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Forecasting of Turkey's net electricity energy consumption on sectoral bases

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Abstract

In this study forecast of Turkey's net electricity energy consumption on sectoral basis until 2020 is explored. Artificial neural networks (ANN) is preferred as forecasting tool. The reasons behind choosing ANN are the ability of ANN to forecast future values of more than one variable at the same time and to model the nonlinear relation in the data structure. Founded forecast results by ANN are compared with official forecasts.

Keywords: Electricity energy forecasting; Artificial neural network; Turkey's electricity consumption

1. Introduction

Turkey is located between Europe and Asia. This geographical location makes it a natural land bridge connecting Europe to Asia. In 2003, the population of Turkey was 70.8 million, 26% over the 1990 level. The average population growth rate was 1.8% per year between 1990 and 2002, the highest among the International Energy Agency (IEA) member countries. Population growth is envisaged to gradually slow down to 1.6% in 2005, 1.4% in 2010 and 1.1% in 2020. With these growth rates, the population will reach almost 88 million by 2020. The economy has undergone a significant shift from agriculture towards the service sector and to some extent industry, although some 30% (43% in 1993) of the active population was still employed in agriculture in 2003 (IEA Report, 2005). Turkey has been rapidly growing in terms of both its economy and its population. In parallel, its demand for energy, particularly for electricity, has been increasing fast. Electricity energy is a vital input for technical, social and economic development of Turkey as the other countries. In the 1990s energy consumption increased about 4.4% per year, with electricity consumption growing at an average annual rate of about 8.5%. Projections for Turkey made officially indicate a continuing increase in demand for energy, especially for electricity, in the next two decades (ESMAP Report, 2000). In Turkey, energy consumption projections are made by Ministry of Energy and Natural Resources of Turkey (MENR). Since 1984, MENR prepares energy demand forecasts by using Model for Analysis of Energy Demand (MAED) simulation technique. MAED requires several types of data related to social, economical and demographical structure of country. However, the governments may tend to use target values of data that mentioned former statement instead of estimated values. For this reason, it is stated in a number of studies that forecast values founded by MAED technique are higher than real values (Ediger and Tatlidil, 2002). In order to achieve lower forecast error, utilizing different techniques based on direct observation values, instead of scenario-based techniques like MAED, will be useful.

There are many studies releated to electricity energy consumption forecast in the literature. In recent studies artificial intelligence (AI) techniques are frequently used as a forecasting tool. Metaxiotis et al. (2003) is giving a literature review related to usage of AI techniques in the forecasting of short term load. Metaxiotis et al. (2003) rewiewed AI techniques used in short term load forecasting under expert systems, artificial neural networks (ANN) and genetic algorithms titles. Bhattacharya and Basu (1993)

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and Basu et al. (1991) utilized Kalman Filter techniques for middle term forecasting. For long-term electricity energy consumption forecasting, Kermanshahi and Iwamiya (2002) used backpropagation network and Jordan recurrent network for the forecasting of Japan's electricity energy consumption until 2020. By employing ANN and Box–Jenkins methods, Al-Saba and El-Amin (1999) forecasted Saudi Arabia's peak load between 1997-2006 and compared performance of these two techniques. Parlos et al. (1996) proposed a hybrid model in which ANN, genetic algorithm and fuzzy logic are used together in the forecasting of long-term energy demand. Padmakumari et al. (1999) used fuzzy neural network for long-term load forecasting. The literature is vast and has been growing. Jebaraj and Iniyan (2006) made a literature survey in order to give a brief overview of the different types of energy modelling and forecasting.

On the other hand, various studies were performed recently on forecasting of Turkey's energy demand. Ediger and Tatlidil (2002) forecasted the primary energy demand and analysed the cyclic patterns. Ceylan and Ozturk (2004), Ozturk et al. (2004) and Canyurt et al. (2004) estimated energy demand and electricity consumption using genetic algorithms. Yumurtaci and Asmaz (2004) forecasted the energy demand until 2050 and calculated which percantage of the requried energy can be produced by hydraulic and termal power stations. Forecasts are made with statistical techniques in Yumurtaci and Asmaz's study. Gorucu et al. (2004) proposed an approach to forecast and evaluate gas consumption by ANN for the capital city of Turkey. Hamzacebi and Kutay (2004) utilized regression, Box–Jenkins and ANN models for forecasting net electricity energy consumption until 2010. Yalcinoz and Eminoglu (2005) presented a neural network (NN) model for short-term peak load forecasting, short-term total load forecasting and medium-term monthly load forecasting in power distribution systems for Nigde city in Turkey. Sozen et al. (2005) devoloped equations for forecasting net energy consumption using by ANN. Madlaner et al. (2005) have applied a dynamic technology adoption model for the evaluation of irreversible investment options for electricity generating technologies in Turkish power supply industry, taking into account uncertainty, vintage-specific life-cycle capital and operation costs. Tunc et al. (2006) predicted Turkey's electricity energy consumption rates with regression analysis for the years of 2010 and 2020 and, developed a linear mathematical optimization model to predict the distribution of future electrical power supply investments in Turkey. Yuksek et al. (article in press) investigated the role of Turkey's hydroelectric power in meeting the long-term electricity energy demand. Yilmaz and Uslu (article in press) investigated energy policies and developments in energy production of Turkey during the period 1923–2003 in order to review the studies about the subject. Salvarli (article in press) mentioned the importance of hydraulic energy for Tukey.

In this study, Turkey's net electricity energy consumption on sectoral basis is forecasted. ANN is chosen as the forecasting tool. The reasons behind this choice are the ability of ANN to forecast future value of many variables simultaneously and to model the nonlinear relation in the data structure. The organization of the rest of the paper is as follows: In the second part, a brief information of ANN is given. In the third part, Turkey's net electricity energy demand is forecasted by ANN technique. In the last part the results are discussed.

2. Artificial neural networks

ANN, imitating the functioning of human brain, is a tool of great importance in sample classification, pattern recognition, and forecasting. Most widely used ANN type for forecasting is multi layer perceptron (MLP). In an MLP designed for time series forecasting, determining the variables, such as number of input, hidden and output neurons, is highly important. However, these parameters are subject to change with respect to the problem at issue.

One of the most important parameters of an MLP set up for forecasting purposes is the number of input neurons. Yet it is not easy to determine the suitable number of input neurons when dealing with a time series forecasting problem. Usually, proper number of neurons are hoped to be achieved via trial and error and heuristic approaches. Another important parameter is the number of hidden layers and hidden neurons. Hidden layers and neurons are of great significance in the efficacy of ANN. Hidden layers and neurons in these layers are the ones bringing out the defining properties within data and helping to establish the nonlinear correlation between input and output. Studies show that one hidden layer yields good results in nonlinear function approximations at any accuracy level (Cybenko, 1989; Hornik et al., 1989). According to Zhang et al. (1998), one hidden layer is sufficient for most forecasting problems. Determining the number of hidden neurons is a critical task. Hence, starting with a small value and increasing this value until network performance maximizes might be brought to mind as a systematic method (Kaastra and Boyd, 1996).

Another factor that may affect MLP performance is the number of output neurons. Number of output neurons directly depends on the problem. In time series prediction problems based on single variable, number of output neuron is equal to one as the iterative forecasting approach is preferred. However, when the interactive predictions of multivariable to be obtained based on the iterative forecasting approach, the number of output neurons is equl to the the number of variables to be considered.

3. Turkey's net electiricity energy consumption forecast with ANN

The gross domestic product (GDP) of Turkey declined by 7.5% in 2001 because of economic crisis, but recovered by