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Mathematical modelling of regional electricity prices and loads

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As consumer energy usage changes, the relationship between weather and power demand has increased. Reliable predictions of the impact of temperature variations can improve demand forecasting and reduce costs to the community caused by unexpected demand on too few resources.

Since open trading and budgeting for electricity demand and pricing was introduced through NEMMCO, the effect of temperature on the electricity market has become more apparent to regulators, participants and observers of the national electricity market.

This analysis examines three of the main periodic measurable elements in the electricity market, temperature, load and market pool price. The analysis then focuses on deriving significant frequencies and attempts to build reasonably accurate models of the expected behaviour for these three elements.

For each of the data sets, a four year period was selected for analysis as this comprises a complete leap year cycle within the data available. The selection of four years of data at 30 minute intervals meant an analysis of 70,128 records for each data set.

The significant cyclic frequencies were extracted from the raw data using Fourier transforms. In order to do this efficiently within the time available, a short program was written, in Java, to implement the Discrete Fourier Transform, from first principles.

$$f_j = \sum_{k=0}^{n-1} x_k \cdot e^{\frac{-2i\pi}{n} \cdot jk}$$

Once the significant cyclic frequencies were determined, a multi-variate linear regression calculation program was written in order to establish the coefficients of the sine and cosine components of each of the frequencies, using the least squares method. Again this was a purpose written program implementing the regression calculation from first principles, in Java.

Forty-eight individual temperature models were created, allowing individual sets of of coefficients for each half-hour period in the day. Also, in order to allow for the effects of different days of the weeks in load and price, 336 distinct models were constructed, for each of load and price, for each half-hour increment within a week. This enabled the modelling of behaviour to each particular time and particular day and of the week.

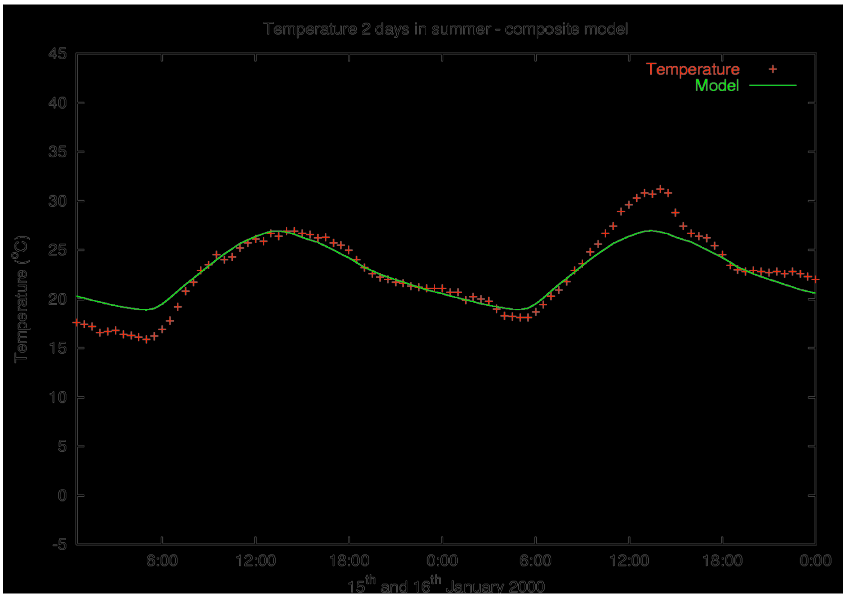
Due to the exponential nature of the price behaviour, it was necessary to find the logarithm of the raw data before processing.

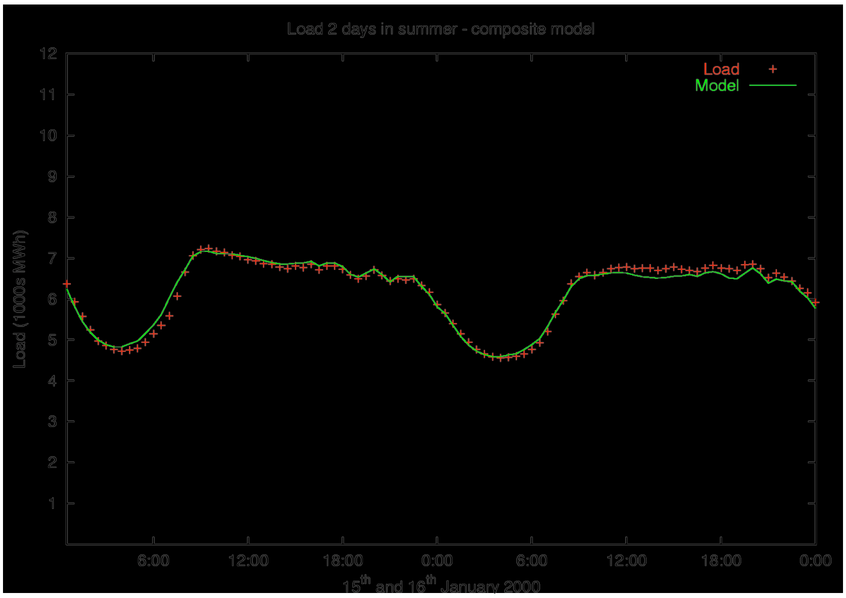
Using the data from the 48 temperature, 336 load and 336 price models enabled the creation of 3 complete models giving a reasonably good calculation of the trend behaviour.

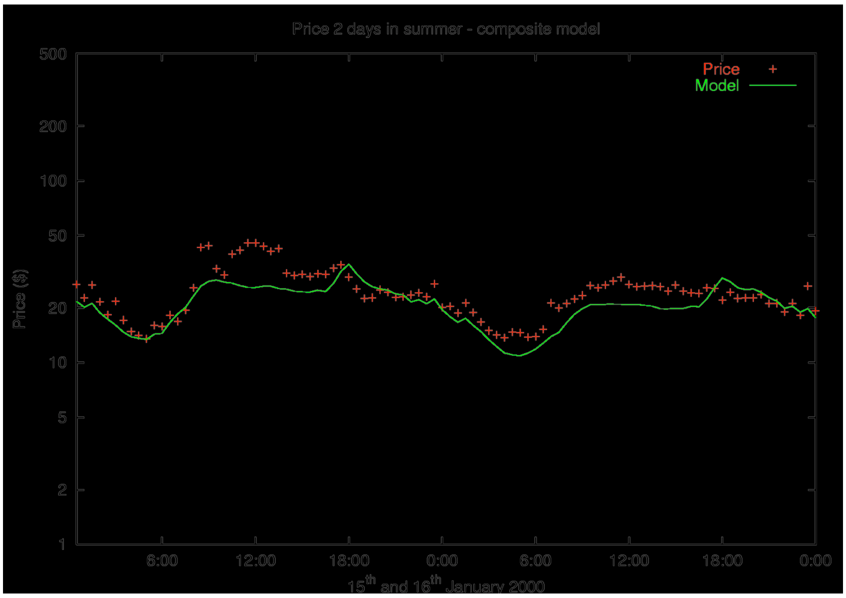
Justin received an ICE-EM Vacation Scholarship in January 2005.
See www.ice-em.org.au/students.html#scholarship.

Further research opportunities lie in developing the models with data over a greater period to reduce the impact of localised load and price disturbances. Also further opportunities exist in investigation of the relationships between out of trend behaviour of the three measurables. Further study could investigate the changes in the behaviour and volatility of the load or price at different times within the week.

This analysis lays the foundation for accurate calculation of the financial risk metrics associated with electricity contracts, especially those that depend on the interplay between temperature, load and pool price.






Price 2 days in summer - composite model
Price
Model
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200
100
50
20
10
5
2
1
Price ($)
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12:00
18:00
0:00
6:00
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15th and 16th January 2000