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Horizontal Market Power in Restructured Electricity Markets

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Office of Economic, Electricity and Natural Gas Analysis
Office of Policy
U.S. Department of Energy
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Executive Summary

What is market power and why is it important to electric restructuring?

Market power is defined as the ability of a supplier to profitably raise prices above competitive levels and maintain those prices for a significant time period. Concerns regarding market power have been widely examined in the economics literature and in antitrust practice across a broad range of industries.

The market power issue is of particular interest to policymakers and legislators as they consider electric power industry restructuring, because the exploitation of market power can significantly erode the consumer benefits that would be expected to result from the transition from regulated to competitive markets for electricity generation.

The economics and antitrust literature identify two types of market power, horizontal and vertical. Horizontal market power is exercised when a firm profitably drives up prices through its control of a single activity, such as electricity generation, where it controls a significant share of the total capacity available to the market. Vertical market power is exercised when a firm involved in two related activities, such as electricity generation and transmission, uses its dominance in one area to raise prices and increase profits for the overall enterprise. **This paper focuses on the issue of horizontal market power, providing evidence regarding its potential impact on restructured electricity markets.**

Antitrust remedies are not well-suited to address problems of market power in the electric power industry that result from existing high levels of concentration in generation. As noted in recent testimony from the Department of Justice, the antitrust laws do not outlaw the mere possession of monopoly power that is the result of skill, accident, or a previous regulatory regime.

What information is available regarding market power in competitive electricity markets?

Many electricity markets are highly concentrated, raising market power concerns. Schmalensee and Golub (1984) calculated values of the Herfindahl-Hirschmann Index (HHI), a standard measure of market concentration developed by the U.S. Department of Justice (DOJ) and the Federal Trade Commission (FTC), for electricity markets throughout the United States for 170 generation markets serving nearly three-quarters of the U.S. population. They found that, depending on the cost and demand assumptions used, 35 percent to 60 percent of all generation markets had HHI values above 1800 (the threshold for "high concentration" under the DOJ/FTC guidelines). A more recent study by Cardell, Hitt and Hogan (1997) suggests that electricity markets are still highly concentrated. Using 1994 data and a narrower definition of the geographic scope of electricity markets, they calculate HHI values for 112 regions based on State boundaries and North American Electric Reliability Council (NERC) subregions. Approximately 90 percent of the markets examined in this study had HHI values above 2500.

There is strong evidence that market power has been exercised in the electricity context. In both the United Kingdom (U.K.) and California, where data from competitive electricity generation markets are now available, researchers have found that wholesale power prices have been as much as 75 percent above competitive levels at times. Other studies examining electricity markets in Australia, New Jersey, and Colorado identify potential market power issues in those areas as well.

Entry or the threat of entry alone is unlikely to alleviate market power concerns. While the threat of entry undoubtedly helps to encourage competitive

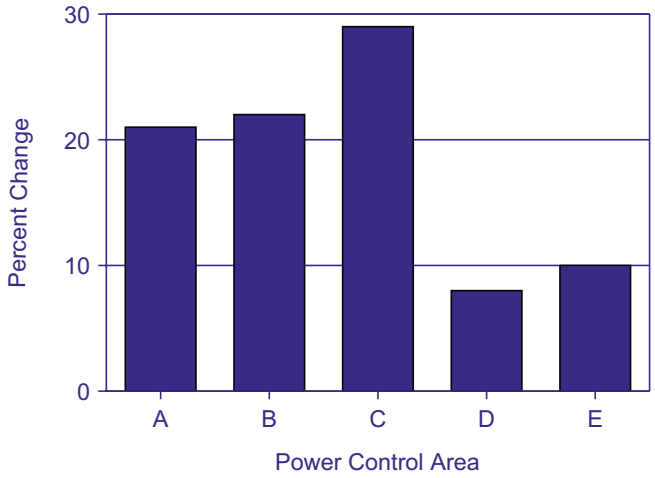
behavior, and actual entry reduces market concentration, both economic reasoning and experience suggest that the possibility of entry alone cannot alleviate all market power concerns in the electricity context. Because new plants must recover their capital costs as well as their operating costs to be attractive investments, there will be situations in which owners of existing plants who have market power can profitably raise prices above the competitive level without triggering entry.

The concern that entry alone will not be sufficient to deter the exercise of market power is borne out by the U.K. experience. Market power problems persisted in the U.K. despite substantial capacity additions by independent power producers and previously committed nuclear capacity between 1991 and 1997 that together represented additions equivalent to 25 percent of total capacity in the England-Wales Pool. Given that conditions within the U.K. market were more favorable to new entry than those in many U.S. regional power markets, potential entry should not be viewed as a "cure all" for market power in the near to medium term.

Opposition from existing competitors is also unlikely to alleviate or prevent the exercise of market power. Because surrounding generators would be able to profit from higher prices without having to idle their own capacity, they will generally welcome rather than oppose the exercise of market power by a dominant supplier.

New simulations of U.S. regional power markets using the Department of Energy's Policy Office Electricity Modeling System (POEMS) are reported in Section 4 of this paper. These analyses confirm that market power can be profitably exploited in some parts of the United States. In markets where concentration is high and transmission constraints impede imports of power from distant generators, firms can employ a simple market power bidding strategy to cut output and increase net revenues from generation by driving up the market price of electricity. The exploitation of market power can have a significant impact on wholesale power prices (Figure ES1), which is in most regions the largest component of the total delivered electricity prices paid by consumers in competitive markets.

Figure ES1. Changes in Wholesale Electricity Prices When Firms Exploit Market Power



Firms considered to have a high potential to exert market power were identified based on their market share and transmission capacity into the local market. The POEMS analysis indicated that these firms would be able to increase profits by 10 percent to 50 percent by reducing output and driving up prices. Wholesale power prices rose in corresponding power control areas (PCAs) by 8 percent to 30 percent as a result of the exercise of market power.

The simulations also show that the totality of restructuring legislation, not just provisions that directly address market power authority, are relevant to the market power issue. For example, the continuation of pancaked transmission rates in the absence of effective Regional Transmission Organizations (RTOs) with adequate size and scope generally increases the opportunity to profit from market power. However, RTOs themselves are not a panacea for market power, as evidenced by the significant opportunities to profitably exploit market power even in simulations that assume the operation of effective RTOs.

In sum, both the record of restructured markets to date and simulation analyses conducted by the Department of Energy suggest that the exercise of market power could, under some circumstances, significantly offset the projected benefits of competition in electricity generation markets.

What remedies can be used to address market power concerns in the electric sector?

Although many antitrust authorities express a preference for structural remedies to address market power concerns, a variety of options that fall along the spectrum between direct regulation of prices and divestiture could be applied as part of a market power mitigation strategy. Such options include creating bidding trusts for certain assets, requiring generators to offer real-time curtailment prices to end-use customers, or placing limits on the variance of bid prices for individual generating units. This paper briefly reviews these and other options that have been discussed, but does not attempt to evaluate them. Provided there is clear authority to address market power concerns and clear empowerment to exercise that authority, it may be appropriate to tailor the application of remedies to the facts of specific situations as they arise.

Introduction: The Issue of Horizontal Market Power

The shift to reliance on competitive market prices instead of regulated rates for electric generation raises the possibility that some firms could drive up prices by exercising market power. Market power is defined as the ability of a supplier to profitably raise prices above competitive levels and maintain those prices for a significant time period.

The economics and antitrust literature identify two types of market power, horizontal and vertical. Horizontal market power is exercised when a firm profitably drives up prices through its control of a single activity, such as electricity generation, where it owns a significant share of the total capacity available to the market, or a significant share of capacity "at the margin" (i.e., higher-cost capacity that tends to set the market price). Vertical market power is exercised when a firm involved in two related activities, such as electricity generation and transmission, uses its dominance in one area to raise prices and increase profits for the overall enterprise. Concerns related to vertical market power in the electricity sector are commonly understood. The mechanisms for addressing them, such as requirements for independent operation of the transmission system and non-discriminatory access to it are widely accepted.

This paper focuses on the issue of horizontal market power,[1] providing evidence regarding its likely importance in restructured electricity markets.

1. What Is Market Power and Why Does It Matter?

In a truly competitive market, market power is not a problem, because no single firm, or small group of firms, can determine market prices. Instead, all sellers (and buyers) are "price-takers," who assume that their own production and purchase decisions do not affect the market price. The most profitable strategy for a price-taking producer in a competitive market is to "bid" the output of each generating plant into the market at its variable cost of operation.[2] If the market price is equal to or greater than the bid for a particular plant, that plant runs, and any surplus of the market price over variable cost is available for contributing toward fixed costs or profits. If the market price is below the bid level for a particular plant, the owner has no regrets about having bid at variable cost, because running that plant would reduce rather than increase profit.[3]

Prices will, at times, rise above the variable cost of production of the most expensive plant serving a market even if no producer exercises market power. This occurs when demand exceeds maximum available supply at the bid price of the most expensive plant, and transmission constraints make it impossible to bring in more power from other regions. Buyers who are willing to pay prices that exceed the highest competitive bid will offer to do so, and prices will rise until they become high enough to balance supply and demand. The increase in price above the short-run variable cost reflects the value

[1]From this point forward in this paper, the term "market power" refers to horizontal market power.

[2]For electricity generators, the variable cost of production is the cost of fuel plus any operating and maintenance costs that vary with the amount of power produced.

[3]Exit from and entry into competitive markets is driven by the difference between a plant's revenue stream and its variable cost. For example, unless the revenue stream from an existing plant provides enough surplus over variable production costs to cover non-variable costs, such as annual and periodic maintenance costs, the owner will choose to retire it, reducing capacity available to serve the market. In addition, an investor contemplating construction of a new plant will not proceed unless he contemplates that its revenue stream will provide enough surplus over variable costs to provide a return of and on invested capital as well as future non-variable costs.

to consumers of consuming additional electricity in times of limited supply. These price increases allow peaking plants that operate only a few hours a year to recover their fixed costs. Such occurrences, or more generally the need to frequently run high-cost plants, can also signal investors that new capacity may be an attractive investment opportunity.

A firm is said to have market power when it acts in a manner that is intended to change market prices and can maintain prices at a non-competitive level for a significant time period. A firm with market power can profitably influence prices by raising its bid above its variable cost or otherwise reducing its output, in order to drive up prices and earn a higher level of total profit notwithstanding the loss of profit on the potential output it withholds.[4]

Any attempt to measure or understand the potential for market power must begin with a clear definition of the market that identifies both the geographic area and the products included. In markets where consumers can easily substitute other products or buy the same product at other locations, a firm's market power potential will generally be low. While defining the relevant market for the purpose of market power evaluation can be difficult even in the best of circumstances, it is especially problematic in the electricity industry.

Electricity markets are dynamic and can change dramatically over the course of just a few hours, creating opportunities to exercise market power even though the market may be very competitive under most circumstances. For example, the geographic scope of an electricity market is determined by the transmission system. Any change in available transmission capacity can quickly alter the geographic boundaries of the market. To cite another example, certain plants may be required to run at certain times in order to meet reliability needs, effectively giving them market power during those periods, because no other plants can act as substitutes. In other words, the "relevant market" for the purpose of gauging market power may be very different at 5 a.m. than at 5 p.m.

Other characteristics of electricity markets also increase opportunities to exploit market power compared with other industries. Because electricity markets have historically been structured as vertical monopolies with franchise territories, companies often own many plants in a region that cannot receive large flows of power from other areas, potentially allowing them to restrict output at one plant and receive higher prices for power produced at all of their other units. Second, there is very little opportunity for real-time demand response in electricity markets. As prices rise for any given product, the quantity demanded will fall, making it more difficult for producers to exercise market power. In current retail electricity markets, very few end-use consumers face real-time prices, or have the opportunity to be compensated at the market-clearing price for reducing their demand below the usual level by cutting load or switching to backup generation (or both).[5]

Conversely, several factors mitigate against the exercise of market power in well-functioning electric markets. First, to the extent that transmission capacity is available and is efficiently organized and priced, competition from distant producers within each of the three major electrical interconnections that serve the United States and Canada can help to deter the exercise of market power. Second, because a potential entrant has the ability to compete in distant as well as local markets for power, threats of retaliation against a new generator who adds capacity in a market where the incumbent exercises market power may not be credible.

[4]The transmission system offers further opportunities to exert market power in competitive electricity markets. Even if a firm does not own a particular transmission line, it could increase generation at particular plants in order to create congestion on the transmission system, thereby restricting imports and limiting competition. See Cardell, Hitt and Hogan (1997).

[5]While these options will not generally be attractive to small residential consumers, the commercial and industrial customers who account for approximately two-thirds of total electricity demand could make overall demand more price responsive and reduce price volatility while benefiting themselves by pursuing such options.

Do antitrust statutes provide sufficient authority to address market power problems that could arise in a restructured electricity sector?

As noted in recent testimony from the Department of Justice,[6] the antitrust laws do not outlaw the mere possession of monopoly power that is the result of skill, accident, or a previous regulatory regime. Antitrust remedies are thus not well-suited to address problems of market power in the electric power industry that result from existing high levels of concentration in generation. If market power in a restructured electricity sector is a matter of concern, it would be appropriate to address it in the context of comprehensive electricity restructuring legislation.

2. Concentration in Electric Generation Markets: An Indicator of Potential Market Power

The Herfindahl-Hirschmann Index (HHI), a widely used measure of market concentration, determines market concentration by computing the sum of the squared market share of each competitor. In a "perfect monopoly," in which one firm supplies 100 percent of the market, the maximum value of the HHI is at the maximum level of 10,000 (100 times 100). In extremely competitive markets, in which hundreds of firms each hold a fraction of 1 percent of the market, the HHI value approaches zero. The Horizontal Merger Guidelines issued jointly by the U.S. Department of Justice and the Federal Trade Commission use the HHI as a primary screening tool to identify whether markets are likely to have enough competitors to be workably competitive following a proposed merger. Markets with an HHI value below 1000 (e.g., 10 firms, each with a 10-percent market share) are presumed to be unconcentrated, while markets with an HHI of 1800 or more are considered to be highly concentrated. For markets with an HHI of 1800 or above, the antitrust agencies consider that a merger increasing the HHI by as little as 50 points has the potential to raise significant competitive concerns. Mergers that raise the HHI by 100 points or more in markets that are already highly concentrated (HHI of 1800 or above) are presumed to be likely to create or enhance market power or facilitate its exercise.[7]

Schmalensee and Golub (1984) calculate HHI values for electricity markets throughout the United States for 170 generation markets serving nearly three-quarters of the U.S. population, using alternative assumptions about the geographic scope of generation markets. They find a significant number of instances where market concentration as measured by the HHI is in the danger zone defined by the Horizontal Merger Guidelines. For example, under the assumption of low transmission capacity, between 35 percent and 60 percent of all generation markets have HHI values above 1800 across a range of alternative marginal cost and demand elasticity cases. The load-weighted mean HHI value ranges from 1590 to 2650, indicating substantial concentration. For the more favorable case of high transmission capacity, concentration is less severe, but up to 33 percent of markets still had HHI values above the threshold value of 1800 used in the merger guidelines to identify markets that are highly concentrated.

While the data used by Schmalensee and Golub do not reflect the increased market role of independent power since 1980,[8] there is little doubt that updated HHI calculations would identify some highly concentrated markets. A recent study by Cardell, Hitt and Hogan (1997) suggests that electricity markets

[6]U.S. Department of Justice (1999).

[7]See U.S. Department of Justice and the Federal Trade Commission (1997), Section 1.5.

[8]Beginning in 1978, Congress has acted to remove impediments to independent power through the Public Utility Regulatory Policies Act (PURPA), which required utilities to purchase power generated by qualified facilities, and the 1992 National Energy Policy Act (EPACT), which allowed for exempt wholesale generators.

are still highly concentrated today. Using 1994 data and a narrower definition of the geographic scope of electricity markets, they calculate HHI values for 112 regions based on State boundaries and North American Electric Reliability Council (NERC) subregions. Although the analysis does not reflect the recent spate of mergers and divestitures, approximately 90 percent of these regions have HHI values above 2500.

HHI indices only identify situations where some firms may possess enough market power to interfere with workable competition. They cannot indicate whether firms will actually exercise that market power, or the possible implications for prices and profits. Insights into those issues drawn from studies of competitive markets in California and the United Kingdom and modeling analyses of U.S. electricity markets are discussed below.

3. Evidence of Market Power in the United Kingdom, California, and Other Markets

Several studies have found evidence of market power in deregulated electricity markets or have analyzed the potential for market power. In both the United Kingdom (U.K.) and California, where data from competitive electric generation markets are now available, researchers have found that prices have been above competitive levels at times. Other studies examining electricity markets in Australia, New Jersey, and Colorado identify potential market power issues in those areas.

The Impact of Market Power on Wholesale Electricity Prices in the United Kingdom and California

Analysts have been able to assess the impacts of market power based on actual data from the U.K. and California. These studies suggest that generators in these two markets may have earned substantial excess revenues due to market power.

The U.K. experience has been the subject of many reviews, in part because that country was one of the first to implement competition in wholesale power markets. Since the creation of the U.K. power pool in 1990, the Office of Electricity Regulation (OFFER)[9] has investigated market power abuses on a number of occasions in response to unusually high pool prices. The U.K. market design provided generators with two types of compensation: capacity payments based on a day-ahead comparison of anticipated capacity requirements with available capacity, and energy payments based on system marginal prices. In early 1992, both system marginal prices and capacity payments rose dramatically. After investigating, OFFER determined that National Power and PowerGen, the two largest generating companies, which together accounted for 70 percent of total capacity in the pool, were bidding prices in excess of their marginal costs. In addition, PowerGen had declared a number of plants unavailable in order to raise the capacity payment. Once the capacity payment had been determined, PowerGen then declared the units available, making them eligible to receive the higher capacity payments. Although OFFER instituted a number of reforms after the episode, they seemed to have somewhat limited success in restraining market power.[10]

Wolfram (1998 and 1999) examined strategic bidding behavior by National Power and PowerGen. Using data on fuel costs and heat rates, she estimated the marginal cost of electricity for the system and compared this cost with the pool's "system

[9]In 1999, OFFER and the Office of Gas Supply were combined to create the Office of Gas and Electricity Markets, OFGEM.

[10]OFFER eventually instituted price caps on system marginal prices, required National Power and PowerGen to divest a portion of their generation assets, and required generators to file annual plans regarding scheduled plant outages.

marginal price"[11] in order to determine the price-cost markup (the difference between a generator's marginal cost and its bid price). Wolfram estimates that from 1992 to 1994, system marginal prices ranged from 19 percent to 25 percent above estimated marginal costs.

Wolak and Patrick (1997) examine the issue of capacity withholding in the U.K. power pool. Because of the structure of the U.K. power pool, firms can benefit significantly by withholding generation. Prices paid to generators include a capacity payment determined each half-hour by the pool operator, based on the level of reserves available and the value of lost load.[12] As reserve capacity falls, the capacity payment increases. By withholding capacity, firms receive both higher capacity payments and higher system marginal prices for their output, making this a very profitable strategy.

After analyzing the half-hourly market-clearing prices and quantities, and half-hourly bids and availability declarations from 1991 to 1995, the authors cite several pieces of evidence to demonstrate that National Power and PowerGen are strategically withholding capacity. First, they find that the percent of total capacity declared unavailable by National Power and PowerGen in 1995 during off-peak months is more than twice the average amount of capacity declared unavailable by all generators in off-peak months. In addition, they calculate average availability factors by fuel type for National Power and PowerGen and compare them to industry benchmarks based on NERC data for comparable units. For every fuel type, the availability factors for both National Power and PowerGen are below the industry benchmark. For example, average availability factors for combined-cycle gas turbines (CCGTs) are 53 percent and 64 percent for National Power and PowerGen, respectively, compared with an industry benchmark of 80 percent. By contrast, availability factors for independent power producers selling to the U.K. pool are all above the industry benchmark, ranging from 81 to 93 percent for CCGTs.

The California wholesale market is much newer than the U.K. market, having opened to competition in 1998. This market has an institutional structure different from that used in the U.K. — for example, there are no payments for capacity outside of those directly related to the provision of ancillary services. Despite the opportunity of California market designers to learn from the U.K. experience, early analyses provide some evidence that market power is being exercised. Borenstein, Bushnell and Wolak (1999) examine the California wholesale market for June-November 1998. They compute the aggregate marginal supply curve based on fuel costs, heat rates, and variable operating and maintenance (O&M) costs, using data from the California Energy Commission and other sources. Using the hourly generation levels from the Independent System Operator, they determine the competitive price for each hour. The competitive price is then compared to the hourly (unconstrained) price in the California Power Exchange (PX) to estimate the price-cost markup. For the entire 6-month period, total payments to generators were 29 percent, or $494 million, above competitive levels. At certain times, prices were as much as 75 percent above competitive levels. The highest markups were found during July and August from noon to 6 p.m., when demand is high. Wolak (2000) recently extended the analysis to include the summer of 1999, resulting in a revised estimate of more than $800 million in payments above competitive levels to generators during the summers of 1998 and 1999 taken together.

The studies discussed in this section generally report the price premium as a percentage of the wholesale market price of power. The wholesale price of power is only one component of the overall

[11]Pool prices in the U.K. include three distinct elements: the system marginal price, which equals the bid of the last generator scheduled for dispatch; a capacity payment designed to compensate generators for supplying capacity; and an uplift charge to adjust for differences in forecasted and actual demand and to cover the costs of additional services provided by generators (e.g., voltage support). Increased costs due to higher capacity payments are not reflected in this analysis, because only the system marginal price is examined.

[12]The value of lost load is the estimated amount that end-use customers receiving electricity with firm contracts would be willing to pay to avoid a disruption in their electricity service.

price paid by consumers for electricity service, which also includes the costs of transmission and distribution and other expenses. The same price impacts measured as a percentage of the total delivered price of electricity to end users would be significantly smaller, in many markets ranging from one-half to two-thirds of the generation-only percentage impact.

Other Evidence of Market Power in the United Kingdom and California

Empirical studies such as those by Wolfram (1998a, 1998b) and by Borenstein, Bushnell and Wolak (1999) measure the extent of market power by first estimating the marginal cost of and then comparing the estimates to prices. There are, however, a number of difficulties in attempting to estimate generation costs. Wolfram, for example, does not include variable O&M costs in her estimates, and thus may be understating actual generation costs. In California, generators do not explicitly submit bids for startup costs (as in other power pools) and must instead include these costs in their bid prices for energy (although the inclusion of startup costs would not fully account for the higher payments to California generators noted above). As such, a generator's bid may appear to be above marginal costs even though the bid price accurately reflects the generator's variable cost of production.

Other evidence, however, suggests that firms are exercising market power — bidding behavior in the U.K., for example. While firms will have an incentive to bid higher prices into the pool in order to receive higher revenues, these incentives are countered by a need to ensure that the plant is dispatched. Economic theory predicts that, if generators are behaving strategically, price-cost markups will be higher for plants that are more likely to set the pool price, and when more of a generator's inframarginal capacity is available. Wolfram finds evidence of both of these outcomes in the U.K. power pool. In addition, she finds that the variation in bid prices for a given generating unit is greater than the variation in bid prices across generating units.

Other analysts have compared actual California PX prices to a 1997 Borenstein and Bushnell study examining the potential for market power in the California wholesale market. In two of the four months examined, the model overestimates prices assuming either competition or market power. In the other two months, however, the model accurately predicts competitive prices for about 80 percent of the hours, generally when loads are low. For approximately 10 percent of the hours during these two months, actual PX prices fall within the range of predicted prices assuming market power.

Effect of Entry on Market Power

The entry of new competitors into the market is one important factor that can limit the ability to sustain prices above the competitive level for a significant time period, which defines market power. The possibility of rapid entry by new competitors can deter the exercise of market power by an incumbent firm that dominates its market, because the entry attracted by the above-normal profits associated with high prices can lead to overcapacity and subpar profits following entry.

While the threat of entry undoubtedly helps to encourage competitive behavior, and actual entry reduces market concentration, both economic reasoning and experience suggest that the possibility of entry alone cannot alleviate all market power concerns in the electricity context. Because new plants must recover their capital costs as well as their operating costs to be attractive investments, there will be situations in which owners of existing plants who have market power can profitably raise prices above the competitive level without triggering entry. For example, if the competitive price based on marginal costs is 2 cents per kilowatthour in a particular market during a particular time period, but a new entrant would not be attracted into the market for a price below 3 cents per kilowatthour, market power could be exercised to raise prices considerably above competitive levels without attracting new entry. There are also considerable lags in the siting and

permitting processes that can both slow and limit entry that would otherwise result from the exercise of market power.

Although there has been considerable entry into the U.K. market since privatization, it has not completely eliminated market power. Pool prices during 1993 and 1994 were, on average, just below a potential entrant's long-run average costs. In addition, National Power and PowerGen retired significant amounts of generation as new firms entered the market in the early 1990s, thus limiting the net increase in capacity within the pool. The most recent price spikes in 1999 suggest that National Power and PowerGen can still exercise market power despite new entry and their subsequent decreases in market share.[13]

Market power problems have persisted in the U.K. despite substantial capacity additions by independent power producers (12,300 megawatts) and previously committed nuclear capacity (3,200 megawatts) between 1991 and 1997 that together represented additions equivalent to 25 percent of total capacity in the England-Wales Pool. Since conditions within the U.K. market were probably more favorable to the early entry of significant independent power producer capacity than those in many U.S. regional power markets, entry should probably not be viewed as the "cure all" for market power in the short to intermediate run.

Studies of Potential Market Power in Other Regions

Borenstein, Bushnell and Knittel (1997) analyze the potential for market power in New Jersey. Because of transmission constraints both within and into the Pennsylvania-New Jersey-Maryland (PJM) power pool, New Jersey ("PJM-East") may at times be a small, geographically distinct market, providing opportunities for generators to exercise market power. The analysis investigates the potential for the five major New Jersey utilities to raise prices by reducing their output, assuming that the surrounding markets (New York and "PJM-West") are perfectly competitive and will sell into the New Jersey market when possible, given prices and transmission constraints. They find that market prices begin to exceed competitive levels when demand in New Jersey rises above 14,500 megawatts (peak demand for New Jersey is assumed to be 16,500 megawatts in 2000 for this analysis). At this level of demand, potential price increases due to market power range from just a few percentage points to a factor of 4.

Colorado is another region in which the potential for market power has been analyzed. Sweester (1998) notes that transmission constraints and the presence of a dominant firm may provide opportunities to exercise market power in eastern Colorado. He examines the mitigating effects of various policy options or market developments. For example, the participation of rural electric cooperatives and municipal power agencies in competitive markets reduces the projected price-cost markups by approximately 10 percent. If 1,000 megawatts of new, competitive generation is assumed to enter the market, price-cost markups fall dramatically. The greatest reduction in price-cost markups under a market power scenario results from requiring 50 percent divestiture by the dominant firm.

Several State public utility commissions have also undertaken market power studies as part of restructuring. In Michigan, for example, staff at the Public Service Commission calculated HHI values for the State and concluded that the Michigan market is "so highly concentrated and the advantages of incumbent utilities are so pervasive that proactive measures are imperative." The Public Service Commission of Utah used simulation studies similar to the New Jersey and Colorado studies and found that the dominant firm would be able to exercise market power 45 to 60 percent of the time.

[13]Pool prices in the U.K. in July 1999 were about 80 percent higher than in the same period in 1998 despite relatively little increase in demand or fuel prices compared to the previous year. OFGEM determined that these price increases were due primarily to higher bid prices for coal-fired units owned by National Power and PowerGen. For a more detailed discussion, see Office of Gas and Electricity Markets (1999).

Impacts of Market Power on Other Generators

Demand for electricity in a particular market is often dispersed among a great number of loads. Given the widespread use of cogeneration by energy-intensive operations in the chemicals, petroleum, and pulp and paper industries, in most cases the net demand for power of the largest user is only a small fraction of total demand in a regional market. The relatively atomistic allocation of net demand among loads limits the attention that individual loads will rationally devote to detecting market power abuse and pursuing redress.

Although there will typically be important secondary suppliers even in markets where ownership of generation is highly concentrated, the exercise of market power by the dominant supplier is likely to be welcomed rather than opposed by its existing competitors. Indeed, these competitors are able to profit from the higher prices resulting from the withholding of capacity by the firm that exercises market power without having to idle their own capacity to achieve those prices. In fact, they will often increase their output in response to capacity withholding by the dominant firm (although if their increase in output is large enough to offset the entire price increase, then by definition the dominant firm does not have market power). In this sense, perhaps it is even better to be the competitor of a firm exercising market power than to have market power oneself. Policymakers should certainly not expect to rely on competitors' opposition to confront market power.

4. Analysis of Market Power Using POEMS

Analysis Methods

To gain additional insights into the potential for electricity generators to exercise market power, the Department's Policy Office carried out an exploratory analysis of market power using the Policy Office Electricity Modeling System (POEMS).[14] To examine the profitability of exploiting market power, we used POEMS to simulate a bidding strategy that raises the bids of plants in the middle of the dispatch order — so-called "mid-merit" plants — above the competitive level. Under many types of load conditions, members of this group are the marginal (price-determining) plants, and a change in their bidding strategy has the potential to affect market prices. We simulated a relatively simple bidding strategy — raising the bid in each hour for mid-merit plants to 150 percent of the competitive level. In reality, a generator with market power would probably attempt to maximize profits by taking a more strategic approach to influencing prices, such as withholding generation or raising bid prices only on certain units or in certain time periods. Nonetheless, the analysis illustrates the conditions under which generators could exert market power and provides some insights into its effects on electricity markets.

Economic reasoning and the market power literature identify high concentration in the ownership of generation that serves or could potentially serve a particular market as a key factor creating the potential to exercise market power. For this reason, two key indicators of a situation where the potential for market power is high are high ownership concentration within the local power control area (PCA)[15] and limited available transmission capacity that would allow generators outside the PCA to wheel power into the area. Together, these two factors

[14]POEMS is a modeling system that integrates the Energy Information Administration's National Energy Modeling System (NEMS) with TRADELEC™, which provides a much more detailed representation of electricity markets than the NEMS electricity module. For a description, application, and documentation of POEMS see U.S. Department of Energy, Office of Policy (1999).

[15]A power control area is an electric power system or combination of systems in a designated geographic area. The control area operator is responsible for controlling the facilities within it to ensure that load and generation are balanced at all times.

allow us to identify highly concentrated electricity markets.

To examine the potential for the exercise of market power in competitive electricity markets, the database supporting POEMS was searched to identify groups of firms with "high" and "low to modest" potential to exercise market power, based on concentration and transmission capacity information. Four to five companies in each category were identified according to the criteria given in Table 1.[16,17]

In addition to physical transmission capability, the organization and pricing structure of transmission markets also affect the ability of outside generators to compete.[18] For a given physical configuration of the transmission system, outside generators are less effective competitors if the system is balkanized and rates are pancaked than if postage stamp transmission charges are applied within appropriately sized Regional Transmission Organizations (RTOs). An additional scenario using pancaked rates was run to assess the impact of transmission pricing on market power. The results of the analysis assuming postage stamp rates are presented first, followed by a comparison of the postage stamp and pancaked rate scenarios.

Results

Result #1: None of the firms in the low market power potential group were able to raise their profitability by bidding their mid-merit units at 150 percent of the competitive bids. They lost more in operating surplus (revenues minus variable costs) from not running these units during periods when the market price fell between 100 percent and 150 percent of the competitive bid than they gained from the impact of their bidding strategy on prices.

In the group of firms with low-to-modest market power potential, each company analyzed owns less than 50 percent of the total capacity within its PCA. Further, these PCAs have transmission interconnection transfer capability that is over 100 percent of each selected company's generating capacity, thus providing an opportunity for generators outside the region to compete somewhat unconstrained by transmission limits. In general, these companies should have less opportunity to exercise market power because other generators within and outside the PCA would likely increase their output as prices began to rise. Each of the four companies is in a different regional transmission group, so there is not likely to be any interaction among the companies.

Table 1. Company Criteria for Market Power Scenarios

Scenario	Concentration of Ownership	Transmission Capability
High Market Power Potential	A single company owns more than 75% of the capacity in the power control area (PCA).	Transmission import capability into the PCA is less than 40% of the company's capacity.
Low to Modest Market Power Potential	The company owns 20% to 50% of the capacity in the power control area (PCA).	Transmission import capability into the PCA is over 100% of the company's capacity.

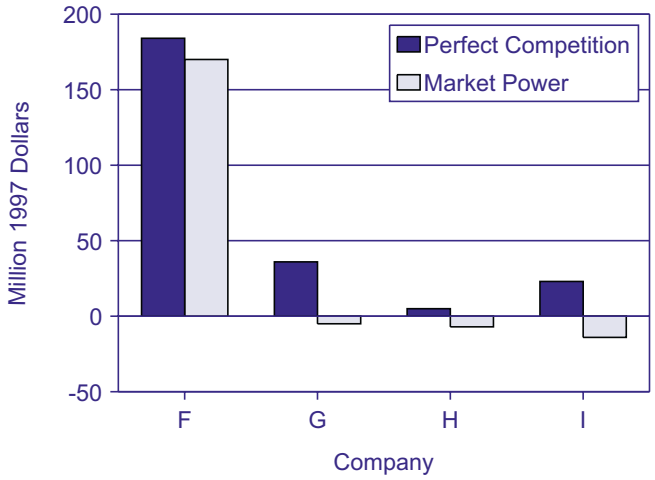
[16]Members of the high market power potential group were selected by applying the criteria in Table 1 to investor-owned utilities (IOUs) in the 20 regions into which the Nation's 140+ power control areas and 3,000+ utilities are assigned for purposes of reporting POEMS results. Then, all IOUs meeting these criteria were sorted by generation capacity and region. The four largest of these utilities (subject to a limitation of one per region) were included in the sample. One smaller firm with a dominant position in a region with smaller load was added to the group to avoid an exclusive focus on larger markets.

[17]Members of the "low to modest" market power potential group were randomly selected from among the many candidates meeting the relevant criteria in Table 1. Firms with "very low" market power potential were not considered in this analysis.

[18]Transmission constraints in POEMS will soon be revised using detailed analyses of bulk power flows. Changes in the representation of the transmission system would likely alter the POEMS results presented here.

In this scenario, none of these firms benefits from raising its bid prices. In fact, the operating surplus for three of the companies becomes negative (Figure 1). In other words, these firms can no longer cover their fixed costs. The higher bids increase generation prices in these PCAs by 2 to 9 percent, and the other companies in the PCA receive higher revenues. However, all the companies attempting to exercise market power lose a significant share of generation and are worse off.

Figure 1. Operating Surplus in 2000 for Firms with Low Market Power Potential Under Perfect Competition and Market Power Bidding Strategies



Result #2: Firms with high potential market power can generally increase their profits by exercising their power to raise prices. Operating surpluses for the six companies in the high market power potential group increase by 25 to 75 percent, and wholesale prices within the PCAs of each of the firms rise by 8 to 30 percent when the firms apply a strategy of bidding their mid-merit units at 150 percent of the competitive bid. Results for each company are given in Table 2.

Each of the firms in the group with high market power potential benefitted from raising its bid price. The increase in the market-clearing price more than offsets the loss of revenue due to decreases in output. For example, generation levels for Company A, which owns roughly 89 percent of the total capacity within its PCA, decline by more than 10 percent as a result of its higher bid price. Operating surpluses, on the other hand, rise by more than 60 percent, from $4.70 per megawatthour to almost $7.70 per megawatthour, leading to a $106 million increase in total revenues — approximately 6 percent. At the same time, total costs fall by $86 million, and Company A's operating surplus increases by nearly $200 million (Figure 2). Altogether, the five generators earn an additional $800 million in operating surplus, and wholesale prices within each of the PCAs rise by 8 to 30 percent as a result (Figure 3).

Table 2. Changes in Operating Margins and Prices for Firms with High Market Power Potential That Adopt a Bidding Strategy To Exploit Market Power

Company	Change in Generation (Gigawatthours)	Change in Revenues (Million 1997 Dollars)	Change in Costs (Million 1997 Dollars)	Change in Surplus (Million 1997 Dollars)	Change in Surplus per Megawatthour (1997 Dollars)
A	-10,185	106	-86	191	3.0
B	-22,468	-167	-493	326	6.7
C	-9,458	49	-182	231	5.7
D	-1,053	15	-22	38	2.4
E	-21,756	-271	-282	11	0.5

Figure 2. Revenues, Costs, and Operating Surplus in 2000 for Company A Under Perfect Competition and Market Power Bidding Strategies

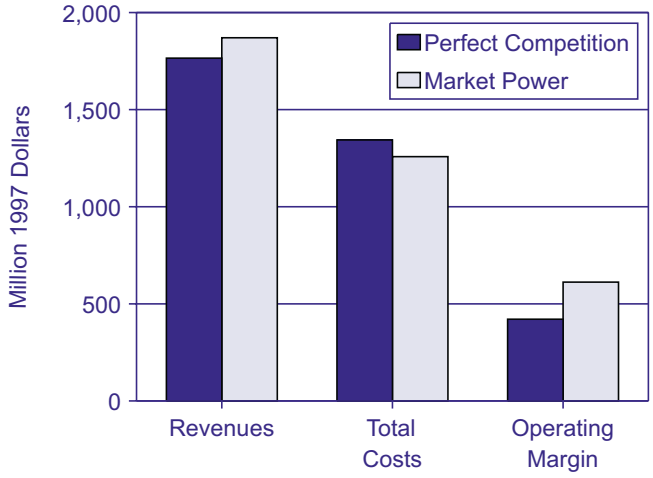
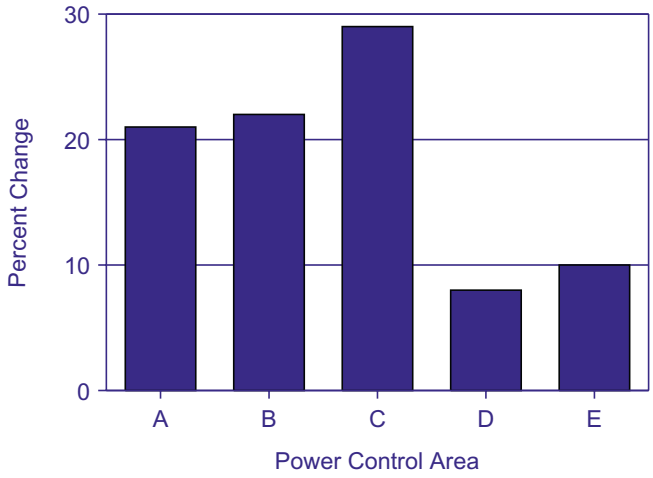
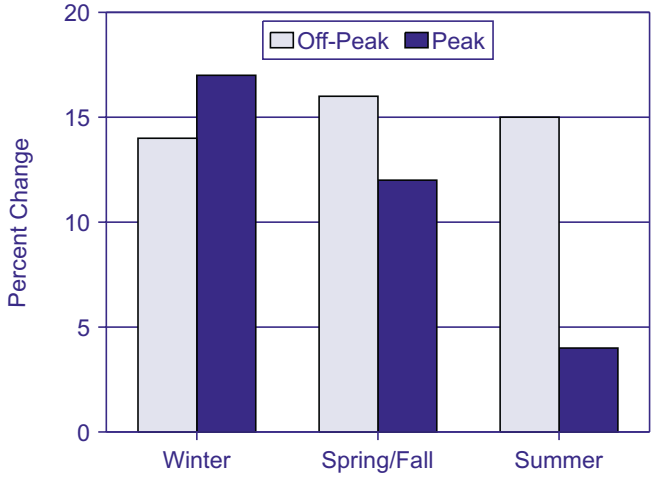


Figure 3. Changes in Wholesale Electricity Prices When Firms Exploit Market Power



For most of these firms, increasing the bid price of selected plants is profitable in virtually all time periods. In other words, at each level of load, the effect of the increase in price more than offsets any loss in generation. Figure 4 illustrates the percentage change in operating margins for Company A for six aggregate time periods: peak and off-peak for three seasons.[19] The largest increase in operating surplus for this firm occurs during the winter peak hours and the off-peak hours of summer, spring, and fall. The smallest increases occur during the summer peak hours. Most of the Company A plants for which prices are increased are relatively low-cost plants. In spite of the increase in bid prices, these plants are still less expensive than the high-cost plants used to satisfy the summer peak loads. Consequently, the market price remains relatively unchanged during the highest summer peak loads, and Company A's operating surplus increases less than during other time periods.

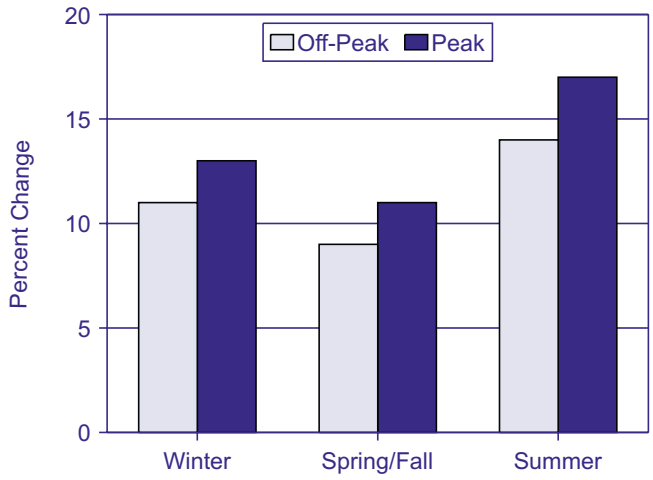
Figure 4. Changes in Operating Surplus in Different Time Periods for Company A



Seasonal variations in market power are quite different for Company B. In this case, the increase in bid prices causes these plants to become the marginal units during the highest demand periods, leading to substantial increases in prices and operating margins during the summer peak period. Operating surpluses increase less during the spring/fall off-peak periods, because the highest cost plants are not always needed. During those hours when demand is very low, raising the bid prices has no effect on market prices, because these plants are not utilized in either the base case or the market power scenarios (Figure 5).

[19]POEMS simulates 72 time periods per year. For the aggregation illustrated here, the off-peak period is defined as the 8 hours from 11 pm to 7 am, and on-peak is the 16 hours from 7 am to 11 pm. The winter months are defined as December through March, summer as June through September, and spring/fall as the remaining months.

Figure 5. Changes in Operating Surplus in Different Seasons for Company B



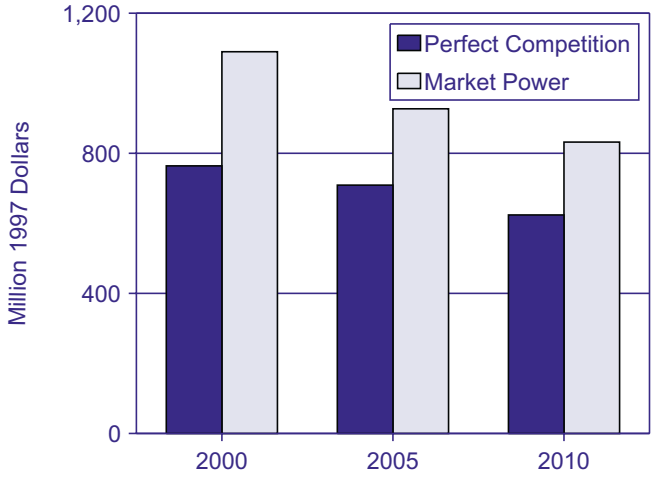
Result #3: The impacts of higher prices due to market power are felt across a wide region and benefit many firms. The increase in operating surplus flowing to all generators as a result of market power is more than twice the amount earned by only those plants exercising market power.

The effects of market power are experienced across a wide region, not just in the immediate PCA or RTG. Other generators both within and around the PCA benefit by receiving higher revenues for their output and by increasing output. For example, as Company A's generation decreases, other generators within the PCA increase their generation by roughly 430 gigawatthours. Generators in PCAs immediately surrounding Company A (those with direct transmission connections to Company A's PCA) increase output by roughly 8,120 gigawatthours. In this case, the PCA was a net exporter and becomes a net importer. Overall, other generators within the PCA earn higher operating surpluses amounting to an additional $41 million due to Company A's higher bid prices. Generators in the surrounding PCAs earn an additional $67 million, for a gain to all generators of $299 million (including Company A). For this particular example, generating capacity for the immediate surrounding competitors amounts to about 28 percent of the entire Eastern Interconnection.

Result #4: New entry by other firms eases market power over time.

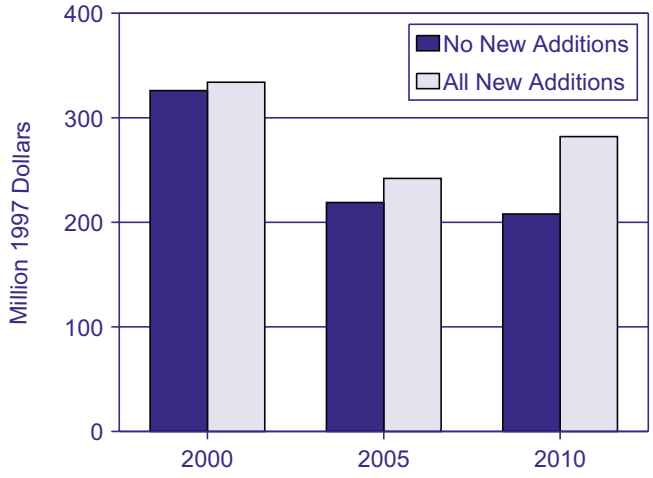
Because market power is driven in part by dominance in an area by one or a few players, a region could "grow" out of a potential market power problem through entry by other firms.[20] Figure 6 shows the operating surplus over time in the market power scenario as compared to the "perfect competition" scenario for Company B. By 2010, the firm's market power has not been eliminated altogether but is substantially diminished. Roughly 9,400 megawatts of new capacity is built in the PCA, and 4,000 megawatts of Company B's capacity is retired. As a result, total capacity owned by Company B within the PCA falls from 80 percent to 53 percent, assuming that other generators build all the new plants. If, however, Company B owns some of the new capacity, then its extra margin from exerting market power still decreases over time but to a lesser extent. Figure 7 illustrates the gain in operating surplus for the company if it builds no new plants and if it is assumed to build all the new plants in the PCA.

Figure 6. Changes in Operating Surplus Over Time for Company B



[20]In addition to the entry of new players, local regulators in some States have ordered current owners of capacity to divest their capacity, thereby immediately increasing the number of players in a given market.

Figure 7. Changes in Operating Surplus for Company B Under Different Ownership Assumptions for New Plants



Effects of Alternative Transmission Rate Structures

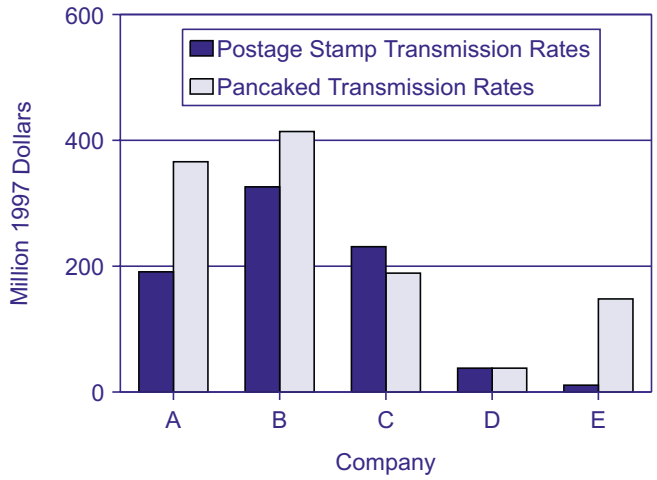
Result #5: The potential to exploit market power in restructured electricity markets increases if restructuring does not include provisions that increase the efficiency of transmission markets.

The results presented above were derived from model runs in which transmission prices were determined through "postage stamp" rates — the same assumption that is used in the underlying POEMS competition case. This assumption reflects the formation of effective regional transmission organizations (RTOs) under the Administration's proposal, which would clarify the authority of the Federal Energy Regulatory Commission (FERC) to mandate RTOs and remove tax law impediments that discourage the participation of public power and cooperative entities in RTOs. In contrast to the existing system of "pancaked" transmission rates, under which fees are paid to each transmission owner along the contract path, generators would pay a flat fee to wheel power anywhere within the RTO regardless of the distance traveled.

To assess the influence of transmission pricing on market power, the scenarios were re-run assuming pancaked rather than postage stamp rates. In both sets of scenarios, wheeling fees are assumed to be 50 percent of rates calculated using the *pro forma* tariffs identified in FERC Order 888. Although transmission rates are the same in both scenarios, the total amount of transmission fees paid by wholesale market participants is higher in this scenario because of the pancaked rate structure (assuming the volume of wholesale wheeling remains unchanged).[21] The additional fees raise the cost of wheeling power across more than one utility system and effectively reduce the geographic scope of several regional markets.

Three of the five firms in the high market power potential group are able to exploit their market power more effectively under pancaked rates (Figure 8). Although, as in the previous scenario, each firm bids 150 percent of its marginal cost, the pancaked transmission fees raise the cost of imported power, allowing generators to raise prices without losing significant market share. Company A, for example, sees a significantly smaller decline in generation output when pancaked rates are in

Figure 8. Change in Operating Surplus Under Different Transmission Rate Structures



[21]Because transmission owners are regulated monopolies, their revenue requirements are determined through rate-of-return regulation. As such, the total level of revenues collected by transmission owners from both wholesale and retail customers remains the same in the two scenarios. In POEMS, any revenue requirements not met through wholesale transmission fees are met through charges on native load customers.

place. Under postage stamp rates its output falls by more than 11 percent, while under pancaked rates its output falls by only 4 percent. Operating surplus per megawatthour increases by roughly 50 percent compared to the postage stamp scenario, because the lack of lower cost imports raises the price within the PCA. Overall, the firm earns an additional $175 million through its market power when pancaked rates are used.[22]

5. Remedies for Market Power

Although many antitrust authorities express a preference for structural remedies to address market power concerns, a variety of options that fall along the spectrum between direct regulation of prices and divestiture could be applied as part of a market power mitigation strategy. This section briefly outlines some of the possible options that have been discussed, but does not evaluate them.

- **Market Monitoring.** Absent the exercise of market power, competitors have an incentive to minimize outages during periods of peak demand and prices, in order to maximize profits. The outage experiences and bid strategies of generators with market power could be monitored, with appropriate penalties applied if evidence of market abuse is uncovered.
- **Creation of a Bidding Trust for Certain Assets.** Generators can agree to place some or all assets in a "bidding trust" to mitigate market power.
- **Contracts for Differences and Call Options.** Generators with market power could provide an RTO or other designated recipient with call options that are "in the money" if prices rise above preset threshold. This can reduce those generators' incentive to withhold capacity.
- **Requirements for Transmission Upgrades.** Generators could be required to upgrade transmission under their control to mitigate their market power in load pockets where they operate.
- **Interconnection Requirements.** Generators could be required to streamline access to transmission lines or plant sites under their control to reduce barriers to entry.
- **Requirements To Offer Real-Time Curtailment Prices to End-Use Customers.** A generation owner with market power could be required to offer its end-use customers real-time market prices for load curtailment. This would mitigate the price effect of any effort to withhold capacity.
- **Limitations on Variance of Bid Prices.** Under competition, bids for running individual units should not vary with market conditions (although market prices will). To mitigate market power, a generator with market power could agree to limited bands for bidding each unit.
- **Denial of Market-Based Rates.** Where allowed by law, regulators could revert to cost-based rates in instances where they have reason to believe that incumbent generators are exercising market power. However, denial of market-based pricing for electricity generation risks jeopardizing the benefits in terms of new products and services and greater incentives for efficiency that competition can bring to electricity consumers.

[22]Companies C and A, although not immediately adjacent to each other, are in nearby markets. In the postage stamp transmission scenario, Company C benefits slightly from the market power exerted by Company A, earning additional revenues over and above the surplus it receives due to its own market power. In the scenario with pancaked transmission rates, however, the two firms are separated into distinct markets as a result of the higher wheeling costs, and Company C earns slightly less revenue than in the postage stamp scenario.

6. Conclusion

The literature on recent experience with electricity sector competition and the new analysis using POEMS presented in this paper both suggest that the potential to exploit market power in restructured electric markets can significantly reduce the benefits to consumers that should result from the advent of competition in electricity markets.

Existing antitrust authority or the threat of new market entry does not appear to be adequate to alleviate concerns surrounding the potential exercise of market power in restructured electricity markets. In recent testimony, the Department of Justice noted that the antitrust laws do not outlaw the mere possession of monopoly power that is the result of skill, accident, or a previous regulatory regime. Antitrust remedies are thus not well-suited to address problems of market power in the electric power industry that result from existing high levels of concentration in generation. As for entry, a considerable exercise of market power is possible without inducing new entry. Moreover, even extensive entry by new competitors apparently did not prevent the exercise of market power in England and Wales over a long period of time.

While consideration of remedies to address market power is generally beyond the scope of this paper, we have briefly reviewed some of the options that have been discussed in the literature. Some options, such as the imposition of cost-based rates instead of market prices for electricity generation, risk jeopardizing the benefits in terms of new products and services and greater incentives for efficiency that competition can bring to electricity consumers. Others can be quite controversial. One attractive policy approach may be to assure adequate authority to address market power while applying a remedy best suited to the facts of each situation as it arises.

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