AN ASSESSMENT OF PHOTOVOLTAIC ENERGY AVAILABILITY DURING PERIODS OF PEAK POWER PRICES

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ABSTRACT

Competitive wholesale power markets have now been functioning for several years in various locations across the nation. Experience suggests that market clearing energy prices for power fluctuate from hour to hour and day to day. Although the availability of photovoltaic (PV) power during peak demand requirements has been well established, the availability of PV power during peak energy prices has not. While peak power prices should be strongly correlated to peak demand periods, it is still important to establish the empirical relationship between peak power prices and PV availability. This paper presents an initial assessment of PV availability during periods of peak power prices. The analysis presented below clearly demonstrates that PV power is readily available during periods of peak power prices.

1. INTRODUCTION

Electric utility deregulation has significantly changed the landscape of the electric industry. In many parts of the country, companies that generate electricity are now actively engaged in selling their capacity and energy in open, competitive markets. To facilitate the purchase and sale of power, new institutions have been established to make possible these transactions. For example, in California the California Power Exchange is responsible for managing the day-ahead and hour-ahead markets for power. The California Independent System Operator operates the regional grid and manages the markets for ancillary services.

The new market structure has resulted in transparent pricing of electricity in the wholesale market. Experience has shown that the price of electricity in these markets can encounter significant fluctuations from day to day and hour to hour (see Figures 1 & 2). These fluctuations in price signal the relative scarcity of the commodity during various time periods in different locations. Alternatively, these dramatic fluctuations in price may signal the existence of market power, whereby large firms selling power into the market manipulate the market for economic gain.

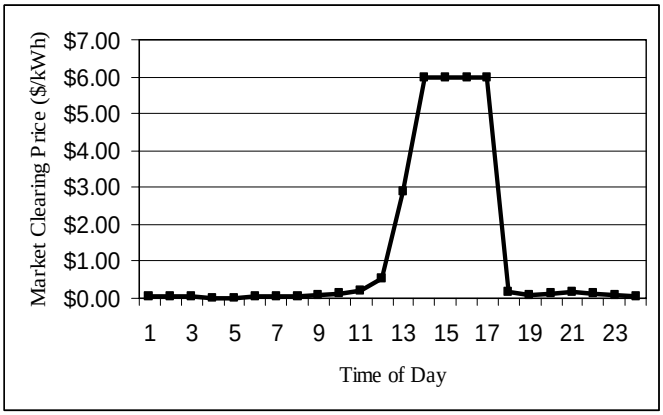

Fig. 1: Market Clearing Price of Power: New England May 8, 2000 (source: ISO New England)

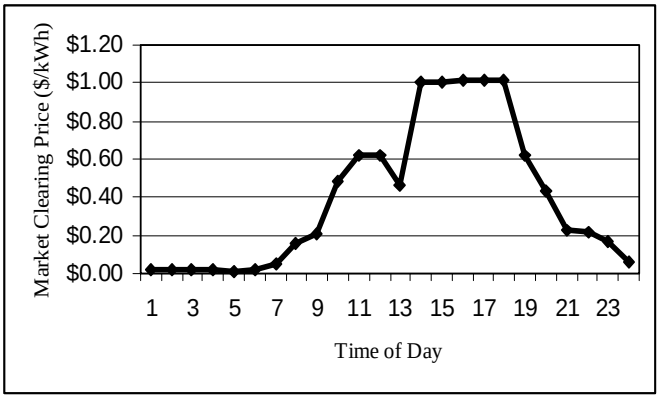

Fig. 2: Market Clearing Price of Power: New York June 26, 2000 (source: New York ISO)

The load matching capability of photovoltaic (PV) power generation with U.S. utility loads has been well-established [1] [2]. The effective load carrying capacity for certain utilities reaches 70% on the eastern seaboard. To date, however, there has been no attempt to assess the availability of PV energy during periods of peak energy prices in various power markets across the country. With the onset of electric utility deregulation, this becomes the more relevant relationship concerning the value of PV generated electricity.

Satellite-based solar resource assessment is a technique that has been developed and validated by several laboratories in the U.S. and abroad. This approach to resource assessment frees researchers from the limitations of traditional solar resource data given that solar resource data are not typically available for specific locations at specific times. Satellite derived resource data have been shown to be a reliable estimator of the actual ground-measured solar resource data [3]. As describe above, NREL has been utilizing satellite-based resource data to investigate the effective capacity of PV for U.S. electric utilities. In addition, solar satellite derived resource data have been utilized to assess market opportunities for PV technology on a state-by-state basis [4]. This paper utilizes this resource assessment technique to understand the relationship between PV output and electricity market prices.

2. ELECTRICITY MARKETS ANALYZED

This paper analyzes market-clearing electricity price data from four different competitive power markets. The power markets analyzed are California, New England, New York and PJM (the power market that serves major portions of the five mid-Atlantic states and the District of Columbia). Data from the summer of 2000 was analyzed to identify the dates and times of day when power prices peaked. We describe each of these power markets in greater detail below, and identify the days and times when PV availability was calculated.

2.1 California Power Exchange (CalPX)

California was the first state to implement comprehensive restructuring of its electric utility sector. The (CalPX) was formed as part of the process to facilitate the purchase and sale of competitive wholesale power in the State. The CalPX operates both day-ahead and hour-ahead markets for power [5]. Energy suppliers bid into these markets to supply power, whereby the bid price at which supply equals demand determines the market-clearing price. Table 1 contains information on when and where power prices peaked in California during the summer 2000. Market data were analyzed for only the day-ahead market.

TABLE 1: CALPX: PEAK POWER PRICES SUMMER 2000

Date	Time	Location	Market Price
5/28/2000	4:00 PM	South, CA	$0.60/kWh
6/28/2000	2:00 PM – 6:00 PM	North, CA	$1.09/kWh
7/25/2000	3:00 PM – 5:00 PM	South, CA	$0.50/kWh
7/31/2000	1:00 PM – 7:00 PM	South, CA	$0.50/kWh
8/1/2000	12:00 PM – 8:00 PM	South, CA	$0.50/kWh
8/2/2000	12:00 PM – 8:00 PM	South, CA	$0.50/kWh
8/3/2000	12:00 PM – 7:00 PM	South, CA	$0.50/kWh
8/4/2000	3:00 PM – 5:00 PM	South, CA	$0.50/kWh

Source: CalPX

2.2 PJM

The PJM Interconnection, L.L.C. (PJM) operates the largest wholesale power market in the world. In 1997, PJM Interconnection replaced its successor organization—PJM Interconnection Association (6). The organization is responsible for the operation and control of the bulk electric power system throughout major portions of five Mid-Atlantic states and the District of Columbia. Similar to the CalPX, PJM operates both a day-ahead and hour-ahead wholesale market for power in the mid-Atlantic region. Historical data on regional market-clearing prices for the day-ahead market were obtained, in the form of locational marginal prices, for the summer of 2000. Table 2 contains

information on the peak power prices during the summer of 2000.

TABLE 2: PJM: PEAK POWER PRICES SUMMER 2000

Date	Time	Location	Market Price
6/8/2000	4:00 PM – 5:00 PM	Southern Delaware	$1.00/kWh
5/8/2000	2:00 PM – 4:00 PM	Entire control area	$0.48/kWh
7/3/2000	5:00 PM – 6:00 PM	PEPCO	$0.19/kWh
8/8/2000	3:00 PM – 5:00 PM	Entire control area	$0.14/kWh

Source: PJM

2.3 New York Independent System Operator (NYISO)

Formed in 1998, the NYISO is a not-for-profit organization established as part of the restructuring of New York State's electric power industry [7]. Its mission is to ensure the reliable, safe and efficient operation of the State's major transmission system and to administer an open, competitive and nondiscriminatory wholesale market for electricity in New York State [7]. NYISO operates the wholesale power market in the state of New York. Again, both day-ahead and hour-ahead markets for power operate in State. Market-clearing prices during the summer of 2000 were obtained for the day-ahead market. Table 3 provides statistics on the dates, times, and location when power prices peaked in New York State during the summer of 2000

TABLE 3: NYISO: PEAK POWER PRICES SUMMER 2000

Date	Time	Location	Market Price
6/26/2000	1:00 PM – 5:00 PM	Eastern NY, Albany - NYC	$1.30/kWh
8/9/2000	1:00 PM – 2:00 PM	Capital District	$1.07/kWh
6/26/2000	1:00 PM – 5:00 PM	Long Island	$0.82/kWh
8/9/2000	1:00 PM – 2:00 PM	Long Island	$0.62/kWh
7/5/2000	2:00 PM – 4:00 PM	Capital District	$0.21/kWh

Source: NYISO

2.4 ISO New England (ISO-NE)

Established in 1997, ISO-NE replaced the New England Power Pool as the institution responsible for managing the region's bulk power market [8]. Beginning in 1999, ISO-NE began administering the restructured wholesale power market in the region. However, unlike the other power markets discussed above, ISO-NE operates only an hour-ahead wholesale market for power. Historical data on market-clearing prices from the summer of 2000 were obtained and analyzed. Table 4 provides that dates and times when power prices in New England peaked during the past summer.

TABLE 4: ISO New England: PEAK POWER PRICES SUMMER 2000

Date	Time	Location	Market Price
5/8/2000	2:00 PM – 5:00 PM	New England	$6.00/kWh
6/27/2000	1:00 PM	New England	$0.34/kWh
5/9/2000	2:00 PM – 4:00 PM	New England	$0.15/kWh
8/8/2000	12:00 PM – 2:00 PM	New England	$0.13/kWh

Source: ISO-NE

3. PV AVAILABILITY

Satellite derived solar resource data were obtained for all the dates, times, and locations listed in Tables 1 – 4. This information was utilized to calculate a measure we call PV availability. The PV availability (percent value) statistic represent the fraction of what a PV system would produce if the sky was ideally clear during the time period and location under consideration, all other conditions being equal. For example, a PV availability value of 90% indicates that the PV system would be producing about 90% of the energy it would if the sky was ideally clear at the particular location under consideration, and the time period when the peak power price occurred.

3.1 PV Availability Results

The results clearly indicate that PV systems are producing close to their rated output, given ideally clear skies, during periods when power prices peak in competitive markets. Approximately half of the 21 peak power occurrences analyzed had PV availability statistics of 90% or greater. Furthermore, over 90% of the peak power occurrences have PV availability statistics of 70% or more. Figure 3 provides

the average and range PV availability calculations for each of the four power markets studied.

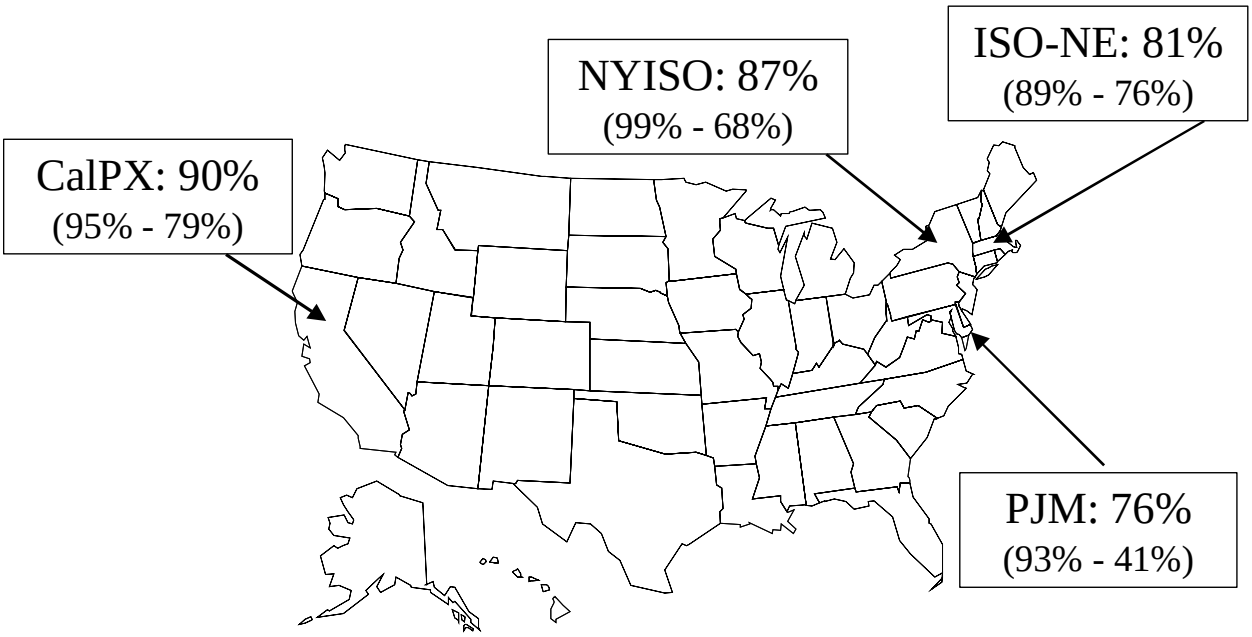

Fig. 3: PV Availability During Peak Power Prices (range and average)

4. CONCLUSIONS

Many states across the nation have made the shift to electric utility competition, in which suppliers of power bid to sell energy into wholesale markets. As a result, market-clearing power prices are readily accessible for the different wholesale markets. Experience has shown that market forces often result in sharp spikes in energy prices. Although PV availability during utility peak demand periods has been well established, the relationship between market prices and PV availability is not. This paper presents an initial analysis of PV availability during periods of peak power prices using satellite derived solar resource data. The analysis clearly demonstrates that PV systems would be producing near their peak ratings, given ideal weather conditions, at the same time when electricity prices peak in competitive markets.

These results have immediate economic and policy implications. PV manufactures and developers now have additional empirical evidence supporting the notion that PV can satisfy high-value niche markets. Although the cost of PV-generated electricity may seem high relative to average electricity prices, it can in fact be an economically competitive resource during certain times and at certain locations. The results presented here support the reform of existing net-metering laws, which compensate customers who generate more power than they consume each month at the utility's avoided cost. Further, we suggest that these net-metered customers should be compensated at a rate much higher than the utility's avoided costs given the fact that they are producing excess power at exactly the same time when market-clearing prices are at their highest.

5. ACKNOWLEDGEMENT

This study was undertaken as a byproduct of NREL contract No. XAD 81767101.

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(7) New York Independent System Operator (www.nyiso.com)
(8) Independent System Operator New England (www.iso-ne.com)