Can the price risks associated with abnormally cold winter temperatures and their impact on short term energy demand be predicted ahead of time? Logical Information Machines' *Sandy Fielden* investigates recent freezing temperatures in Boston, Massachusetts.

A fact of life?

★ This January (2004), temperatures in the northeast US dipped below zero Fahrenheit (–18 centigrade) twice in the space of one week. US weather service records show that in Boston, Massachusetts, the low temperature for January 15, 2004 was –5 Fahrenheit (–21 centigrade) and on January 16 it dipped down to –7 Fahrenheit (–22 centigrade). This two-day icy blast was the coldest it has been in Boston since 1980 and the coldest on successive days since February 1943. Chart 1 shows this winter's temperatures in relation to the expected 30-year normal low of around 22 Fahrenheit (–6 centigrade).

Cold weather translates into heavy demand for energy across the northeast US. The New England Independent System Operator (ISO), which manages generation in the New England states, registered a record high demand of 22,732 MW during the hour commencing 6.00pm on January 15.

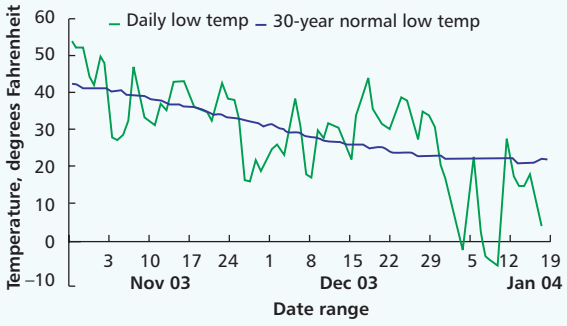
In New England, real-time ISO electricity prices reached $920 per Megawatt-hour (MWh) at 5.00pm on January 14 as the ISO scrambled to meet rising demand. Natural gas prices for the day-ahead market on January 14 also rose to a record high of $72.67 on the Algonquin gas transmission pipeline for deliveries to city gates in Connecticut, Massachusetts and Rhode Island. Daily peak electricity prices for Massachusetts Hub rose to $315 for the day-ahead market on 14 January.

In this 'day-ahead' pricing situation, generating electricity using natural gas became a loss-making proposition. For example, if a typical power plant has a heat rate of 10,000 British thermal units (Btu) per hour, then the cost of generating 1 MWh of electricity would be 10 times the price of natural gas in $/mmBtu. If gas prices are $72.67, as they were on the Algonquin pipeline, then the cost of generation would be $726.70/MWh. If you can only sell that electricity for $315 MWh, you are losing at the rate of $411.70 per MWh. This negative spark spread on January 15, 2004 actually led to calls for an investigation by Connecticut Attorney General Richard Blumenthal, as some believed that power generators may have sold gas for cash rather than generate much needed power at a loss – making the situation worse for consumers.

So what means might be available to identify volatile weather patterns ahead of time so that there is a chance of reacting to them before prices start spiking upwards?

Although price volatility following record low temperatures is to be expected, it is useful to be able to compare periods of volatile weather today with what happened in the past. Logical Information Machines (LIM) uses a patented analog study to compare today's data with past activity in equity, commodity

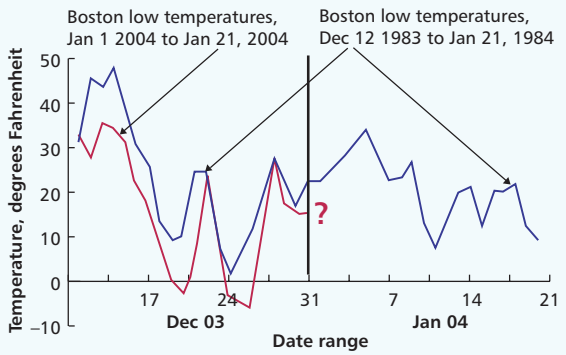
Fig 1. Boston daily temperatures Nov 2003 – Jan 2004.



Source: NOAA

Extremely low temperatures during successive weeks in January 2004 were well below seasonal norms, making this one of the coldest winters on record in the Northeast US.

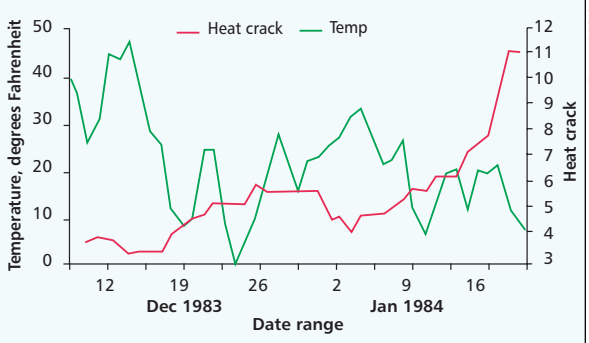
Fig 2. LIM study of Boston low temperatures since 1920



Source: LIM, NOAA

The study looked at Boston low temperatures since 1920 to find which period most closely resembled January 2004 data. December 1984 was the best match. The chart also shows what happened in the 20 days following the period of the match.

Fig 3. Boston low temperatures and the Nymex heat crack



Source: NOAA, Nymex

Boston low temperatures and the Nymex 'heat crack' (Nymex heating oil minus Nymex crude) in the winter of 1983/1984: From January 1 to January 21,1984, the heat crack increased by 93%, from $5.78 to $11.14. This could help predict future price jumps.

and futures markets in order to identify matching patterns. The analysis can easily be performed using weather data. Indeed, records of weather (temperature) data go back much further and more reliably than market price information in many countries.

Temperature comparisons

LIM used its analog study to analyse the history of low temperatures in Boston, Massachusetts. The study starts by looking back from the the present day for the last 20 days of temperatures and then compares the pattern of daily lows during that 20-day period with every other 20-day period in the weather database, going back all the way to 1920. The purpose of the study is to identify the closest pattern match in history and see 'what happened next' when this weather pattern was last experienced. The results of the study can then be used to try and predict weather patterns or to compare the historic reactions of the markets in similar circumstances. This can provide risk managers with a useful 'heads up' when navigating periods of extreme weather .

Once the study identifies the closest match in the database history, using best-correlation analysis, the latest 20 days of data is shown on a chart (see figure 2), lined up with the pattern of the best historical match. The chart also shows 'what happened next' by plotting the 20 days following the historical period with the best match. Over the period from 1920 to the present (in this case, January 19, 2004), the best match for the last 20 days of low temperatures in Boston was the 20 days leading up to January 1, 1984.

In the year with the best pattern match (1984), cold weather in December with the distinctive double dip pattern seen during January 2004, was followed by a milder month of January with two more lows that were less severe. If 2004 continues to follow the 1984 trend, this could indicate that the worst is over for Boston in 2004, although the return of single-digit temperatures (Fahrenheit) within the next twenty days is very likely.

So what can we learn about prices by identifying a weather pattern match in 1984?

In this instance, there is price information available for Nymex heating oil going back to 1984. The Nymex heating oil contract is based on delivery into New York Harbor. As it happens, heating oil prices in New York are strongly affected by demand in the New England states, where oil is the traditional fuel of choice for home heating in the Winter. Much of that heating oil is refined in the US Gulf or New York Harbor regions and moved by pipeline or ship cargo up the northeast coast.

In fact, Nymex heating oil prices rose by 22% between January 5 and January 21 in 1984, indicating that the very cold December period identified by the LIM analog study was a catalyst for higher fuel prices that winter.

Heat crack

However, it is considered more accurate to look at the difference between Nymex heating oil and Nymex crude prices for the period (the 'heat crack'), since by doing so, we remove any influence of rising crude prices on the market. In that context, the heat crack jumped from $5.78 on January 1 1984 to $11.14 on January 21 1984 – a leap of 93%. (see figure 3).

So although we don't have fundamental data as far back as 1984 (from the Department of Energy) in order to review the supply situation, we can certainly infer that higher fuel prices resulted from the very cold winter and, in particular, that a period of extreme cold early on in the winter is likely to affect fuel prices to the upside for the rest of the season.

Lastly, LIM looked at historical weather data for Boston to see whether very cold weather was preceded by strong cooling trends in daily temperatures, and if these cooling trends would give market players enough warning to take action in the futures market to profit from higher heating oil prices. So, when daily high temperatures in Boston fell on four successive days and ended up below 25 degrees Fahrenheit (–4 degrees centigrade), what was the impact (percentage move) on Nymex heating oil prices over the next two days?

The result is that, of the 13 times in history (1978 to present) that the Boston high temperature dipped below 25 degrees on the fourth day of a downward trend, on 77% of those occasions, Nymex heating oil prices went up by an average of 2.24% over the following two days.

So while an extremely cold winter can wreak havoc with prices in the short term, careful analysis of the market data can provide insight into price direction. When looking at the whole season you can discern a lot of information by identifying a really cold winter early on. When looking at the next few days you may have time to respond quickly to cooling temperatures to protect fuel costs. ER

Sandy Fielden is Energy Products Manager for Logical Information machines, **Email** sandy@lim.com