980 * 1000

The total cost borne by load under nodal pricing is therefore:

$8,040,000 – $6,305,000 – $980, 000 = $755,000. [14]

Once again, it is seen that the total costs borne by load are higher under zonal pricing than under nodal pricing.

The CAISO's example overlooks the fundamental reality that generators will bid differently depending on how they are compensated. If the market rules provide that generators scheduled in the market will be paid the market clearing price, then competitive generators have an incentive to bid their costs. If the market rules provide that generators scheduled in the market will be paid their bid, then competitive generators will have an incentive to bid the higher of their costs or the expected market clearing price.

In practice, of course, competitive generators at 1A would not have perfect information about load or the level of bids by the firm exercising market power at 1B. However, the lack of perfect information would not generally alter the impact of zonal pricing. There would be bidding mistakes, to be sure, but there is no reason to believe that the mistakes would be such that the competitive suppliers would leave very much money on the table. Furthermore, the mistakes would produce added inefficiencies in the choice of the best plants to run, which would ultimately raise costs to load.

The CAISO's example is noteworthy in three respects. First, the logic that zonal pricing will reduce payments by load does not require that the generators at location 1B be exercising market power. The logic would remain the same if these marginal generators simply had higher incremental costs than the generators at 1A. The CAISO logic suggests that the ISO should implement a zonal pricing system to reduce payments to the competitive generators at 1A. It is important to recognize the implication that higher payments should go to high cost generators than to low cost generators. This kind of policy will not create or sustain the competitive markets that are the focus of policy behind electricity market reform.

Second, the logic the CAISO uses to argue that zonal pricing will reduce payments by load could equally well be applied to argue that every generator should be paid its bid rather than the market clearing price. If generators had different costs, and generators bid their costs, this pricing rule would also appear to reduce payments by load. The only difference is that it is perhaps more obvious in this case that rational generators would not bid their costs under such a pricing rule.

[14] Another way of thinking about this calculation is that the load buys 1500 MW @ $1000/MWh at node 1, 2000 MW at $20 at node 2, self-provides 6500 MWh at a cost of $30/MWh and receives congestion rents of $980/MWh on the power imported to node 1 from node 2.

Third, CAISO's assumption is that payments to generators can be reduced under zonal pricing because generators will bid their costs even when the pricing system in effect pays them the lower of their bid or the market clearing price. This assumption should be placed in context by a review of the various analyses the CAISO has undertaken over the past year that have been premised on the view that generators should bid their costs and the concern expressed by the CAISO that generators did not appear to be bidding their costs. But as we see here, when faced with price discrimination, generators should bid the market price, not their costs.