

# Going to extremes

With regional generating capacity in the US having to tackle temperature extremes, software provider Logical Information Machines looks at Pennsylvania-New Jersey-Maryland market data history to suggest how we might forecast such extremes

Risk managers and traders alike want to know if US regional generating capacity will continue to be challenged by temperature extremes. This knowledge is particularly important now, as, following Enron's collapse, the high cost of constructing power plants is forcing energy firms to re-evaluate their building plans as Wall Street puts the spotlight on debt ratios – on or off the balance sheet.

What is the impact of this reduction in planned new generating capacity? Should we expect more periods of extreme pricing when excess consumption loads outweigh a region's generating capacity? Using historical research tools, here we look back at the data history for the Pennsylvania-New Jersey-Maryland (PJM) market during the summer of 2001 to find answers.

## Market analysis

First, we will examine Pennsylvania temperatures and power pricing during July and August 2001, because this period exhibited classic examples of power/price extremes – that is, when high temperatures combined with capacity constraints to stress the PJM power pool mechanism.

Figure 1 shows daily high temperatures in Harrisburg, Pennsylvania alongside hourly real-time locational marginal prices (LMP) for the Pennsylvania Power and Light (PPL) zone – a

utility company zone of the PJM power pool – in July and August 2001. It is clear that the occurrence of temperatures well above 90° Fahrenheit sets off extreme volatility in the real-time power market.

Also significant for this analysis is day-ahead pricing measured against real-time pricing, in the PJM PPL zone. Figure 2 gives hourly data for August 9, 2001. The LMP day-ahead prices show where generators and consumers believed the market would fall as they submitted generation and consumption bids during the period before midday on August 8. The August heat wave and power squeeze was two days old and temperatures had already reached very high levels. The day-ahead market forecast that power prices for August 9 would rise as high as \$700 a megawatt hour (MWh) in the early afternoon.

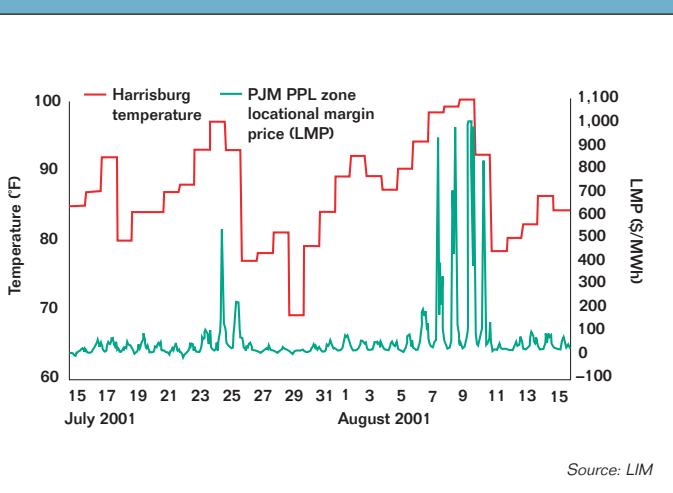
The figure also shows where the real-time market eventually settled prices for the day – with the LMP values hitting the market maximum of \$1,000/MWh for a five-hour period in the afternoon and taking another unexpected leap at 8pm that evening.

We also need to examine hourly load, hourly generation and hourly price figures. These figures are important because if available capacity is not sufficient to meet demand – as is the case here – then traders need to buy in power generated outside the pool and will probably have to pay a hefty premium if there is competition for those megawatts (MW).

Figure 3 shows the actual hourly power generation and load situation in the PJM area on August 8 and 9, 2001. The load exceeded power generation all day long on both days, with PJM therefore reliant on outside supplies.

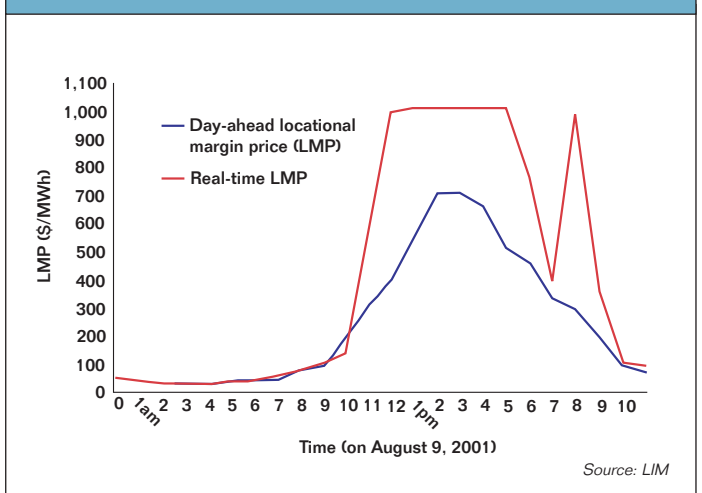
During the peak-load periods, the real-time, hour-ahead price for buying these extra MW leaps by hundreds of dollars an hour during the early afternoons on both days and then again by \$500 in a single hour between 7pm and 8pm on August 9 as available supplies tightened.

Figure 1: Harrisburg temperature v. hourly PPL LMP



High daily temperatures in Harrisburg, Pennsylvania during July and August set off price spikes in the real-time locational marginal pricing (LMP) market

Figure 2: PJM hourly day-ahead and real-time LMPs



Day-ahead hourly prices determined by the PJM pool exchange mechanism, compared with the hour-ahead real-time prices that transpired on August 9, 2001

We should note the scale of the price increase in one hour on August 9. The price at 7pm is \$375/MWh and the price at 8pm is \$910/MWh – a rise of \$533, or a 142% increase.

### Lessons for the future?

So how can market participants learn from these dramatic examples to better prepare for future extreme weather situations?

One way is to use technology, such as LIM's XMIM language, which allows users to query a historical database directly in order to identify similar situations in the data history and thereby help pinpoint cause and effect.

We entered two queries into such a database. The first query simply asked the database to show the three variables of temperature, load and generation when the real-time price in any hour exceeded the day-ahead price by \$350/MWh or more. We would expect this set of circumstances to result in a price spike. We also input a query to identify the temperature in Harrisburg when real-time LMP prices in the PJM region exceeded day-ahead LMP prices by more than \$350/MWh.

The results of the first query (shown in table 1) identify eight days when the conditions were met and real-time prices exceeded day-ahead prices by \$350. On all except one of these days, the temperature was 90°F or above and the load (or demand) exceeded available generation – that is, a power generation constraint existed. This result suggests there is a high degree of correlation between very high temperatures, power generation constraints and pricing spikes.

To test this hypothesis, we then reversed the query by asking what was the impact on price (real-time versus day-ahead) when temperatures were high – 90°F or above – and load exceeded

generation? The results validated our hypothesis, as these conditions almost always led to price spikes.

Table 2 shows part of that analysis – for August 9 – and provides further insight into the circumstances by giving the hourly breakdown of real-time/day-ahead price spreads. The afternoon hours turn out to be those when price spikes occur most often.

### Summary

The analysis tools have, then, clearly identified the stress points in the PJM system as times when high temperatures tested the region's generating capacity. In a situation where new capacity is not being brought online, only improvements in transmission infrastructure or better customer conservation can relieve this stress.

For the moment, it seems likely that price extremes will be repeated every summer and that for the power market the price volatility will represent either a risk management 'problem' or a speculative trading opportunity. [EPRM](#)

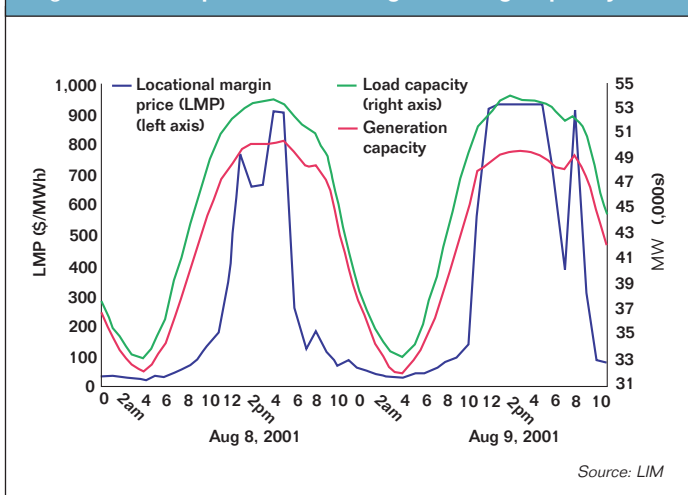
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Table 1: Results of first database query

| Date       | Time | Day | Temp. (°F) | Load (MW) | Generation |
|------------|------|-----|------------|-----------|------------|
| 26 Jun '00 | 3pm  | Mon | 90.000     | 49,212    | 46,807     |
| 17 Dec '00 | 6pm  | Sun | 56.000     | 33,883    | 34,222     |
| 24 Jul '01 | 3pm  | Tue | 97.000     | 51,104    | 49,315     |
| 25 Jul '01 | 1pm  | Wed | 93.000     | 51,686    | 46,731     |
| 7 Aug '01  | 2pm  | Tue | 98.000     | 52,394    | 48,839     |
| 8 Aug '01  | 1pm  | Wed | 99.000     | 52,815    | 49,679     |
| 9 Aug '01  | 12pm | Thu | 100.000    | 52,527    | 48,587     |
| 10 Aug '01 | 11am | Fri | 92.000     | 51,109    | 46,620     |
|            |      | Avg | 90.625     | 49,341    | 46,350     |

Source for tables: LIM

Figure 3: PJM price, load and generating capacity



Source: LIM

Actual hourly system demand (load) consistently exceeded PJM system generation on August 8 and 9, causing wild price volatility as the real-time buyers dashed to get power from outside the PJM pool

Table 2: Results of second database query

| Date       | Time    | Day      | Real-time v. day-ahead price (\$/MWh) |
|------------|---------|----------|---------------------------------------|
| 9 Aug 2001 | 10.00am | Thursday | -38.6400                              |
| 9 Aug 2001 | 11.00am | Thursday | 303.4400                              |
| 9 Aug 2001 | 12.00pm | Thursday | 532.7800                              |
| 9 Aug 2001 | 01.00pm | Thursday | 381.6000                              |
| 9 Aug 2001 | 02.00pm | Thursday | 231.7000                              |
| 9 Aug 2001 | 03.00pm | Thursday | 231.0700                              |
| 9 Aug 2001 | 04.00pm | Thursday | 282.4200                              |
| 9 Aug 2001 | 05.00pm | Thursday | 432.4100                              |
| 9 Aug 2001 | 06.00pm | Thursday | 243.0500                              |
| 9 Aug 2001 | 07.00pm | Thursday | 18.5000                               |
| 9 Aug 2001 | 08.00pm | Thursday | 612.7000                              |
| 9 Aug 2001 | 09.00pm | Thursday | 146.3000                              |
| 9 Aug 2001 | 10.00pm | Thursday | 1.1098                                |