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Density forecasting for the efficient balancing of the generation and consumption of electricity

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Abstract

The transmitters of electricity in Great Britain are responsible for balancing generation and consumption. Although this can be done in the hour between closure of the market and real-time, off-loading or calling-up electricity at this late stage can be costly. Costs can be substantially reduced if the imbalance can be anticipated ahead of time and balanced by trading on the market. Efficient trading relies on accurate density forecasts for the Net Imbalance Volume, which is defined as the sum of all actions taken to balance the system. Forecasting this density is the focus of this paper. We break down the problem into point and volatility prediction. We evaluate density forecasts in terms of the economic benefit generated from trading advice resulting from the forecasts. Promising results were achieved using a seasonal ARMA model or a periodic AR model for point forecasting, with a simplistic approach to volatility forecasting.

Keywords: Electricity markets; Volatility forecasting; Density forecasting; Seasonality; Periodic models; Economic value

1. Introduction

In the wholesale electricity market of Great Britain, National Grid is the company that operates the transmission system, and balances supply and demand. The market involves suppliers undertaking contracts with generators to meet their anticipated requirements. An hour ahead of real time (known as "gate closure"), the market closes and market participants indicate what electricity they intend to produce or consume to meet their contractual obligations. In the hour between gate closure and real-time, National Grid must ensure that the demand is balanced by an equal amount of generation. To do this, they take "bids" and "offers" from generators and suppliers, who indicate the prices at which they would be prepared to change their intended generated output or consumption.

The energy imbalance is known as Net Imbalance Volume (NIV). It is defined for each half-hour as the sum of all actions, in the market and after gate closure, that National Grid undertook to balance the system for that half-hour. The convention is that a negative value for NIV means that contracted generation exceeded consumption, forcing the com-

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pany to undertake sales of electricity or accept bids from generators to reduce their generation. These actions by the company are based on the 1-h ahead prediction of NIV.

Accepting bids or offers after gate closure can be very costly for the company. These costs can be substantially reduced if NIV can be anticipated ahead of gate closure and balanced by trading on the market. Indeed, the costs tend to decrease as the lead time increases. Efficient trading relies on accurate forecasts for the probability density function of NIV. This is the focus of this paper. We break down the problem of density forecasting into point and volatility prediction. By making a distributional assumption, the point and volatility forecasts can then be converted into a density forecast for NIV. It is not only National Grid that forecast NIV, but also generators seeking to gain an advantage by being able to anticipate the trades of the company. The problem of forecasting NIV is common to any self-dispatching electricity market, of which there are several in Europe and the US.

In Section 2, we describe the NIV time series. Sections 3 and 4 evaluate the accuracy of point and volatility forecasting methods, respectively, using error summary measures. In Section 5, we evaluate the quality of density forecasting methods in terms of economic benefit by deriving the monetary outcome that is generated from trading advice resulting from the density forecasts. The final section provides a summary and concluding comments.

2. Net imbalance volume

In this paper, we analyse half-hourly NIV observations for the 1-year period from 11 March 2003 to 10 March 2004, inclusive. This series is plotted in Fig. 1. We chose not to use data prior to 11 March 2003 because a change was introduced to the electricity trading rules on this day, and the forecasters at National Grid felt that it was quite possible that this would have led to a change in the structure of the NIV time series. We considered omitting observations for the days immediately following the potential structural change, but we did not do this because informal inspection of the series around this period did not actually reveal any clear evidence of structural change in the series.

We used the first nine months of observations (273 days or 13,104 observations) to estimate model parameters, and the remaining three months (93 days or 4464 observations) for post-sample forecast evaluation. The use of 9 months of data for model estimation was recommended by National Grid from previous experience. In our study, we focused on the two forecast origins, and associated lead times, for which the National Grid trading support team are required to supply the company's traders with NIV forecasts. Forecasts from a 3 pm origin are required each day for the 48 half-hours from 11:30 pm on the next day through to 11 pm on the day after. The lead times from this origin are, therefore, from 65 to 112 steps ahead. Forecasts

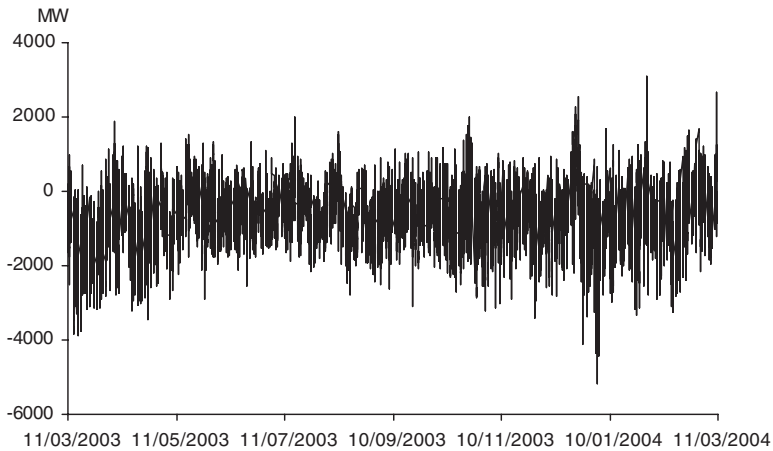

Fig. 1. Half-hourly Net Imbalance Volume for the period 11 March 2003 to 10 March 2004.