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A COMPARISON OF ARIMA AND GREY MODELS FOR ELECTRICITY CONSUMPTION DEMAND FORECASTING: THE CASE OF TURKEY[1]

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Abstract:

During last two decades energy requirements continue to rising with increasing population. The development and growth of a country and people living of standards are almost related to the energy utilization rate. Authors and researchers made different studies on Turkish electricity consumption that among the European Union and made predictions for the coming years. The purpose of this study is to compare ARIMA and Grey models each other with error estimations and estimate future electricity demand. This study is a proposition of a new approach by comparing grey prediction and ARIMA models with Model of Analysis of the Energy Demand (MAED) from 1970 until 2013. This study also explores new approach by using more data and suggestions regarding to electricity consumption. As a result, proposed approaches estimates have more accurate results than MAED model in the comparison of electricity consumption.

Keywords: Turkey's electricity consumption forecasting; ARIMA, Grey model

JEL Classifications: *C51, Q47*

ELEKTRİK TÜKETİMİ TALEP TAHMİNİNDE ARIMA VE GRİ MODELLERİNİN KARŞILAŞTIRILMASI: TÜRKİYE ÖRNEĞİ

Özet:

Son yirmi yıldır enerji gereksinim miktarı artan ülke nüfusu ile birlikte artmaya devam etmektedir. Bir ülkede harcanan enerji kullanım miktarı ile ülkenin gelişimi, kalkınması ve ülke insanının yaşam standartları hemen hemen doğru orantılıdır. Birçok araştırmacı ve yazar Avrupa Birliği'ne girmeye aday olan Türkiye'nin enerji kullanım miktarları üzerinde çalışma yapmakta ve gelecek yıllar için tahminlerde bulunmaktadırlar. Bu çalışma daha önceki çalışmalardan farklı olarak ARIMA ve Gri modelleri karşılaştırmayı ve geleceğe yönelik

[1] This paper was presented before as "*A Comparison of Decision Making Models and Electricity Energy Demand Forecasting for Turkey"* in "International Conference on Economic and Social Studies 2013" and it was reanalized by expanding because of criticism coming from professors.

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elektrik enerjisi talep tahmininde bulunmayı amaçlamaktadır. Çalışmada yeni bir yaklaşım önerilmektedir. Gri ve ARIMA modelleri 1970 ile 2013 yılları arasındaki Türkiye'nin elektrik enerjisi ihtiyacını tahmin ederek Bakanlığın kullanmış olduğu MAED modeli ile karşılaştırılmıştır. Aynı zamanda bu çalışma, diğer çalışmalara göre daha fazla veri kullandığı ve enerji kullanımına yönelik önerilerde bulunduğu için literatüre yeni bir yaklaşım getirmiştir. Çalışmanın sonucunda önerilen yaklaşımlar MAED modeline göre daha hassas sonuçlar vermiştir.

Anahtar Kelimeler: Türkiye'nin elektrik tüketim tahmini; ARIMA, Gri modelleme

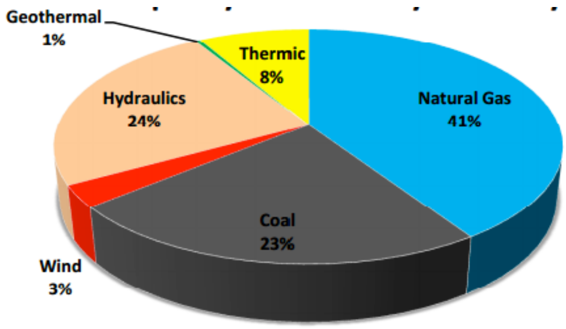
Jel Kodları: C51, Q47

1. INTRODUCTION

For developing governments, making a long term electricity consumption forecasting is a vital for increasing energy productivity. Overestimation of the consumption would lead to superfluous idle capacity which means wasted financial resources, whereas underestimation would lead the higher operation costs for energy supplier and would cause potential energy outages. Therefore, modeling electricity consumption with good accuracy becomes vital in order to avoid costly mistakes (Kaytez et al., 2015: 431).

Energy consumption in Turkey has increased dramatically for ten years because of its increasing population and economic development. Turkey is a central country because of between Europe and Central Asian Regions. In 2011, Turkey's population was 74,5 million, 24% over the 1989 level (Turkstat, 2012). Energy is one of the most significant development priorities for Turkey. Energy, particularly electricity, is essential for improving quality of live and developing as social and economic like European Countries. Electricity energy is producing with various sources like oil, natural gas, hydro, coal and biofuels. Oil and natural gas reserves are extremely limited (Tunç et al., 2006). Figure 1 shows electricity production for Turkey in 2014. Especially, hydro energy sources began to use in recent years.

Figure 1: The Source of Electricity in Turkey



(**Source:** TEIAŞ, 2014)

Electricity energy is a vital input for social, economic and technical development of Turkey like the other countries. Projections for Turkey demonstrate positive results from the use of energy, especially for electricity, and identify key areas for improvement by 2023 (ESMAP Report, 2011). In Turkey, energy consumption projections are made by Ministry of Energy and Natural Resources of Turkey (MENR). MENR has carried out energy forecasting studies by using Model for Analysis of Energy Demand (MAED) simulation technique since 1984. MAED performs higher values than real results because of too much data observed (Hamzacebi, 2007). That is a handicap of this technique. MENR is forced to revises these results every six months. Even though, this paper does not claim our methods are the best, but we just try to develop new and alternative techniques which is able to apply for estimating electricity consumption.

Turkey is a developing country and many socio ecenomic indicators and demand management data are changing. The average economic growth rate is about 4.8% last 5 years, while the rate of 2014 2.9% (Turstat, 2014). Today, one of the most important indicators of developing countries is considered to be electricity consumption for individuals because of easy to use, able to convert other types of energy at any time. Electricity energy is used in nearly all kinds of activities, such as: industrial production, lighting, transportation, agriculture, residential, and heating. In parallel with the development and growth of the Turkish economy, increasing population and rising living standards, electric power consumption has shown a steady increase over the years. On the other hand, Turkey's electricity consumption not only influces big pressure for energy supply system, but also emerges lots of environmental problems, so this becomes one of the most important key elements of Turkey's sustainable development. Turkey's electricity consumption forecasting can not only provide for Turkey's economic policy, but also some contributions for understanding international energy market trends. However the electricity consumption per capita was 207 kwh in 1970, this number becomes 3210 kwh in 2013. But this amount of consumption is still under the European Union average about 6750 kwh (IEA report, 2014:138). According to the experience of development countries, the cost of electricity saving will become increasingly high and their effects can be mitigated.

Actually, there are many studies related electricity forecasting with models. So, the purpose of this study is to compare electricity consumption for Turkey by using ARIMA, GP and MAED models results each other according to proximity of the actual values. Better accuracy can be achieved when the electricity consumption would like to predict to obtain sustainable development. In addition, there is not compare studies of different methods about enegry consumption in the national literature. Moreover, it is quite evident from every standpoint that proper predictions will provide energy cost saving and methods which is applied will be proposed for government policy. Grey Prediction (GP) approach is used because of high prediction accuracy, requirement of little computational effort and applicability in case of limited data situations and ARIMA model respond less to the fluctuations because they have bounded by its long-term trend. In this respects, the present study attempts to forecast the consumption of electricity between 2006 and 2013 by using ARIMA and GP models. Variables in the case study of Turkey for estimation of consumption values are introduced. These dependent variable's estimation is rough and it will reduce the accuracy of Turkey's electricity consumption forecasting. So, the univariate models are used due to the dependent variable need to be predicted. Then actual data is compared with MAED, ARIMA and GP models.

In the following sections; literature is reviewed in section two. In the third section, ARIMA, and GP approaches forecasting methods are introduced shortly. Data analysis, performance evaluation and results of electricity demand forecasting are presented in section four. Finally, the section five has conclusion and recommendations.

2. LITERATURE REVIEW

In the literature, there are studies related to long time electricity energy consumption estimate. In recent studies neural networks (Sozen and Arcaklıoglu, 2007; Chen et al. 2014), econometric models (Ho et al., 2002; Khashei and Bijari, 2011; Yu et al., 2012), ant colony optimization (Toksari, 2009), genetic algorithm (Azadeh and Tarverdian, 2007; Haldenbilen and Ceylan, 2005), regression models (Yumurtacı and Asmaz, 2004; Ediger and Akar, 2007), and grey models (Zhou et al., 2006; Lee and Tong, 2011) are the most commonly used techniques in energy forecasting studies for different countries (Suganthi and Samuel, 2012). Egelioglu et al. (2001) used multiple regression analysis to investigate the relationship between energy consumption with the price of electricity, the number of customers and the number of tourists is determined in N. Cyprus. Tso and Yau (2007) compare the accuracy of regression analysis, decision trees, and neural networks in predicting electricity energy consumption in Hong Kong. Al-Ghandoor et al. (2008) are developed empirical multivariate regression model to predict the electricity requirement of Jordon's industrial sector. Electrical power demand is affected by capacity utilization and industrial production outputs. Azadeh et al. (2008) present an Artificial Neural Network (ANN) model for annual electricity consumption in industrial sectors with high energy. ANOVA variance analysis shows the advantages of ANN approach. Some publications try to compare and combine models each other. For example, Yao and Chi (2004) compared taguchi method with GM to optimize electricity demand settings. Electricity demand predictor system with PC based was expected to decrease the usage of electricity. Lu et al. (2009) used GM with time series model (ARIMA) for correction. Vehicular energy consumption, CO_2 emission and the amount of motor vehicles are studied in Taiwan. ARIMA and GM models are used to forecast China's primary energy consumption in the study of Yuan et al. (2016). Lee and Tong (2011) forecasted energy consumption by using genetic programming model that combines genetic algorithm. Zhao et al. (2014) proposes a novel method that are high order Markov chain based Time varying weighted average method to estimate the monthly electricity consumption in China. Amber et al. (2015) presents a multiple regressions and genetic programming model to forecast daily electricity consumption London South Bank University buildings for the period of January 2007 and December 2012 in London. The total absolute errors for multiple regression and genetic programming are 6% and 7% respectively.

Some studies are related to Grey Model (GM). Hsu and Chen (2003) used improved GM to forecast energy demand for Taiwan. Energy demand is influenced GDP, fuel price, the vehicle kilometers of travel and the number of motor vehicles per energy. Ma et al. (2007) studied GM to predict China's energy production and consumption. Pao and Tsai (2011) predict and investigate the relationship between energy consumption with output, income and pollution emission by using GM for Brazil. The causality results show that there is a bidirectional strong causality running between energy consumption, emissions and income. Hamzacebi and Es (2014) used optimized grey modeling to predict electric energy demand of Turkey for the 2013-2025 periods. As a result, Turkey's total electricity energy demand was estimated 354 TWh in 2015. In addition these results will be guide Turkey's MENR and other institutions related to energy production for future policy.

On the other hand, except for the MENR, some researchers were studied on forecasting of Turkey's energy demand. Yumurtaci and Asmaz (2004) was calculated the energy use projection of Turkey for the period of 1980-2050 based on the increase of population and energy consumption rates per capita. The study also evaluates energy needs in the year of 2050 by using all potential hydro energy resources. Ozturk et al. (2005) utilized heuristic approach like genetic algorithm to investigate the relationship between electricity consumption and GNP, import, export and population for the period of 1980-2001 in Turkey. By using genetic algorithm electricity demand model, electricity consumption was estimated between 220 and 300 TWh in 2020. The Authors also emphasized that electric energy demand was based on socioeconomic indicators and could be forecasted with different mathematical models. Tunc et al. (2006) used multiple regression analysis to predict Turkey's electricity consumption for the period of 2010-2020 and modeled a linear mathematical model to minimize distribution costs for future electrical power supply investment. Hamzacebi (2007) studied Turkey's net electricity consumption on sectoral basis by choosing ANN model. ANN model is able to forecast future values of many variables simultaneously and solve nonlinear structures. Yüksek (2008) claimed hydro electric power will satisfy Turkey's electricity demand after 2020. Kucukali and Baris (2010) have tried to estimate the net electricity consumption with fuzzy logic model in Turkey. This model uses more than one parameter unlike than other forecasting models about Turkey's electricity demand. This study takes into account internal uncertainties and system behavior at different time periods. Fuzzy logic model has advantage in the ability of human thinking and reasoning. As a result, Turkey's electricity demand was estimated 230 TWh in 2040. Cunkas and Taskiran (2011) used genetic programming unlike genetic algorithm that does not need any relationship between dependent and independent variables to forecast Turkey's electricity consumption. Because of Turkey's electricity consumption is unstable, complex and uncertain, genetic programming method is a well forecasting tool. This study presents the symbolic regression model for the best fitting structure by using annual data for previous years. According to the genetic programming model, the electricity consumption is predicted to be 315 TWh in 2020. In the PHd dissertation Ozer (2012) tried to estimate electricity demand by using population, previous consumption, GDP, value added of each activity sector and the ratio of each sector about electricity demand. The net electricity demand was forecasted to be 416 TWh in 2020.

3. FORECASTING METHODOLOGIES

For developing countries, forecasting of electricity is one of the basic practices during the energy consumption planning process. Electricity consumption is based on various direct and indirect parameters like previous data, population, manufacturing numbers, exports, imports, GDP, GNP, human thinking and so on. The electricity forecasting is precise because it provides the dynamic and structural windows on behalf of the future for countries and organizations. Accurate forecasting needs both statistical data and forecaster awareness and experience during the period. Traditional methods such as econometric models, regression, time series, grey prediction as well as soft computing techniques such as fuzzy logic, genetic algorithms and artificial intelligence are being broadly used for electricity consumption forecasting (Avdakovic, 2015: 11). Besides these particle swarm optimization, ant colony optimization and support vector regression are emerging techniques in electricity demand modeling. In order to enhance the predicting accuracy, we introduce two improved techniques that are ARIMA and GP models.

3.1. ARIMA Model

AR(p) models refers to autoregressive model of order p. MA(q) model mentions to the moving average model of order q. the ARMA(p,q) model refers to the model with p autoregressive terms and q moving average terms this model contains the AR(p) and MA(q) models and following equation (Yuan et al. 2016):

$$y_t = c + \ _1 y_{t\ 1} + \ldots + \ _p y_{t\ p} + u_t + \ _1 u_{t\ 1} + \ldots + \ _q u_{t\ q} \qquad (1)$$

AR(p), MA(q) and ARMA(p,q) models are applied non-stationary variables. When data show non-stationary case, an initial difference step should be applied to reduce it and becomes ARIMA model. ARIMA models denoted ARIMA (p,q,d), where p is the order of the AR model, q is the order of the MA model and d is the degree of differencing.

3.2. Grey Prediction Model

Grey Prediction is an alternative forecasting method for those systems whose structure is uncertain, complex and imperfect information. GP has advantages with higher forecasting accuracy and requiring low data items to make forecasting models when compared with other techniques. GP has been used successfully in many disciplines such as electricity demand, material handling, consumption estimate and results help managers for strategically decision making Hsu and Chen (2003).

In the following, there are GP steps (Akay and Atak, 2007)

Step 1: Original data sequence with n samples defined as;

$$x^{(0)} = \left(x^{(0)}(1), x^{(0)}(2), \ldots, x^{(0)}(n)\right) \tag{2}$$

Accumulated Generation Operation AGO formulation of $x^{(0)}$ is expressed as;

$$x^{(1)} = \left(x^{(1)}(1), x^{(1)}(2), \ldots, x^{(1)}(n)\right) \tag{3}$$

That is:

$$x^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i) \quad k = 2,3,\cdots,n \tag{4}$$

Step 2: A first order grey differential equation is establishing to construct the GM (1,1) model;

$$\frac{x^{(1)}(k)}{k} + az^{(1)}(k) = b \tag{5}$$

Where,

$$z^{(1)}(k) = 0.5x^{(1)}(k) + 0.5x^{(1)}(k \quad 1) \quad k = 2,\cdots,n \tag{6}$$

k is a time point, a is called development coefficient and b is called driving coefficient. *[a,b]*^{T} can be estimated by using least mean square estimation technique coefficient as

$$\begin{matrix} a \\ b \end{matrix} = \left[B^T B\right]^{1} B^T Y \tag{7}$$

Where,

$$B = \begin{matrix} z^{(1)}(2) & 1 \\ z^{(1)}(3) & 1 \\ \cdots & 1 \\ z^{(1)}(n) & 1 \end{matrix}, \qquad Y = \begin{matrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(n) \end{matrix} \tag{8}$$

Step 3: After computed estimated coefficient a and b, GM(1,1) cumulative equation can be obtained by solving differential equation;

$$\hat{x}^{(1)}(k+1) = \; x^{(1)}(0) \quad \frac{b}{a} \; e^{\;ak} + \frac{b}{a} \tag{9}$$

Where $\hat{x}(k)$ denotes AGO prediction of x at time k point. Reduction of the randomness of data makes AGO one of the most important characteristics of grey theory. $\hat{x}^{(0)}(k)$ series can be predicted by performing:

$$IAGO\hat{x}^{(1)}(k) \quad x^{(1)}(k+1) \tag{10}$$

4. DATA ANALYSIS

Various models have been developed in different studies in order to predict electricity consumption on economic indicators. Prediction models, such as MAED, ARIMA and GP, in this study will be compared with each other. The net electricity consumption data used for this study is shown in Table 1.

Table 1: Turkey Net Electricity Consumption Period of 1970-2005

Years	Net electricity consumption (GWh)	Years	Net electricity consumption (GWh)	Years	Net electricity consumption (GWh)
1970	7307	**1982**	23586	**1994**	61401
1971	8289	**1983**	24465	**1995**	67394
1972	9527	**1984**	27635	**1996**	74157
1973	10530	**1985**	29708	**1997**	81885
1974	11358	**1986**	32209	**1998**	87705
1975	13491	**1987**	36697	**1999**	91202
1976	16078	**1988**	39721	**2000**	98296
1977	17968	**1989**	43120	**2001**	97070
1978	18933	**1990**	46820	**2002**	102948
1979	19663	**1991**	49283	**2003**	111766
1980	20632	**1992**	53985	**2004**	121142
1981	22030	**1993**	59237	**2005**	130263

Seasonality and fluctuations was not observed in data that examined before. Electricity consumption level is decreasing just in the times of crisis as well as they show linear distribution. Electricity energy consumption data were taken from Turkish Statistical Institute (TurkStat) and Electricity Distribution and Consumption Statistics of Turkey (TEDC). Comparison of annual electricity consumption forecasts for 2006 to 2013 using ARIMA and GP models are shown Table 5 and Figure 2 with their signs.

4.1. Performance Criterion

There are four measures used as performance criterion: mean absolute errors (MAE), root mean square errors (RMSE), absolute percentage error (APE) and mean absolute percentage error (MAPE). In decision-making, APE and MAPE used for the comparison of ANN and MAED results and for the best network structure two criteria (MAE and RMSE) results were taken into account. To avoid this problem we will use MAPE performance criteria and its formulation is given below (Hamzaçebi, 2007);

$$MAPE = \frac{1}{n}\ {}_{i=1}^{n}\ \frac{e_i}{Y_i}\ 100 \tag{11}$$

Where e_i shows the differences between forecasted and actual values, Y_i shows the actual values for *i.* year and *n* shows number of years. If the forecast item is measured in thousands, the MAE and RMSE values can be very large (Heizer and Render, 2008:114).

4.2. Forecasting with ARIMA Model

The time series of Turkey's electricity consumption is shown in Table 1. It has found that there is an increasing point in 1997. After this year Turkey's electricity consumption is rising with growth rate due to Turkey's accession to World Trade Organization (WTO) the sustained and rapid economic growth have influenced faster increase in electricity consumption. In addition, we see a sudden change after 1997 that make a structural break. In econometric time series analysis, a dummy variable may be used to address the case of strikes, wars and crisis and it takes the value 0 and 1. If Turkey is a WTO member after 1995 a dummy variable, as we say K, is assigned the value 1; otherwise it get the value 0. And also ın order to verify time trend and non-stationarity, the following model is structured:

$$Y = c + b_1 t + b_2 K + \tag{12}$$

Where Y is Turkey electricity consumption, c is a constant, t is year, K is dummy variable and ε is error value. After Equation (12) is calculated the coefficients of t and K are statistically significant at 5% significance level *(p: 0.000<0.05; F: 246.922).*

Due to the time trend and changes of Turkey's electricity consumption, stationary test will be making by ADF methods and the results shown in Table 2.

Table 2: Stationary Tests

		t-Statistic	Prob.
ADF test		1.609233	0.9993
Test critical values:	1% level	-3.632900	
	5% level	-2.948404	
	10% level	-2.612874	
Second difference		-8.456962	0.0000
Test critical values:	1% level	-4.243644	
	5% level	-3.544284	
	10% level	-3.204699	

According to the Table 2, it has shown that second order difference is stationary at 5% significance level. Because of this unexpected situation we will use automatic forecasting Eviews 9.0 to forecast the electricity consumptions values from 2006 to 2013. The results of the auto ARIMAX estimation are shown in Table 3.

Table 3: Automatic ARIMA Forecasting

Automatic ARIMA Forecasting
Selected dependent variable: DLOG(Electricity_consumption)
Date: 04/26/16 Time: 15:47
Sample: 1970 2005
Included observations: 35
Forecast length: 8
Number of estimated ARMA models: 100
Number of non-converged estimations: 0
Selected ARMA model: (1,4)(1,0)
AIC value: -3.63191842051

The summary table indicates that 100 different models are estimated and the chosen ARMA is a (1,4)(1,0) model. The automatic transformation detection decided that logging electricity consumption would provide better model. A first order difference was performed.

$$D(\log Y) = c + b_1 t + b_2 K + \ {}_1 AR(1) + \ {}_1 MA(1) + \ {}_2 MA(2) + \ {}_3 MA(3) + \ {}_4 MA(4) \tag{13}$$

The Equation (13) will be calculated and results are shown in Table 4. The coefficient of *t* and *K* are significant at 5% significance level and R-squared is 0.43 which indicates the model is available.

Table 4: Estimation of ARIMA Model*

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.650681	1.640621	2.225183	0.0350
K	0.011457	0.022708	0.504547	0.0181
T	-0.001797	0.000827	-2.172258	0.0391
AR(1)	-0.082414	0.535976	-0.153764	0.8790
MA(1)	0.292828	845.1512	0.000346	0.9997
MA(2)	-0.366400	196.4811	-0.001865	0.9985
MA(3)	-0.363900	797.9156	-0.000456	0.9996
MA(4)	-0.562519	2325.540	-0.000242	0.9998
SIGMASQ	0.000795	0.401730	0.001978	0.9984

R-squared	0.436100	Mean dependent var	0.082306
Adjusted R-squared	0.262593	S.D. dependent var	0.038090
S.E. of regression	0.032709	Akaike info criterion	-3.679775
Sum squared resid	0.027817	Schwarz criterion	-3.279829
Log likelihood	73.39607	Hannan-Quinn criter.	-3.541714
F-statistic	2.513438	Durbin-Watson stat	1.966134
Prob(F-statistic)	0.035975		

Inverted AR Roots	-.08			
Inverted MA Roots	1.00	-.17-.75i	-.17+.75i	-.94

*ARIMA model are made with Eviews9.

4.3. Forecasting with GM Model

GM is one of many forecasting models that used grey prediction. This model which is used in this study helps to find *a* and *b* coefficients for GM variables. GP function is created with these coefficients. As a result of the transactions are;

a = -0.069

b = 12791.375

The solution of GM (1,1) cumulative equation is;

$$\hat{x}^{(1)}(k+1) = 192689.25e^{0.069k} \quad 185382.25$$

4.4. Results

The MAED and forecasting results of ARIMA and GP models are compared with actual data in Table 5. The last 8 observed data from 2006 to 2013 is used to validate obtained model.

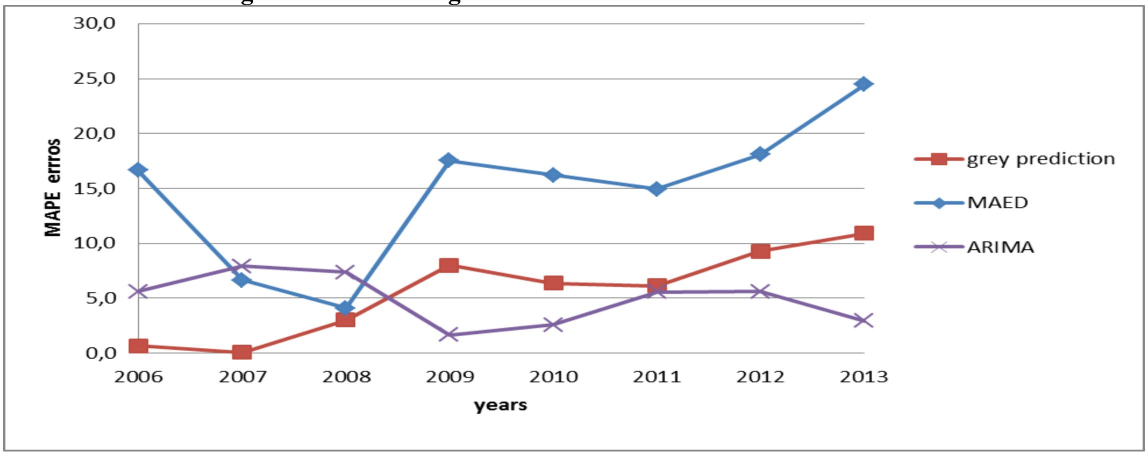
Table 5: Comparison of Models with MAPE Errors from 2006-2013

Years	Actual	MAED	ARIMA	GM (1,1)
2006	143071	166892	135032	147027
2007	155135	165427	142856	158030
2008	161948	168604	150039	169819
2009	156894	184403	159513	169451
2010	172051	199928	167575	182984
2011	186100	213880	175728	197485
2012	194923	230155	183945	213021

2013	198045	246500	192200	219667
MAPE error (%)		14.8	4.9	5.6

In Table 5, electricity consumption estimates values of the MAED model which was used MENR is different from actual consumptions nearly 14.8% in the period of 2006-2013. ARIMA and GP models analysis results vary from 4.9% and 5.6% respectively, from actual ones. According to these results, the ARIMA gives better results than GP and MAED model in the comparison of electricity consumption. It shows that, two methods will be effective in order to forecast long term perspective. Figure 2 presented the prediction error values of electricity consumption using three models from 2006 to 2013.

Figure 2: Forecasting Errrors of The Models Period 2006-2013



As it can be deduced from Figure 2, although estimates for the global crisis in 2008 are quite close to each other, there are big differences between results of other years for the period 2006-2013. The reason in those differences is that the MAED model uses many variables, and in case of variability level in them, this brings high error effects on the result. On the other hand, GP and ARIMA use only consumption data of the last nine years. In this respect, they have both simplicity and not too much prediction inaccuracy, and can be implemented easily.

5. CONCLUSION

Turkey is developing and growing country respect to its production, management, organization, transportation and so on. The government of Turkey should monitor electricity consumption growth with a focus on demand side initiatives and facilitate sufficient investments. So, forecasting is quite significant for effective application of energy. Accurate forecasts of electricity consumption are vital when demand grows faster. On the other hand, Turkey's electricity consumption values can be offered as fluctuating and increasing. Especially, some socioeconomic indicators which have uncertain factors are also effects electricity demand of Turkey. Population, export and import data and GDP are the most used variables in order to forecast future demand, but sectoral demand rate, the energy intensity of sectors, income rates, prices and ability to pay should be used for the forecast results. Sectoral electricity consumption projections are also important than aggregate projections.

The aim of this study is to compare of different decision making types for electricity energy demand forecasting in Turkey. First of all, this paper focused on forecasting the annual electricity consumption for Turkey, and secondly, compared estimated errors (MAPE) between MAED, ARIMA and GP models with actual data in the period of 2006-2013. Results have revealed that ARIMA and GP models perform close findings MAPE errors with 4.9% and 5.6% respectively. But, MAED results are higher than others with 14.8%. It shows that, ARIMA and GP methods are effective and give better results than MAED in order to forecast long term perspective. In addition, it appears that, the original ARIMA and GM(1,1) models have powerful forecasting model.

In the future, following works may be focus on many sectoral areas, namely industrial, residence, transportation and agricultural by using GP, Artificial Neural Networks (ANN) and some meta-heuristic methods such as ant colony optimization, genetic algorithm, annealing simulation and so on. In addition, these results from different models studies and variables are very important for energy policy makers and planners about Turkey's future electricity energy investments.

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Extended Abstract

The purpose of this study is to compare electricity consumption demand for Turkey by using ARIMA, GP and MAED models results each other according to proximity of the actual values. Better accuracy can be achieved when the electricity consumption would like to predict to obtain sustainable development. In addition, there is not compare studies of different methods about enegry consumption in the national literature. Moreover, it is quite evident from every standpoint that proper predictions will provide energy cost saving and methods which is applied will be proposed for government policy. In this respects, the present study attempts to forecast the consumption of electricity between 2006 and 2013 by using ARIMA and GP models. Variables in the case study of Turkey for estimation of consumption values are introduced. These dependent variable’s estimation is rough and it will reduce the accuracy of Turkey’s electricity consumption forecasting. So, the univariate models are used due to the dependent variable need to be predicted. Then actual data is compared with MAED, ARIMA and GP models. Results have revealed that ARIMA and GP models perform close findings MAPE errors with 4.9% and 5.6% respectively. But, MAED results are higher than others with 14.8%. It shows that, ARIMA and GP methods are effective and give better results than MAED in order to forecast long term perspective. In addition, it appears that, the original ARIMA and GM(1,1) models have powerful forecasting model.