Market Power

How Demand Response Addresses Market Power Concerns in Wholesale Energy Markets

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WHITE PAPER

INTRODUCTION

In deregulated energy markets, market power is a major concern for utilities and regulators. When demand on the power grid is high relative to available supply, there is a significant risk that generators, recognizing that their individual output is critical for avoiding a full or partial blackout, will charge well above normal prices for their energy output. Several prominent examples of the abuse of market power occurred during California's energy crisis of 2000, when wholesale electricity prices soared from a range of $25 - $75 per megawatt-hour (MWh) in the summer of 1999 to $100 - $500 per MWh just one year later.[1]

Demand response can protect against market power and the high prices that can result. This, in turn, provides cost savings for both utilities and their customers and helps markets operate more efficiently.

HOW REAL-TIME MARKETS WORK

Independent system operators (ISOs), such as PJM or ERCOT, often use real-time energy imbalance markets to meet demand in excess of what was met in the day-ahead or earlier forward markets.[2] In real-time markets, ISOs take offers from generators that have available capacity. Generators specify a quantity of energy they are able to supply and the price at which they are willing to supply that energy. The ISO ranks these offers from lowest to highest price and accepts as many offers as it needs in order to meet excess demand.

MARKET OUTCOME UNDER COMPETITIVE CONDITIONS

Let's look at an example of how these markets function under normal conditions. Suppose in a given period, an ISO needs to procure 70 MWh of energy. It receives the following bids from the four available generators in its system:

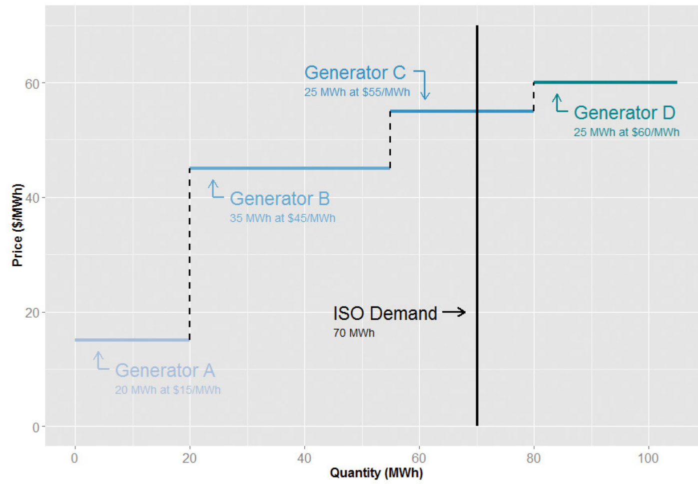
	Quantity (MWh)	Price ($/MWh)
Generator A	20	$15
Generator B	35	$45
Generator C	25	$55
Generator D	25	$60

[1] "The Western Energy Crisis, the Enron Bankruptcy, and FERC's Response"

[2] This paper offers a stylized description of what happens in ISO markets. Actual market rules and practices vary tremendously from region to region, but the basic logic presented here applies in all markets.

The ISO takes these offers and stacks them to form a supply curve:

Figure 1: Supply and Demand Under Competitive Conditions



The ISO sorts the offers it receives from lowest to highest price and generates a supply curve (depicted in shades of blue). The vertical axis represents price, and the horizontal axis represents the cumulative quantity available for purchase at each price. The ISO's requirement to procure 70 MWh is depicted as a vertical demand curve, implying that the ISO will purchase 70 MWh regardless of price. The market clearing price is determined by the intersection of the supply and demand curves.

The ISO has to procure enough supply to meet demand, which is depicted by the vertical line on the chart. If the ISO doesn't procure this much, the system's reliability will be in jeopardy as a result of a supply-demand imbalance.

In this scenario, the ISO takes the full 55 MWh offered by Generators A and B, and takes 15 of the 25 MWh offered by Generator C. They pay all generators the market-clearing price of $55/MWh, equal to Generator C's bid, since that is the minimum price at which enough generators are willing to supply energy to meet demand.[3]

Under the conditions depicted above, there is excess supply. Generator C may notice that its bid is setting the price in the market, but what would happen if it tried to raise its price to $65 to make more money? The ISO would turn to Generator D instead. Generator D has submitted an offer of $60, so if Generator C exceeded that price, the ISO would simply replace the 15 MWh of energy it was getting from C with 15 MWh from D, and the price would not rise above $60. Generators C and D have incentive to compete with each other on price, so that the ISO will decide to take their output over the alternative. As long as the ISO has a choice of generators to call on to meet demand, competition keeps prices low—close to the marginal cost that generators incur to serve load.[4]

[3] ISOs operate uniform clearing price markets, meaning they pay the same price to all cleared generation in a particular location, regardless of the generators' bids. The price they pay is determined by the "marginal" generator, i.e., the highest-priced resource on which the ISO relies to meet demand. "Uniform-Pricing versus Pay-as-Bid in Wholesale Electricity Markets: Does it Make a Difference?"

[4] Market power may appear even when the ISO has a choice between generators if generators are able to tacitly or explicitly collude to raise prices. We will not explore an example of this in detail, but demand response can help mitigate the effect of this type of market power as well.

MARKET OUTCOME UNDER SCARCITY CONDITIONS

We can compare the competitive scenario above to a scenario with tighter system conditions. Suppose the ISO receives the same generation offers but needs to procure 100 MWh of energy:

Figure 2: Supply and Demand Under Scarcity Conditions

Under these conditions, the ISO faces the same supply curve but must satisfy demand of 100 MWh.

Now the ISO takes all the energy offered by Generators A, B and C, and takes 20 MWh from Generator D. The clearing price is $60, based on Generator D's offer. In this case, if Generator D notices it is setting the price and tries to raise its bid to make more money, there is nothing stopping it. It can raise its price to astronomically high levels and the ISO will still have to buy the energy it offers because the ISO has no alternative; it needs output from every single available generator to meet its 100 MWh of demand. The only limiting factor on how high Generator D can raise its price is how much the ISO is willing to pay to avert a blackout. The same is true for all generators in this market. Each is a "pivotal supplier"—i.e., a supplier whose output the ISO needs in order to ensure reliability— and could raise its price to thousands of dollars per MWh.

COMMON SOLUTIONS TO THE MARKET POWER PROBLEM

Grid operators and regulators attempt to mitigate this concern through various measures, including:

» Offer caps that limit the price at which all generators can sell their energy

» Individual bid mitigation measures that require generators' bids to be intrinsically tied to production cost (e.g., cost plus 10%) during periods of scarcity

» Anti-trust requirements that limit how much capacity a company can control in a particular area[5]

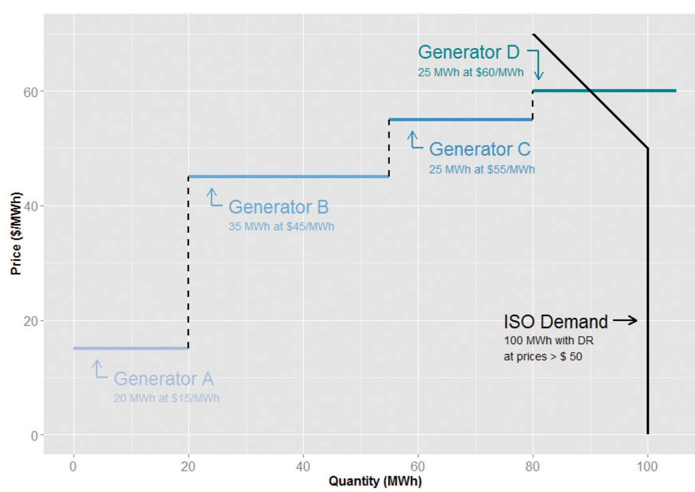
Unfortunately, all of these methods have disadvantages. Offer caps and bid mitigation can be administratively burdensome and often put too-severe a limit on peak-hour pricing. If a peaking generator that only runs a few hours a year makes only enough to cover its marginal operating cost in those hours, developers have no incentive to make a large capital expenditure to build that plant in the first place. This is often referred to as the "missing money" problem in energy markets.[6]

Anti-trust requirements that limit the amount of capacity a company can own in a particular area can be costly or ineffective when (1) they prevent companies from operating at an efficient scale, or (2) congestion on the transmission network creates a small pocket of isolated load where it is inefficient to have more than a single power plant.

HOW DEMAND RESPONSE CAN HELP

Demand response can mitigate the effects of market power by changing the nature of the demand curve in real-time energy markets. It adds what economists call "elasticity," or the ability to respond to price. In simple terms, demand response reduces the amount of energy the ISO has to procure when prices get high, which gives generators an incentive to limit price increases to ensure that the ISO still purchases their output.

Here's an example of how demand response could help our hypothetical ISO. Suppose that when prices exceed a certain threshold, say $50, the ISO can call on end-users to start reducing their consumption. The higher the price, the more reduction they can call for. This would lead to a bent demand curve as depicted below. With prices as high as $70, the ISO only needs to procure 80 MWh instead of the 100 MWh they would need to procure without demand response.



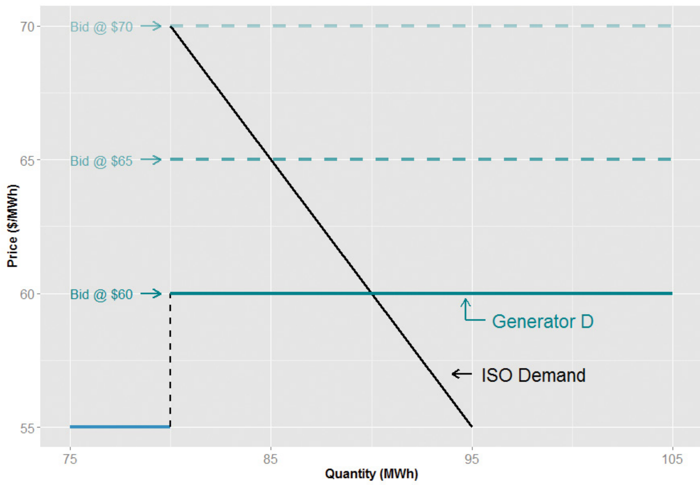
With the introduction of demand response, the shape of the ISO's demand curve changes. At prices above $50, the ISO can call on end users to reduce consumption, thereby reducing the quantity of energy the ISO needs to procure. The demand curve slopes downward to reflect that the ISO can call on more end-use reduction as price increases.

[5] For more on market power mitigation practices around the US an abroad, read "Review of PJM's Market Power Mitigation Practices in Comparison to Other Organizes Electricity Markets"

[6] The "missing money" problem is the reason many ISOs have developed forward capacity markets, in which generators receive payments in exchange for agreeing to be available in day-ahead and real-time energy markets, regardless of whether they actually produce output. Demand response can help mitigate market power concerns in these markets as well and reduce the quantity of generation capacity that needs to be procured.

Figure 3: Supply and Demand Under Scarcity Conditions with Demand Response

Now what happens to Generator D's market power—i.e., its ability to raise prices? It can bump its bid up a few dollars, but for each dollar it increases its bid, the ISO will buy less energy. In the figure below, we zoom in on the top of the supply stack and consider three possible bids for Generator D: $60, $65 and $70.



The market clears wherever the ISO's demand curve intersects the supply curve. Generator D could consider many different bidding strategies, three of which are pictured here. Note that as Generator D raises its bid, the market clearing price increases, but the quantity Generator D is able to sell into the market decreases. This limits Generator D's incentive to raise the price.

Figure 4: Potential Bidding Strategies for Generator D

Notice that as Generator D increases its bid price, the ISO, thanks to demand response, is able to procure less of its output. At $60, the ISO procures 10 MWh from Generator D; at $65, 5 MWh; and at $70, none of Generator D's quantity. If Generator D incurs costs of $55 to produce each MWh of output, it can earn the profits depicted in the chart below from each of these bidding strategies.

From a profit-maximizing perspective, Generator D is indifferent between bidding $60 and $65, and it would lose profit by increasing its bid to $70. Its optimal bid would be $62.50, an increase of less than $3 from its bid under competitive conditions.[7] This is in stark contrast to a world without demand response, where Generator D's incentive would be to raise price as much as several thousand dollars, limited only by the maximum price the ISO is willing to pay before it turns to load shedding.

Price	Quantity Sold	Total Revenue	Marginal Cost	Total Cost	Profit
$60	10	$600	$55	$550	$50
$65	5	$325	$55	$275	$50
$70	0	$0	$55	$0	$0

CONCLUSION

A little bit of demand response goes a very long way in helping protect electricity consumers against supply-side market power. It gives ISOs an alternative to turn to, even when additional generation resources are not available.

Furthermore, demand response is a useful complement to simple offer caps or other mitigation measures. Regulators and grid operators face a difficult task in determining the right level for offer caps and mitigation—high enough to incentivize peaking generation, but low enough to protect consumers against the undue exercise of market power. In markets with demand response, operators can rest assured that even with a high offer cap, there is a mechanism in place to limit generators' ability to raise the price, driven by customers' willingness to pay for energy.

Demand response, even if adopted only by some utilities or end-use customers in a larger market, benefits all buyers in that market by putting downward pressure on prices. However, the benefits of DR are greatest for those utilities and customers who adopt demand response directly. They not only enjoy lower market prices like all buyers in the market, but also avoid purchasing extra energy altogether when it is not cost-effective for them to do so.

[7] Generator D would select the price that maximizes profit, $\pi=q(p)*(p-c)$, where p is price, q is quantity sold (a function of p), and c is marginal cost. In the example laid out here, $\pi=(70-p)*(p-55)$. Solving the first order condition $\partial\pi/\partial p=0$, yields p=62.5.

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