Journal of Asian Scientific Research
ISSN(e): 2223-1331
ISSN(p): 2226-5724
DOI: 10.18488/journal.2.2018.82.52.60
Vol. 8, No. 2, 52-60

URL: www.aessweb.com

FORECASTING ENERGY CONSUMPTION OF TURKEY BY ARIMA MODEL

Suat Ozturk[1]
Feride Ozturk[2+]

[1]*DERAC, Bülent Ecevit University, Zonguldak, Turkey*
[2]*Department of International Trade and Business, Bülent Ecevit University, Zonguldak, Turkey*
[2]*Email: feride.ozturk@beun.edu.tr*

(+ Corresponding author)

Article History
Received: 5 December 2017
Revised: 3 January 2018
Accepted: 9 January 2018
Published: 15 January 2018

Keywords
Forecasting
ARIMA
Renewable energy consumption
Coal consumption
Oil consumption
Natural gas consumption
Turkey.

ABSTRACT

Forecasting energy consumption has an important role in planning energy strategies for both policy makers and related organizations in any country. In this study, coal, oil, natural gas, renewable and total energy consumption data for 1970-2015 is used to forecast energy consumption of Turkey for the next 25 years, using autoregressive integrated moving average (ARIMA) model. The ARIMA models are determined to be ARIMA(1, 1, 1) for coal consumption, ARIMA (0, 1, 0) for oil consumption, ARIMA (0, 0, 0) for natural gas consumption, ARIMA (1, 1, 0) for renewable energy consumption and ARIMA (0, 1, 2) for total energy consumption. The results indicate that Turkey's energy consumption will continue to increase by the end of 2040. Consumption of coal, oil, natural gas, renewable energy and total energy will continue to increase at an annual average rate of 4.87 %, 3.92 %, 4.39 %, 1.64 % and 4.20 %, respectively in the next 25 years.

Contribution/ Originality: This study is one of very few studies, which have forecasted energy consumption of Turkey. Moreover, the forecasted results provide a reference for Turkey to develop energy strategy to solve prevenient energy supply shortage in the future.

1. INTRODUCTION

Energy is one of the important factors affecting the development of modern human life nowadays. Population growth, rising living standards, urbanization, technological developments and industrialization raise energy demand of countries. Energy can be produced from different sources such as natural gas, oil, coal, sun, wind, ocean waves, biofuels, water falling etc. The world energy production sources consist of 36.1% oil, 18% coal, 26% natural gas, 5.8% biofuels and waste, 9.8% nuclear, 2.2% hydro and 2.1% others in 2015 [1]. Because of global warming and climate change caused by greenhouse gas emissions originating from the use of fossil based fuels, renewable energy sources such as sun, wind, biomass, geothermal come to the forefront and increase its usage percentage in recent years with respect to others [2, 3].

Turkey is a natural bridge between Asia and Europa with approximately 80 million population. It is also about to become the main energy transit point among high energy consuming west and oil/gas-producer of middle east countries. Energy consumption sources of Turkey are 8.8% coal, 29.3% oil, 12% renewable, 16.2% gas, and 33.5%

others (predominantly hydraulic power) in 2015 [4]. Turkey is the 17th largest economy in the world considering GDP based on Purchasing Power Parity valuation and its energy consumption has grown with the economy since 1970s. The average population growth and energy consumption rates of Turkey are 1.86% and 4.8%, respectively for 1970-2015. It is expected that its population and energy consumption will rise further in the long term because of increasing violence and wars in Iraq and Syria causing migration to Turkey.

Forecasting energy consumption has a vital role in short and long term energy planning for both policy makers and related organizations in any country. In the related literature, many researchers applied different methods such as moving average, multiple regression, exponential smoothing, neural network, grey, etc. to forecast energy consumption on sectoral bases or total. For instance, Hamzacebi and Es [5] used grey model to forecast an annual electricity consumption of Turkey. Kankal, et al. [6] investigated future projections for Turkey's energy consumption with socio-economic and demographic variables. Ayvaz and Kusakci [7] determined electricity consumption of Turkey using nonhomogeneous discrete grey model. Boran [8] also predicted natural gas consumption of Turkey using a grey prediction with rolling mechanism approach. Barak and Sadegh [9] predicted energy consumption of Iran with ARIMA, adaptive network based fuzzy inference systems and AdaBoost models. Yuan, et al. [10] compared ARIMA and GM (1, 1) models to forecast China's primary energy consumption. Pao [11] studied on linear and nonlinear artificial neural network method to forecast Taiwan's electricity consumption. Adom and Bekoe [12] forecasted electricity consumption of Ghana using an autoregressive distributed lag and partial adjustment models. Nai-Ming, et al. [13] used grey and Markov models to predict China's energy demand. Hussain, et al. [14] applied Holt-Winter and ARIMA methods to forecast electricity consumption of Pakistan. Deb, et al. [15] forecasted energy consumption of institutional buildings in Singapore. Lee and Tong [16] used a grey model improved by genetic programing to predict energy consumption of China. Chavez, et al. [17] studied on Asturias's energy production and consumption forecasting with ARIMA model. Bianco, et al. [18] predicted electricity consumption in Italy with linear regression models. Kaboli, et al. [19] determined long-term electricity consumption of Iran via an artificial cooperative search algorithm. Wu, et al. [20] used online training algorithms based single multiplicative neuron model for energy consumption forecasting of US. Zhang, et al. [21] forecasted building energy consumption using weighted support vector regression with differential evolution optimization technique in Singapore. Kumar and Jain [22] estimated energy consumption of India using grey-Markov and grey model with rolling mechanism and singular spectrum analysis. Saab, et al. [23] determined energy consumption of Lebanon with univariate model. Tornai, et al. [24] predicted power consumption in Hungary using smart grid. Pao [25] forecasted energy consumption in Taiwan by a hybrid nonlinear model combining a linear model and an artificial neural network. Feng, et al. [26] studied on energy consumption of China by grey prediction model.

In this study, coal, oil, natural gas, renewable and total energy consumption data of Turkey for 1970-2015 is used to forecast energy consumption for the next 25 years, using a class of univariate ARIMA models. It is believed that the present study will contribute to the limited amount of contributions in the related literature on Turkey's energy consumption. The rest of the study is organized as follows. Section 2 presents the data and methodology used. Section 3 consists of the application of the ARIMA models in forecasting yearly coal, oil, natural gas, renewable and total energy consumption of Turkey and discussion of the results. Finally, concluding remarks are presented in Section 4.

2. DATA AND METHODOLOGY USED

This study is based on annual coal, oil, natural gas, renewable and total energy consumption data in Turkey for the period ranging from 1970 to 2015. Data on consumption of renewable energy is downloaded from the OECD [27] while data on coal, oil and gas consumption are extracted from Turkish General Directorate of Energy Affairs [28]. Total energy consumption per capita data is obtained from World Bank [29] and multiplied by population to generate total energy consumption variable. All the energy consumption variables are measured in tons of oil equivalent (toe). E-Views 9 statistical software is used to build a class of ARIMA models.

ARIMA models are, in theory, the most commonly used to forecast future values of times series data. ARIMA model was first popularized by Box and Jenkins [30]. It forecasts future values of a time series as a linear combination of its own past values and/or lags of the forecast errors (also called random shocks or innovations). Box and Jenkins [31] stated that these models do not involve independent variables, but rather make use of the information in the series itself to generate forecasts. Therefore, ARIMA models depend on autocorrelation patterns in the series.

An ARIMA (p, d, q) model has three parameters. AR parameter 'p' represents the order of autoregressive process, I parameter 'd' represents the order of difference to obtain stationary series if the series are non-stationary, and MA parameter 'q' represents the order of moving average process. Autoregressive revolves around regressing the variable on its prior terms. The I parameter of the model is generally applied when the data in the sample are non-stationary. If the series are stationary, then d=0, and if the series are first-difference stationary then d=1 and so forth. The moving-average parameter states that the variable linearly depends on the present and past values of a stochastic term. The generalized univariate ARIMA model with p, d, q process has the following specification:

$$Y_t = \mu + \alpha_1 Y_{t-1} + \ldots + \alpha_p Y_{t-p} - \theta_1 e_{t-1} - \ldots - \theta_q e_{t-q} \quad (1)$$

where Yt is the differenced time series value, α and θ are unknown parameters and e are independent identically distributed error terms with zero mean. The lagged autoregressive (AR) process are symbolized by p and that of a moving average (MA) process are symbolized by q.

3. EMPIRICAL RESULTS AND DISCUSSION

As a first step to model identification, Augmented Dickey-Fuller (ADF) unit root test is carried out with and without a time trend variable to determine whether the variables of interest are stationary or not. Because the presence of unit root indicates the non-stationary in time series, using non-stationary series will result in spurious regression. As shown in Table 1, the ADF test results indicate that natural gas consumption data is stationary while others are stationary in their first differences. Therefore, first difference of the coal, oil, renewable energy and total energy consumption data are included as dependent variable in each univariate ARIMA model, meaning that process I of the ARIMA models are determined as I (1).

Table-1. The ADF unit root test results

Variables and Time Spans		Level	First Difference
Coal Consumption (CC) (1970-2015)	wc	-1.50	-9.05*
	wct	-3.99**	-9.00*
Oil Consumption (OC) (1970-2015)	wc	-2.39	-5.42*
	wct	-3.29***	-5.42*
Natural Gas Consumption (NGC) (1976-2015)	wc	-3.83*	-2.81***
	wct	-0.72	-3.88**
Renewable Energy Consumption (RC) (1970-2015)	wc	-1.31	-9.44*
	wct	-2.05	-9.31*
Total Energy Consumption (TC) (1970-2015)	wc	-1.18	-6.08*
	wct	-4.63*	-6.06*

Notes: *, **, and *** indicate significant at 1%, 5%, and 10%, respectively. wc and wct are the test statistics for a unit root with a constant and with constant and trend. ADF lag lengths are selected based on Schwartz information criteria (SIC).

Then, the following four different univariate ARIMA model is estimated in the following form:

$$Y_t - Y_{t-1} = \mu + \alpha_1 Y_{t-1} + \ldots + \alpha_p Y_{t-p} - \theta_1 e_{t-1} - \ldots - \theta_q e_{t-q} \quad (2)$$

where, Yt – Yt-1 is the first difference of energy consumption variables (CC, OC, NGC, RC, and TC), α and θ are unknown parameters and e are independent identically distributed error terms with zero mean. The order of the models parameters and thus the best fitted ARIMA models are determined based on model selection criteria such as

Akaike information criterion (AIC). Figure 1 and Table 2 show that the ARIMA (1, 1, 1), ARIMA (0, 1, 0), ARIMA (0, 0, 0), ARIMA (1, 1, 0) and ARIMA (0, 1, 2) models give the smallest AIC for CC, OC, NGC, RC and TC, respectively.

Model	LogL	AIC*	BIC	HQ
(1,1)(0,0)	**22.471306**	**-0.803100**	**-0.644088**	**-0.743533**
(0,3)(0,0)	22.720761	-0.770468	-0.571703	-0.696009
(2,1)(0,0)	22.547064	-0.762916	-0.564150	-0.688457
(1,2)(0,0)	22.520909	-0.761779	-0.563013	-0.687320
(0,2)(0,0)	21.377786	-0.755556	-0.596544	-0.695989
(3,3)(0,0)	25.288656	-0.751681	-0.433656	-0.632547
(0,1)(0,0)	20.258347	-0.750363	-0.631104	-0.705688
(2,3)(0,0)	24.183129	-0.747093	-0.468821	-0.642850
(0,4)(0,0)	23.068601	-0.742113	-0.503595	-0.652763
(1,3)(0,0)	22.883509	-0.734066	-0.495547	-0.644715
(3,1)(0,0)	22.829798	-0.731730	-0.493212	-0.642380
(2,2)(0,0)	22.613091	-0.722308	-0.483790	-0.632958
(4,2)(0,0)	24.481702	-0.716596	-0.398571	-0.597462
(1,4)(0,0)	23.319117	-0.709527	-0.431255	-0.605285
(1,0)(0,0)	19.208308	-0.704709	-0.585450	-0.660034
(4,0)(0,0)	22.044076	-0.697569	-0.459050	-0.608218
(4,3)(0,0)	24.904120	-0.691483	-0.333706	-0.557458
(3,2)(0,0)	22.841899	-0.688778	-0.410507	-0.584536
(4,1)(0,0)	22.775204	-0.685878	-0.407607	-0.581636
(3,4)(0,0)	24.678484	-0.681673	-0.323896	-0.547648
(2,0)(0,0)	19.482850	-0.673167	-0.514155	-0.613600
(2,4)(0,0)	23.359456	-0.667802	-0.349778	-0.548669
(4,4)(0,0)	25.288604	-0.664722	-0.267191	-0.515805
(3,0)(0,0)	20.006528	-0.652458	-0.453692	-0.577999
(0,0)(0,0)	16.799841	-0.643471	-0.563965	-0.613688

(a)

Model	LogL	AIC*	BIC	HQ
(0,0)(0,0)	**57.726894**	**-2.422908**	**-2.343402**	**-2.393125**
(1,0)(0,0)	57.996784	-2.391165	-2.271905	-2.346489
(0,1)(0,0)	57.944079	-2.388873	-2.269614	-2.344198
(0,2)(0,0)	58.262408	-2.359235	-2.200223	-2.299668
(2,0)(0,0)	58.253546	-2.358850	-2.199838	-2.299283
(1,1)(0,0)	58.149175	-2.354312	-2.195300	-2.294745
(0,3)(0,0)	58.304829	-2.317601	-2.118836	-2.243143
(1,2)(0,0)	58.299334	-2.317362	-2.118597	-2.242904
(2,4)(0,0)	61.274731	-2.316293	-1.998268	-2.197159
(2,1)(0,0)	58.265804	-2.315905	-2.117139	-2.241446
(3,0)(0,0)	58.265450	-2.315889	-2.117124	-2.241430
(1,3)(0,0)	58.749234	-2.293445	-2.054927	-2.204095
(3,3)(0,0)	60.711053	-2.291785	-1.973760	-2.172651
(2,2)(0,0)	58.584230	-2.286271	-2.047752	-2.196920
(0,4)(0,0)	58.371398	-2.277017	-2.038499	-2.187667
(4,0)(0,0)	58.281619	-2.273114	-2.034595	-2.183763
(3,1)(0,0)	58.267139	-2.272484	-2.033966	-2.183134
(4,2)(0,0)	60.125813	-2.266340	-1.948315	-2.147206
(3,2)(0,0)	58.947507	-2.258587	-1.980316	-2.154345
(4,3)(0,0)	60.794825	-2.251949	-1.894171	-2.117923
(3,4)(0,0)	60.777359	-2.251190	-1.893412	-2.117164
(1,4)(0,0)	58.757645	-2.250332	-1.972061	-2.146090
(2,3)(0,0)	58.299642	-2.230419	-1.952148	-2.126177
(4,1)(0,0)	58.291536	-2.230067	-1.951795	-2.125825
(4,4)(0,0)	60.795987	-2.208521	-1.810990	-2.059604

(b)

Model	LogL	AIC*	BIC	HQ
(0,0)(0,0)	**-73.896957**	**3.794848**	**3.879292**	**3.825380**
(0,2)(0,0)	-72.147700	3.807385	3.976273	3.868450
(1,0)(0,0)	-73.679362	3.833968	3.960634	3.879767
(0,1)(0,0)	-73.726813	3.836341	3.963007	3.882139
(1,2)(0,0)	-71.815561	3.840778	4.051888	3.917109
(0,3)(0,0)	-71.905655	3.845283	4.056393	3.921613
(0,4)(0,0)	-71.042953	3.852148	4.105480	3.943744
(2,0)(0,0)	-73.676283	3.883814	4.052702	3.944879
(1,1)(0,0)	-73.678460	3.883923	4.052811	3.944988
(1,3)(0,0)	-71.922407	3.896120	4.149452	3.987717
(3,3)(0,0)	-70.032393	3.901620	4.239396	4.023749
(3,0)(0,0)	-73.407558	3.920378	4.131488	3.996709
(2,3)(0,0)	-71.481435	3.924072	4.219626	4.030935
(4,3)(0,0)	-69.631984	3.931599	4.311597	4.068994
(1,4)(0,0)	-71.632878	3.931644	4.227198	4.038507
(2,1)(0,0)	-73.658614	3.932931	4.144041	4.009261
(3,4)(0,0)	-69.740189	3.937009	4.317007	4.074405
(4,0)(0,0)	-73.205255	3.960263	4.213595	4.051860
(3,1)(0,0)	-73.369002	3.968450	4.221782	4.060047
(4,1)(0,0)	-72.767242	3.988362	4.283916	4.095225
(2,4)(0,0)	-71.891310	3.994566	4.332341	4.116695
(2,2)(0,0)	-73.901069	3.995053	4.248385	4.086650
(3,2)(0,0)	-73.427439	4.021372	4.316926	4.128235
(4,2)(0,0)	-73.001484	4.050074	4.387850	4.172203
(4,4)(0,0)	-73.905606	4.195280	4.617500	4.347942

(c)

Model	LogL	AIC*	BIC	HQ
(1,0)(0,0)	**57.357470**	**-2.363368**	**-2.244109**	**-2.318693**
(2,0)(0,0)	57.464255	-2.324533	-2.165521	-2.264966
(1,1)(0,0)	57.451347	-2.323972	-2.164959	-2.264405
(0,2)(0,0)	57.268542	-2.316024	-2.157011	-2.256457
(0,1)(0,0)	56.176570	-2.312025	-2.192766	-2.267350
(3,1)(0,0)	58.805225	-2.295879	-2.057361	-2.206529
(2,1)(0,0)	57.581510	-2.286153	-2.087387	-2.211694
(3,2)(0,0)	59.482101	-2.281830	-2.003559	-2.177588
(3,0)(0,0)	57.481632	-2.281810	-2.083045	-2.207351
(1,2)(0,0)	57.467924	-2.281214	-2.082449	-2.206755
(0,3)(0,0)	57.340633	-2.275680	-2.076914	-2.201221
(4,1)(0,0)	59.041759	-2.262685	-1.984414	-2.158443
(0,4)(0,0)	57.626309	-2.244622	-2.006104	-2.155272
(2,2)(0,0)	57.585335	-2.242841	-2.004322	-2.153490
(4,0)(0,0)	57.516448	-2.239846	-2.001327	-2.150495
(2,4)(0,0)	59.515809	-2.239818	-1.921793	-2.120684
(1,3)(0,0)	57.477231	-2.238140	-1.999622	-2.148790
(0,0)(0,0)	52.933572	-2.214503	-2.134997	-2.184720
(3,4)(0,0)	59.906002	-2.213304	-1.855527	-2.079279
(3,3)(0,0)	58.905119	-2.213266	-1.895241	-2.094132
(1,4)(0,0)	57.894593	-2.212808	-1.934537	-2.108566
(4,2)(0,0)	58.808858	-2.209081	-1.891056	-2.089947
(2,3)(0,0)	57.633840	-2.201471	-1.923200	-2.097229
(4,4)(0,0)	60.182806	-2.181861	-1.784330	-2.032944
(4,3)(0,0)	52.885392	-1.908061	-1.550283	-1.774035

(d)

Model	LogL	AIC*	BIC	HQ
(0,2)(0,0)	**53.585618**	**-2.155896**	**-1.996884**	**-2.096329**
(1,1)(0,0)	53.427464	-2.149020	-1.990008	-2.089453
(0,3)(0,0)	54.335294	-2.145013	-1.946247	-2.070554
(2,1)(0,0)	54.301340	-2.143537	-1.944771	-2.069078
(1,2)(0,0)	53.953975	-2.128434	-1.929668	-2.053975
(1,4)(0,0)	55.782311	-2.120970	-1.842699	-2.016728
(0,4)(0,0)	54.679718	-2.116509	-1.877991	-2.027159
(3,1)(0,0)	54.648796	-2.115165	-1.876647	-2.025815
(4,3)(0,0)	57.641870	-2.114864	-1.757086	-1.980838
(2,2)(0,0)	54.473185	-2.107530	-1.869011	-2.018179
(1,3)(0,0)	54.465151	-2.107180	-1.868662	-2.017830
(4,4)(0,0)	58.003098	-2.087091	-1.689560	-1.938174
(2,3)(0,0)	54.808491	-2.078630	-1.800359	-1.974388
(2,4)(0,0)	55.797253	-2.078141	-1.760117	-1.959007
(4,1)(0,0)	54.649540	-2.071719	-1.793448	-1.967477
(3,2)(0,0)	54.636949	-2.071172	-1.792900	-1.966930
(3,0)(0,0)	52.086840	-2.047254	-1.848489	-1.972795
(4,2)(0,0)	54.939299	-2.040839	-1.722814	-1.921705
(4,0)(0,0)	52.809095	-2.035178	-1.796660	-1.945828
(0,1)(0,0)	49.566952	-2.024650	-1.905391	-1.979975
(0,0)(0,0)	48.268118	-2.011657	-1.932151	-1.981874
(2,0)(0,0)	49.866456	-1.994194	-1.835181	-1.934627
(1,0)(0,0)	48.750182	-1.989138	-1.869879	-1.944463
(3,3)(0,0)	48.143262	-1.745359	-1.427335	-1.626225
(3,4)(0,0)	48.145089	-1.701960	-1.344183	-1.567935

(e)

Figure-1. Model selection criteria tables: (a) coal consumption, (b) oil consumption, (c) natural gas consumption, (d) renewable energy consumption, (e) total energy consumption

Table-2. Evaluation of various ARIMA models based on AIC

Dependent Variable	ARIMA (p, d, q)	AIC
CC	ARIMA (1, 1, 1)	-0.803
OC	ARIMA (0, 1, 0)	-2.442
NGC	ARIMA (0, 0, 0)	3.794
RC	ARIMA (1, 1, 0)	-2.363
TC	ARIMA (0, 1, 2)	-2.155

Turkey's energy consumption is likely to increase by the end of 2040. Regarding forecasted coal consumption values, Figure 2 (a) and Table 3 indicate that coal consumption will rise in Turkey. The consumption of coal will continue to increase at an annual average rate of 4.87 % and will be over 35 million toe in 2040, indicating an approximately 212 % increase from its value in 2015.

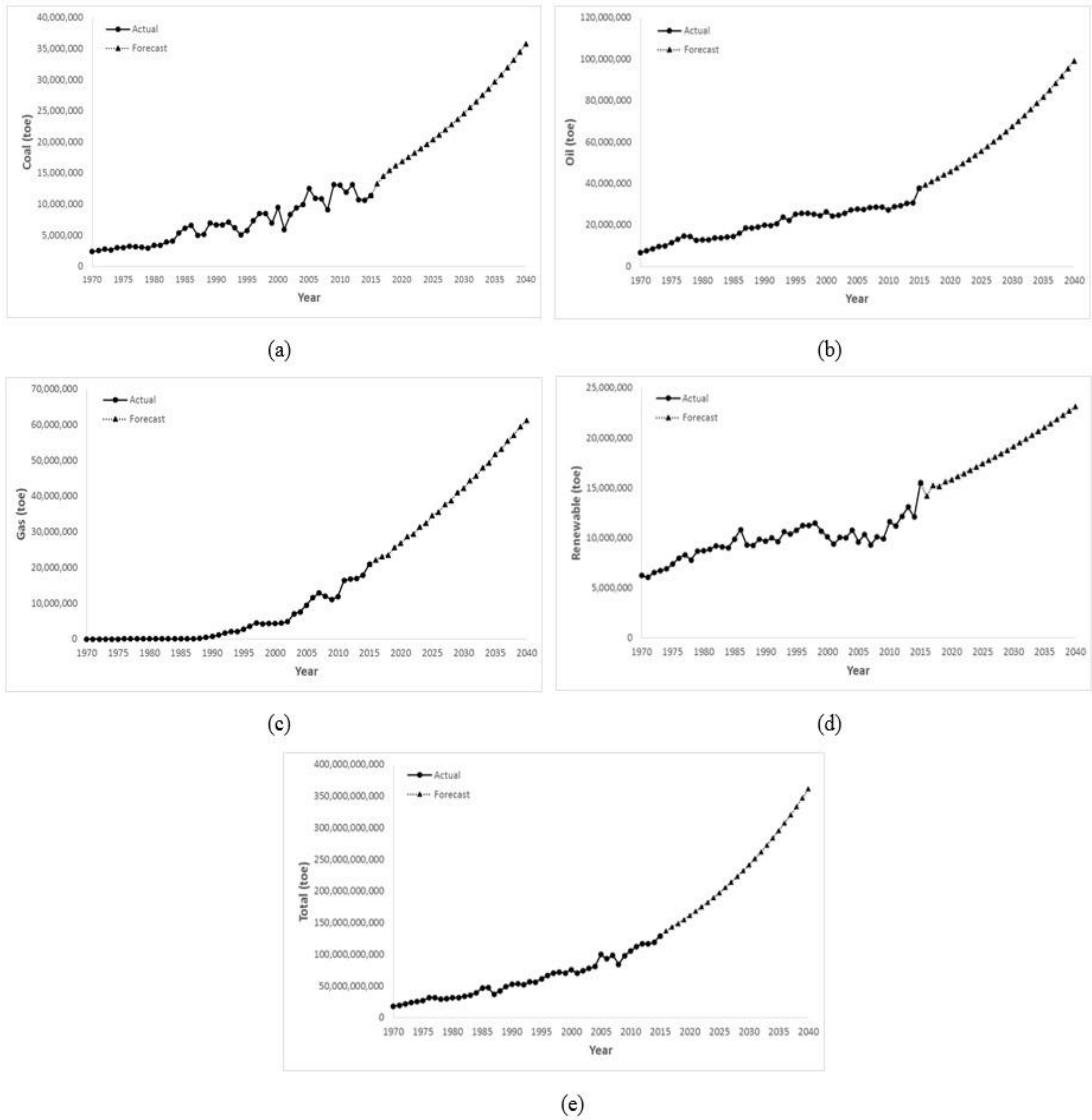

Figure-2. Forecasted and actual values of energy consumption (toe): (a) coal consumption, (b) oil consumption, (c) natural gas consumption, (d) renewable energy consumption, (e) total energy consumption

In Figure 2 (b) oil consumption forecast is presented. It is expected that oil consumption will increase 3.92 % on average in the next 25 years and will be over 99 million toe in 2040. Oil consumption is forecasted to increase 162% from 2015 to 20140. In the case of natural gas consumption, calculated results indicate that natural gas consumption will be over 61 million toe in 2040 (Figure 2 (c)), representing an increase of 4.39 % at an annual average rate (Table 3). It is expected to increase by 192%.

The results show that compared with the data of 2015, the renewable energy consumption will increase at the annual average rate of 1.64 % in the next 25 years and its value will be over 23 million toe in 2040 as shown in Figure 2 (d) and Table 3. Moreover, renewable energy consumption is forecasted to increase by 51%. Regarding total energy consumption forecasting, total energy consumption is expected to increase at the annual average rate of 4.20 % and will be over 361 million toe in 2040, indicating about 180 % increase from its 2015 level (Figure 2 (e) and Table 3).

Table-3. Forecasted energy consumption in Turkey (Toe)

Year	CC	OC	NGC	RC	TC
2016	13,267,875	39,317,601	22,115,833	14,181,234	137,186,100
2017	14,495,288	40,862,912	23,130,896	15,216,335	143,126,741
2018	15,402,599	42,468,958	23,507,736	15,134,088	149,007,900
2019	16,160,570	44,138,127	25,672,038	15,601,063	155,130,700
2020	16,858,022	45,872,899	26,811,637	15,812,916	161,505,100
2021	17,539,190	47,675,854	28,686,818	16,156,012	168,141,423
2022	18,225,894	49,549,671	29,363,976	16,444,521	175,050,441
2023	18,929,064	51,497,135	31,375,752	16,767,953	182,243,344
2024	19,654,424	53,521,141	32,438,042	17,083,412	189,731,815
2025	20,405,240	55,624,697	34,560,457	17,411,698	197,527,978
2026	21,183,628	57,810,929	35,540,965	17,742,976	205,644,500
2027	21,991,182	60,083,088	37,639,695	18,082,150	214,094,545
2028	22,829,274	62,444,550	38,777,345	18,427,042	222,891,786
2029	23,699,188	64,898,825	40,986,675	18,778,882	232,050,524
2030	24,602,194	67,449,561	42,191,747	19,137,262	241,585,600
2031	25,539,580	70,100,549	44,404,581	19,502,568	251,512,455
2032	26,512,670	72,855,730	45,701,396	19,874,804	261,847,220
2033	27,522,830	75,719,198	47,982,601	20,254,166	272,606,659
2034	28,571,476	78,695,210	49,377,541	20,640,758	283,808,200
2035	29,660,074	81,788,189	51,691,293	21,034,734	295,470,000
2036	30,790,148	85,002,733	53,170,801	21,436,228	307,611,000
2037	31,963,280	88,343,618	55,533,804	21,845,388	320,250,900
2038	33,181,108	91,815,811	57,109,633	22,262,356	333,410,173
2039	34,445,336	95,424,472	59,516,766	22,687,282	347,110,179
2040	35,757,730	99,174,966	61,179,555	23,120,320	361,373,100
Average Growth Rate (%)	4.87	3.92	4.39	1.64	4.20

Turkey's energy policy has continuously improved to meet the needs of a growing population and economy, ease the import dependence on energy, and meet the environmental goals of the country. Turkey is implementing new energy goals under the Vision 2023, its economic development strategy plans to 2023. The energy targets include the reduction of energy intensity by 20% below 2010 levels, the launch of two nuclear power plants, the extension of domestic energy sources such as coal and increasing a share of renewable energy in the electricity mix to 30%. As it is presented above, consumption of coal, oil, natural gas, renewable energy and total energy will increase by 212%, 162%, 192%, 51%, and 180%, respectively from 2015 to 2040. Turkey has a series of policy to implement and investment to make to meet its increasing energy consumption in the future. In this regard, the government of Turkey should [32]:

- Enhance energy security by ensuring nuclear energy safety and security through legal arrangements, by ensuring investment in gas and electricity networks through establishing competitive energy markets.

- Determine a long-term energy and climate strategy as a basis for a sustainable economic growth with a monitoring system to track the impact of policies.
- Accelerate the process of liberalization of Turkey's natural gas and electricity markets to establish more transparent and competitive market place.
- Set out sectorial targets for the use of renewable energy sources to attract investors in the long-term.

4. CONCLUSION

In this study coal, oil, natural gas, renewable energy and total energy consumption of Turkey from 2016 to 2040 are forecasted according to the established ARIMA models. The ARIMA (1, 1, 1) for coal consumption, ARIMA (0, 1, 0) for oil consumption, ARIMA (0, 0, 0) for natural gas consumption, ARIMA (1, 1, 0) for renewable energy consumption and ARIMA (0, 1, 2) for total energy consumption are chosen to forecast future values of energy consumption variables since these models give the smallest AIC. The results indicate that Turkey's need for coal, oil, natural gas, renewable energy is increasing continuously. Consumption of coal, oil, natural gas, renewable energy and total energy will continue to increase at an annual average rate of 4.87 %, 3.92 %, 4.39 %, 1.64 % and 4.20 %, respectively in the next 25 years. Moreover, consumption of coal, oil, natural gas, renewable energy and total energy are forecasted to increase by 212%, 162%, 192%, 51%, and 180%, respectively from 2015 to 2040.

Currently, Turkey is depended on imported energy, mainly on natural gas and oil and is able to meet only around 26 % of its total energy consumption from its own resources. Increasing energy consumption will result in energy shortage in the future as well. The forecast results provide a reference for Turkey to develop energy strategy to solve prevenient energy supply shortage in the next 25 years. It is our opinion that Turkey's energy strategy should incorporate allocating more resources to research and development on energy technologies, increasing the ratio of renewable energy such as solar energy, wind, biomass, and geothermal energy in our energy mix, establishing competitive energy market conditions through liberalization and reforms.

Funding: This study received no specific financial support.
Competing Interests: The authors declare that they have no competing interests.
Contributors/Acknowledgement: Both authors contributed equally to the conception and design of the study.

REFERENCES

[1] International Energy Agency, "The world energy production sources." Retrieved from http://www.iea.org/publications/freepublications/publication/KeyWorld2016.pdf, 2017a.

[2] A. Sözen, Z. Gülseven, and E. Arcaklioğlu, "Forecasting based on sectoral energy consumption of GHGs in Turkey and mitigation policies," *Energy Policy*, vol. 35, pp. 6491-6505, 2007. *View at Google Scholar | View at Publisher*

[3] S. Tsai, Y. Xue, J. Zhang, Q. Chen, Y. Liu, and J. Zhou, "Models for forecasting growth trends in renewable energy," *Renewable and Sustainable Energy Reviews*, vol. 77, pp. 1169-1178, 2017. *View at Publisher*

[4] Turkish General Directorate of Energy Affairs, "Energy consumption sources of Turkey." Retrieved from http://www.eigm.gov.tr/tr-TR/Anasayfa, 2017a.

[5] C. Hamzacebi and H. A. Es, "Forecasting the annual electricity consumption of Turkey using an optimized grey model," *Energy*, vol. 70, pp. 165-171, 2014. *View at Google Scholar | View at Publisher*

[6] M. Kankal, A. Akpınar, M. İ. Kömürcü, and T. Ş. Özşahin, "Modeling and forecasting of Turkey's energy consumption using socio-economic and demographic variables," *Applied Energy*, vol. 88, pp. 1927-1939, 2011. *View at Google Scholar | View at Publisher*

[7] B. Ayvaz and A. O. Kusakci, "Electricity consumption forecasting for Turkey with nonhomogeneous discrete grey model," *Energy Sources, Part B: Economics, Planning, and Policy*, vol. 17, pp. 260-267, 2017. *View at Google Scholar | View at Publisher*

[8] F. E. Boran, "Forecasting natural gas consumption in turkey using grey prediction," *Energy Sources, Part B: Economics, Planning, and Policy*, vol. 10, pp. 208-2013, 2015. View at Google Scholar | View at Publisher

[9] S. Barak and S. S. Sadegh, "Forecasting energy consumption using ensemble ARIMA–ANFIS hybrid algorithm," *Electrical Power and Energy Systems*, vol. 82, pp. 92-104, 2016. View at Google Scholar | View at Publisher

[10] C. Yuan, S. Liu, and Z. Fang, "Comparison of China's primary energy consumption forecasting by using ARIMA (the Autoregressive Integrated Moving Average) model and GM(1,1) model," *Energy*, vol. 100, pp. 384-390, 2016. View at Google Scholar | View at Publisher

[11] H. Pao, "Comparing linear and nonlinear forecasts for Taiwan's electricity consumption," *Energy*, vol. 31, pp. 2129-2141, 2006. View at Google Scholar | View at Publisher

[12] P. K. Adom and W. Bekoe, "Conditional dynamic forecast of electrical energy consumption requirements in Ghana by 2020: A comparison of ARDL and PAM," *Energy*, vol. 44, pp. 367-380, 2012. View at Google Scholar | View at Publisher

[13] X. Nai-Ming, Y. Chao-Qing, and Y. Ying-Jie, "Forecasting China's energy demand and self-sufficiency rate by grey forecasting model and Markov model," *Electrical Power and Energy Systems*, vol. 66, pp. 1-8, 2015. View at Google Scholar | View at Publisher

[14] A. Hussain, M. Rahman, and J. A. Memon, "Forecasting electricity consumption in Pakistan: The way forward," *Energy Policy*, vol. 90, pp. 73-80, 2016. View at Google Scholar | View at Publisher

[15] C. Deb, L. S. Eang, J. Yang, and M. Santamouris, "Forecasting energy consumption of ınstitutional buildings in Singapore," *Procedia Engineering*, vol. 121, pp. 1734-1740, 2015. View at Google Scholar | View at Publisher

[16] Y. Lee and L. Tong, "Forecasting energy consumption using a grey model improved by incorporating genetic programming," *Energy Conversation and Management*, vol. 52, pp. 147-152, 2011. View at Google Scholar | View at Publisher

[17] S. G. Chavez, J. X. Bernat, and H. L. Coalla, "Forecasting of energy production and consumption in Asturias (Northern Spain)," *Energy*, vol. 24, pp. 183-198, 1999. View at Google Scholar | View at Publisher

[18] V. Bianco, O. Manca, and S. Nardini, "Linear regression models to forecast electricity consumption in Italy," *Energy Sources, Part B*, vol. 8, pp. 86-93, 2013. View at Google Scholar | View at Publisher

[19] S. H. A. Kaboli, J. Selvaraj, and N. A. Rahim, "Long-term electric energy consumption forecasting via artificial cooperative search algorithm," *Energy*, vol. 115, pp. 857-871, 2016. View at Google Scholar | View at Publisher

[20] X. Wu, J. Mao, Z. Du, and Y. Chang, "Online training algorithms based single multiplicative neuron model for energy consumption forecasting," *Energy*, vol. 59, pp. 126-132, 2013. View at Google Scholar | View at Publisher

[21] F. Zhang, C. Deb, S. E. Lee, J. Yang, and K. W. Shah, "Time series forecasting for building energy consumption using weighted support vector regression with differential evolution optimization technique," *Energy and Buildings*, vol. 126, pp. 94-103, 2016. View at Google Scholar | View at Publisher

[22] U. Kumar and V. K. Jain, "Time series models (Grey-Markov, Grey Model with Rolling Mechanism and Singular Spectrum Analysis) to forecast energy consumption in India," *Energy*, vol. 35, pp. 1709-1716, 2010. View at Google Scholar | View at Publisher

[23] S. Saab, E. Badr, and G. Nasr, "Univariate modeling and forecasting of energy consumption: The case of electricity in Lebanon," *Energy*, vol. 26, pp. 1-14, 2001. View at Google Scholar | View at Publisher

[24] K. Tornai, L. Kovacs, A. Olah, R. Drenyovszki, I. Pinter, D. Tisza, and J. Levendovszky, "Classification for consumption data in smart grid based on forecasting time series," *Electric Power systems Research*, vol. 141, pp. 191-201, 2016. View at Google Scholar | View at Publisher

[25] H. T. Pao, "Forecasting energy consumption in Taiwan using hybrid nonlinear models," *Energy*, vol. 34, pp. 1438-1446, 2009. View at Google Scholar | View at Publisher

[26] S. J. Feng, Y. D. Ma, Z. L. Song, and J. Ying, "Forecasting the energy consumption of china by the grey prediction model," *Energy Sources, Part B*, vol. 7, pp. 376-389, 2012. View at Google Scholar | View at Publisher

[27] OECD, "Data on consumption of renewable energy." Retrieved from https://data.oecd.org/energy/renewable-energy.htm, 2017.

[28] Turkish General Directorate of Energy Affairs, "Data on coal, oil and gas consumption." Retrieved from http://www.eigm.gov.tr/en-US/Balance-Sheets, 2017b.

[29] World Bank, "World deveopment indicators." Retrieved from http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators, 2017.

[30] G. P. E. Box and G. M. Jenkins, *Time series analysis: Forecasting and control*. San Francisco: Holden Day, 1970.

[31] G. E. P. Box and G. M. Jenkins, *Time series analysis: Forecasting and control*, Revised Edition ed. Oakland, CA: Holden-Day, 1976.

[32] International Energy Agency, "Energy policies of iea countries, Turkey." Retrieved from http://www.iea.org/publications/freepublications/publication/energy-policies-of-iea-countries---turkey-2016-review.html, 2017b.