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Model estimation of ARMA using genetic algorithms: A case study of forecasting natural gas consumption

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Abstract

Energy is accepted as a vital strategic issue all over the world due to the important hesitations/concerns about energy reliability, sustainability and affordability. The future of the any country's economy entirely depends on energy because it is the major input and indispensable resource for all sectors. Particularly, natural gas is a common used energy source for electricity generation, heating and cooking. Natural gas dependency on the foreign countries leads to economic damages for developing countries like Turkey, due to the high import costs. In this respect, precise forecasting of natural gas consumption plays crucial role in energy projections and economic progress. Underestimating natural gas demand leads to unsatisfied demand for both industrial and residential needs. In this study, we propose a forecasting method integrating Genetic algorithms (GA) and Autoregressive Moving Average (ARMA) method to take advantages of the unique strength of ARMA and genetic algorithms model. In order to predict natural gas consumption of İstanbul, which is the most important metropolitan city of Turkey, with a lower percentage error and with a greater sensitivity based on penalty function. According to the experimental results, the developed combined approach is more robust and outperforms classical ARMA models in terms of mean absolute percentage error (MAPE) and cost function values.

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Keywords: Natural gas consumption; forecasting; genetic algorithms; ARMA

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1. Introduction

Natural gas is mostly preferred primary energy resource due to the numerous advantages. Natural gas is an environmental friendly energy source and it can be easily stored and more smoothly transported compared to the other fuels. Additionally, it has a very wide application area such as commercial, industrial, electric power generation and residential applications.

The growing energy demand have resulted in dependency on energy imports, primarily of oil and gas ("From Rep. of Turkey Ministry of Foreign Affairs," 2016). In Turkey, the largest share in the primary energy sources is natural gas with a rate of 35 %, then coal (28, 5 %), hydro (7 %) and other sources (2, 5 %) follow, respectively. According to Ministry of Energy and Natural Resources (MENR), natural gas accounted for 37, 8 % of total electric generation in 2015 (in Fig. 1). In this viewpoint, accuracy of the prediction model of natural gas consumption has emerged as a crucial energy strategy for policy makers and energy authorities in order to minimize economic losses and eliminate undesired conditions (Taşpınar, Çelebi, & Tutkun, 2013).

In the literature, many forecasting studies have been recently applied to formulate natural gas consumption (Ali Azadeh, Saberi, Asadzadeh, Hussain, & Saberi, 2013; Soldo, 2012; Y. Yu, Zheng, & Han, 2014). Forecasting models can be classified into traditional methods, artificial methods and hybrid approaches (F. Yu & Xu, 2014). Time series modelling is one of the most used traditional econometric methods which is widely used in natural gas consumption. Demirel et al. (2012), Erdogdu (2010), Kumar and Jain (2010), Ediger and Akar (2007), Sarak and Satman (2003), Liu and Lin (1991) have applied time series modelling for prediction of natural gas consumption. Artificial methods include Artificial Neural Networks (ANNs) and Genetic Algorithms (GAs). Szoplik (2015), Azadeh et al. (2015), Rodger (2014), Gorucu et al. (2004), Hong et al. (2013), Azadeh et al. (2010), Eynard et al. (2011), Kizilaslan and Karlik (2008) have developed ANN for natural gas prediction, and also Izadyara et al. (2015), Askari et al. (2015), Wang et al. (2012), Thomas et al. (2008) have considered GA approach for natural gas forecasting model, respectively. Hybrid models provide advantages over the single models since combinational methods collect the strong sides of the used methods. Some of the studies include combinational methods as follows: Yu and Xu (2014) used real-coded GA and modified BP neural network, Hong et al. (2013) have conducted GA-support vector machine together, Song and Song (2012) have applied BP neural network with GA on short term gas load prediction. Ong et al. (2005) proposed a GA based model identification to cope with the problem of local optima in ARIMA models and they have concluded better solutions than any ARIMA model.

In this study, we aim to conduct one of the conventional methods is namely ARMA and genetic algorithms, with combining best sides of each method, in order to increase the chance to capture various patterns in the data and improve prediction accuracy (Zhang, 2003). This study will be helpful for energy policy makers with accurate estimation of consumption model by enabling long term planning and investments in the natural gas sector. Different from other works in the literature, this study takes into consideration a fitness function value with reflecting prediction power of the model by considering financial dimension of the model according to over/under estimate.

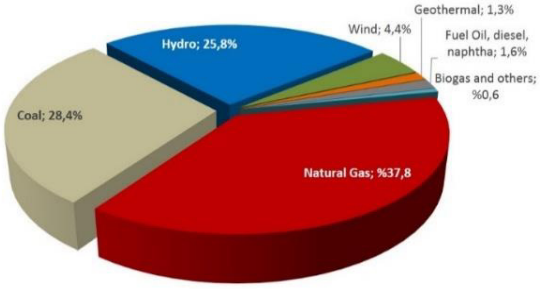

Fig. 1. Electricity generation by type (MENR, 2015)