FORECASTING DAILY ELECTRICITY DEMAND FOR TURKEY

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Abstract

The aim of this study is to enhance a time series model that estimates daily electricity energy demand for Turkey. In literature, annual and monthly electricity demand has been forecasted to take long term decision mostly, this study distinctively makes daily predictions to help daily operations for Turkish electricity market. Using Box-Jenkins methodology, an ARIMA model is constructed to forecast daily electricity demand for Turkey.The best model is found to be SARIMA(1,1,0)(1,0,1)$_7$ to estimate the consumption for a day later. According to this time series model, Turkey daily electricity demand in January and February of 2018 is forecasted about 1.45% deviation. As the data is limited, only the first two month of 2018 can be compared to the actual daily consumption. This study will be carried on for the purpose of validating the model for other months of 2018.

Keywords: ARIMA, Electricity demand, Forecast, Turkey.

1. Introduction

Electricity energy is a type of energy that needs to be transmitted in a fast, high quality and efficient manner worldwide since storage of the electricity energy generated from oil, coal, hydraulic, natural gas, nuclear and renewable energy sources (wind, solar, biofuels, etc.) is not possible. With increasing population, urbanization, industrialization, and especially the rapidly developing technology the need for electricity energy is increasing gradually. Along with the energy crises of the 1970s, the impact of increasing energy demand on the economy has been recognized thoroughly and, the studies on producing electricity steadily, sustainable electricity sources and supply-demand balance continue without slowing down. (Akan and Tak, 2003: 23,24; Altınay, 2010: 6-7; Başoğlu and Bulut, 2017: 576-578 ; Dilaver and Hunt, 2011a: 426-427; Nişancı, 2005: 108-111; Vaghefiet al., 2014: 186-188).

The constant increase in the requirement for electricity, the limited availability of resources and the lack of storage of electricity force the sector participants to prepare various action plans and safety measures. The necessity of consuming electricity at the moment it is produced imposes the provision of supply-demand balance to market actors. In recent years, the emphasis has been placed on balancing supply and demand, especially in economic terms, due to rapid increase in electricity demand. On the other hand, environmental factors such as global warming or national factors such as dependence to external/foreign resources for electricity generation raise demand and obligations for savings in electricity consumption. Considering all these aspects, planning activities are carried out in production, transmission and distribution systems to prevent bottlenecks/shortages/surpluses in the electricity market. Therefore, accurate forecast of electricity demand is important for the operation of electricity power systems, energy suppliers, consumers and policymakers for control, planning, export/import and regulation purposes. (Toker and Korkmaz, 2009: 1, Yavuzdemir, 2014: 15-16).

Since Turkey is highly dependent on foreign sources in electricity generation, it becomes crucial to make accurate and precise forecasts of electricity demand. If energy demand cannot be predicted correctly, the differences between supply and demand will have a negative impact on the country's economy. If the supply of electricity compared to the demand is higher, this will cause energy surplus and waste of current energy. If electricity demand is greater than the supply, the resulting energy deficit would lead to interruptions and system bottlenecks. For this reason, studies on energy demand, especially the estimation of electricity demand in recent years, have become very important. (Gültekin, 2009: 1-3; Taylor et al., 2006: 1,2).

The aim of this study is to reach a model that produces accurate forecasts of Turkey's daily electricity demand. In the literature, long-term (monthly and annual) demand forecasting models, in which economic and demographic factors are influential, have been made; these estimates have been used in capacity building and investment activities. Akan and Tak (2003) employed the population, the number of electrical household appliances production and the number of buildings to predict electricity demand. Demirel et al. (2010) used the gross national product (GNP), the amount of energy produced, population and installed power factors to project long-term electricity demand. However, the subject of this study is to make short-term (daily) demand forecast, in which seasonal factors are more effective.

It is expected that the results of such a study would be of interest of market participants in their daily operations. Participants of the day-ahead market are expected to benefit from this work in forecasting electricity demand and price for the next day. In the next section, literature on forecasting electricity demand of Turkey will be given. Section three will present the data and discuss the findings. The last section will summarize the study.

2. Literature Review

Demand forecasts can be divided into short, medium and long-term estimates based on the frequency of the data under consideration. In general, short-term estimates are given hourly, daily and weekly; medium-term estimates are given monthly and quarterly; long-term estimates are made on annual basis. Short-term estimates are very important for production planning, transmission and for safety analysis. Medium-term forecasts are useful for producer companies to plan supply of energy resource; while long-term estimates are particularly important in determining capacity (Almeshaie and Soltan, 2011: 128, Feinberg and Genethliou, 2005: 267-271; Rothe et al., 2009: 302-303).

In order to ensure the supply-demand balance of electricity, state-owned and private sector firms work independently and develop different models. Different models are developed to make precise predictions. Many demand forecasting methods are used in the literature and the most common ones are the multiple ordinary least squares (OLS), iterative methods, autoregressive moving average methods (ARIMA), genetic algorithm and neural networks. (Singh et al., 2013: 39-45).

Akan and Tak (2003) set up multiple OLS models using annual electricity prices, GNP, population,production of electrical appliances, number of buildings and annual electricity consumption. The estimate made by Akan and Tak (2003) has a deviation of approximately 12.5%.

Uslu et al. (2013) proposedan OLS model to produce electricity demand projections with different scenarios in which industrial production index, temperature and calendar data are used. Dilaver and Hunt (2011b), Demirel et al. (2010) and Mahmutoğlu and Öztürk (2015) made electricity demand forecasts based on the ARIMA methodology using the past annual electricity consumption data.

Altınay (2010) applied ARIMA method with monthly electricity consumption between the years of 1995-2000 and successful results were obtained. Toker and Korkmaz (2009) suggested an artificial neural network model using temperature, humidity, warm-up days and calendar days to estimate electricity consumption. A hybrid model with an error margin less than 2.5% was presented.

Hamzaçebi (2007) used annual data on electricity consumption during 1970-2004 to construct a neural network based model for forecasting the annual electricity consumption in 2020.However, preliminary forecasts of electricity demand in 2003-2004 deviated from actual values by approximately 3.3% for residence, 2.5% for industry, 3.5% for agricultural irrigation and 23.59% for transportation.

Akay and Atak (2007) usedgrey prediction method to predict electricity demand in 2015. The electricity consumption in 2015 was estimated 265 thousand GWh and the real electricity consumption was 263 thousand GWh.

Erdoğdu (2007) made electricity demand forecasts using the cointegration analysis and the ARIMA model then; compared the results with the official forecasts of the Ministry of Energy and Natural Resources. Annual deviation of approximately 2.2% was observed between estimated and actual consumption figures.

3. Data and Analysis

The daily electricity consumption amounts are taken from the official website of Energy Exchange İstanbul (EXIST) in hourly frequency then; daily values are obtained by taking daily totals. Data between 2010 and 2017 are used to construct the model, and then daily electricity demand for January and February 2018 are forecasted using the model at hand and compared to actual values. As it is seen in the Figure 1, electricity consumption tends to increase and has seasonal characteristics. The Box-Jenkins methodology is used to build an estimation model which uses only past data of time series to be forecasted (Demirel et al., 2010).

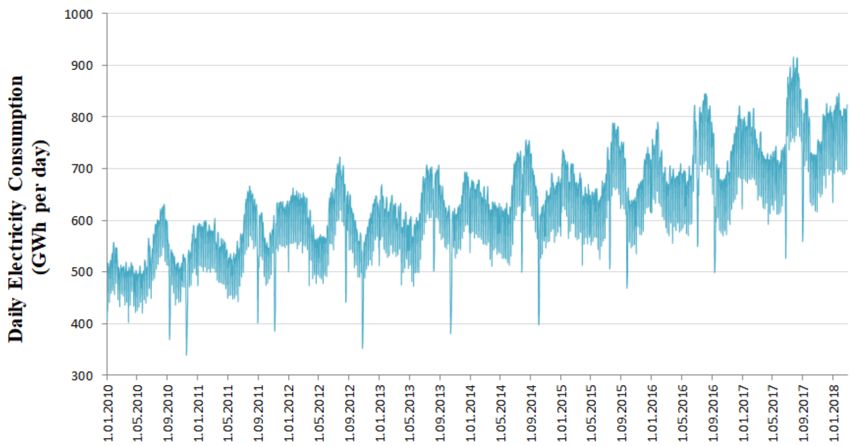

Figure 1: Turkish daily electricity consumption during 2010-2018 (GWh) (EXIST, 2018) (https://www.epias.com.tr/en/)

At first, natural logarithm of the raw consumption data is taken for the analysis. The augmented Dickey-Fuller (ADF) unit root test is applied to this series to see whether the data is stationary or not. Figure 2 shows the results of ADF unit root test. Since null hypothesis of unit root cannot be rejected for the level of 1%, the first difference of data is taken for making the series stationary. In general, to get more significant results and reduce the level of deviation the data need to become approximately stationary. Once again, ADF unit root test is used to see the first-differenced data is non-stationary or not. As it is seen in Figure 3, null hypothesis of unit root is rejected and data becomes stationary. This means natural logarithm of daily electricity consumption data is integrated of the order one (I(1)).

Null Hypothesis: LNCONSUMTION has a unit root
Exogenous: Constant
Lag Length: 28 (Automatic - based on SIC, maxlag=28)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.134351	0.0242
Test critical values:	1% level	-3.432376	
	5% level	-2.862321	
	10% level	-2.567230	

Figure 2: ADF test result of data

Null Hypothesis: DIFFLNCONSUMPTION has a unit root
Exogenous: Constant
Lag Length: 27 (Automatic - based on SIC, maxlag=28)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.80044	0.0000
Test critical values:	1% level	-3.432376	
	5% level	-2.862321	
	10% level	-2.567230	

Figure 3: ADF test results of first-differenced data

Application of Box-Jenkins methodology to the first-differenced data revealed that the model SARIMA(1,1,0)(1,0,1)$_7$ best explains the daily electricity consumption data. Here, week is taken as periodicity of the data since electricity consumption cycles are repeated weekly. Normal probability plot of the error terms of the model estimates is given in Figure 4, pointing that errors are distributed normally.

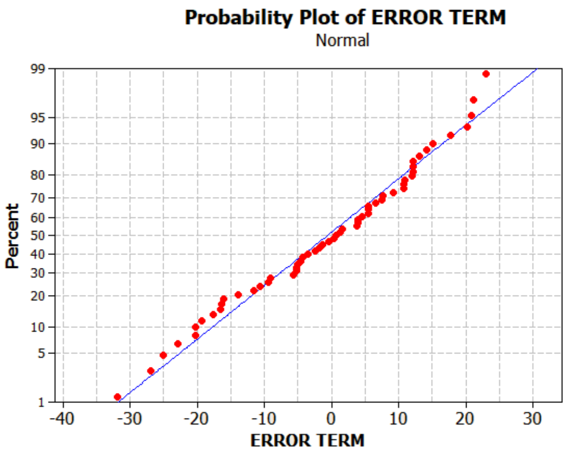

Figure 4: Normality test result of error terms

Then, daily electricity demand for January and February 2018 are forecasted using this model. The forecasted and actual values are given in Figure 5. The average deviations between actual and predicted values are 1.63% and 1.19% for January 2018 and February 2018, respectively.

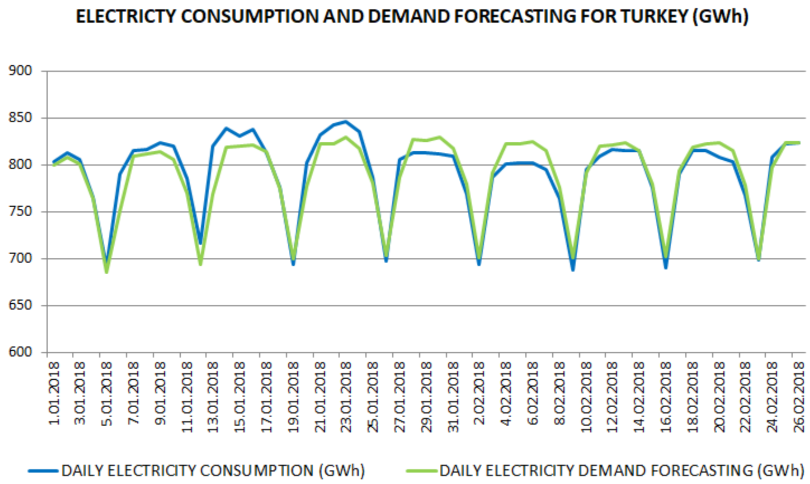

Figure 5: Actual and forecasted data for January and February 2018.

4. Conclusion

In our country, electricity demand forecasts are generally made for medium and long-term, and estimates are mainly used for investment and capacity determination purposes. However, short-term demand forecasting studies should be widespread for distribution and retail companies to plan electricity generation and transmission. Efficiency of these companies highly depends on the success of short-term forecasts that enable sustainable and efficient roadmapping, as well as uninterrupted, continuous and affordable service to consumers. In order to achieve these goals and to increase efficiency in the use of electricity energy resources, Day-Ahead Market was established in 2011 to provide a trading platform for suppliers and demanders of electricity. In this market participants declare electricity generation and consumption forecasts for the next day, so that supply-demand equilibrium could be achieved and shortages and/or surpluses could be prevented. Therefore, it is highly critical to have accurate electricity demand forecasting models to be a player in such a market.

Besides, with the aim of having a free market economy, short-term forecasts have to be made in the electricity market, where many reforms have been made, especially with data sets constantly updated to serve the Day-Ahead Market. In order to contribute to this progress, this work has been put forward to provide the most up to date data possible.

The success of short-term electricity consumption estimates is proportional to the length of the data set used. In this study, the length of the data set is comprised of 2922 successive daily consumption data (GWh per day). The results obtained in the case of the established model are satisfactory. The average deviations between actual and predicted values are 1.63% and 1.19% for January 2018 and February 2018, respectively. Additively, the weekly trend on consumption is provided. The established model estimates the daily electricity demand in Turkey. However, the effects of factors such as temperature and humidity, which affect electricity demand, vary from region to region or even city to city. For this reason, making estimates based on regions and cities will further reduce the mistakes. In addition, electricity consumption should be examined on a sector-by-sector basis, and different or weighted models should be established for industry, residence, business, lighting and others. It is thought that the models to be installed by paying attention to these points will give closer results to reality.

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