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ESTIMATION OF NET ELECTRICITY CONSUMPTION OF TURKEY

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Abstract: This paper deals with estimation of the net electricity consumption of Turkey until the year 2012 based on linear regression (LR), nonlinear regression (NLR), and artificial neural networks (ANNs) methods. Installed capacity, gross electricity generation, population and total subscribership are selected as independent variables. Two different scenarios (high and low) are proposed for predicting the future electricity consumption. The LR, NLR and ANN model results are also compared with each other, and the Ministry of Energy and Natural Resources (MENR) projection and literature results. Results show that the performance values of the ANN method are better than the performance values of the LR and NLR models. According to the high and low scenario, and ANN model, Turkey's net electricity consumptions will be 251.1 and 221.07 TWh by the year 2012, respectively.
Keywords: Artificial neural networks (ANNs), Electricity consumption, Electricity generation, Installed capacity, Linear regression (LR), Nonlinear regression (NLR).

TÜRKİYE'NİN NET ELEKTRİK TÜKETİMİNİN TAHMİNİ

Özet: Bu çalışma lineer regresyon (LR), lineer olmayan regresyon (NLR) ve yapay sinir ağları (YSA) metotları kullanılarak 2012 yılına kadar Türkiye'nin net elektrik tüketiminin tahmini ile ilgilidir. Kurulu güç, brüt elektrik üretimi, nüfus ve toplam abone sayısı bağımsız değişkenler olarak seçilmiştir. Gelecek elektrik tüketimi tahmini için iki farklı senaryo (yüksek ve düşük) önerilmiştir. LR, NLR ve YSA modelleriyle elde edilen sonuçlar birbirleriyle ve ayrıca Enerji ve Tabi Kaynaklar Bakanlığı (ETKB) ve literatürdeki sonuçlarla karşılaştırılmıştır. YSA metodunun performans değerleri, lineer ve lineer olmayan metotlarının performans değerlerinden daha iyi sonuçlar vermiştir. Sonuç olarak YSA metoduna göre, 2012 yılında Türkiye'nin net elektrik tüketiminin yüksek senaryo için 251.1 TWh, düşük senaryo için ise 221.07 TWh olacağı hesaplanmıştır.
Anahtar Kelimeler: Yapay sinir ağları (YSA), Elektrik tüketimi, Elektrik üretimi, Kurulu güç, Lineer regresyon (LR), Lineer olamayan regresyon (NLR).

Nomenclature

α	Equation parameter
ANN	Artificial Neural Network
BP	Back-Propagation
β	Equation parameter
φ	Activation function
IEA	International Energy Agency
LM	Levenberg-Marquardt
LR	Linear Regression
MAED	Model for Analysis of Energy Demand
MENR	Ministry of Energy and Natural Resources
NLR	Nonlinear Regression
RP	Resilient Propagation
SCG	Scale Conjugate Gradient
TEDAS	Turkish Electricity Distribution Corporation
TEIAS	Turkish Electricity Transmission Company
θ	Threshold
TUIK	Turkish Statistics Institute
u	Summation function
X	Independent variable
w	Weight
y	Input, output or signal
Y	Dependent variable

INTRODUCTION

Turkey is located in the Northern Hemisphere at the junction Europe and Asia, and it has a land surface area of 774,815 km^2 officially. Because of its geographical position, it has an increasingly important role to play as an "energy corridor" between the major oil and natural gas producing countries in the Middle East, Caspian Sea and the Western energy markets (IEA, 2005; Bilen et al., 2008). More than about 70% of energy consumption in the country is met by imported energy sources, and the share of imports grows each year continuously. The economy and population of Turkey grow rapidly. According to the Turkish Statistics Institute (TUIK), Turkey's population as of December 31, 2007 is

70,586,256. It grew by 4.1 percent since 2000 (TUIK, 2008). As a developing country, Turkey's population is estimated to be over 100 million by the year of 2020 (Yüksek et al., 2006). For this reason, demands for energy and particularly for electricity have been growing rapidly.

Because of the uncertain economic structure of the country, electricity consumption has a chaotic and nonlinear trend. Hence, forecasting studies of net electricity consumption constitute the vital part of energy policy of countries, especially for those countries whose energy demand grows rapidly, as in the case of Turkey. Accurate forecasts of net electricity consumption are important for effective implementation and decision on capital-intensive investments. In Turkey, energy forecasting studies have been officially carried out by the Turkish Ministry of Energy and Natural Resources (MENR) by using Model for Analysis of Energy Demand (MAED) simulation technique. In literature, various techniques have been applied for energy demand forecasting of Turkey, such as degree-day, linear and multivariable regression, autoregression, genetic algorithm, and artificial neural networks (Akay and Atak, 2007; Ediger and Akar, 2007). A summary of the studies on forecasting energy demand in Turkey between 2004 and 2008 is given in Table 1.

The main objective of the present study is to apply linear regression (LR), nonlinear regression models, and also artificial neural network (ANN) methodology for the forecasting of Turkey's net electricity consumption in order to analyse energy use and make future projections. The electric energy demand of Turkey for the period of 2008-2012 is estimated based on the installed capacity, gross electricity generation, population and total subscribership.

Table 1. A summary of the studies on forecasting energy demand in Turkey between 2004 and 2008.

Method	Reference
Linear regression	Yumurtacı and Asmaz, 2004
Multivariable regression model	Görücü and Gümrah, 2004
First order autoregressive time series model	Aras and Aras, 2004
Regression, Autoregressive integrated moving average (ARIMA) and seasonal ARIMA (SARIMA) methods	Ediger and Akar, 2007; Ediger et al., 2006; Erdogdu, 2007
Linear mathematical model	Tunç et al., 2006
Grey prediction with rolling mechanism (GPRM) approach	Akay and Atak, 2007
Ant colony optimization energy demand estimation model	Toksarı, 2007
Particle swarm optimization energy demand forecasting (PSOEDF) model	Ünler, 2008
A new criterion method on previous prediction models	Yüksek, 2008
Genetic algorithm (GA)	Ozturk and Ceylan, 2005; Canyurt et al., 2004; Ceylan and Ozturk, 2004; Ozturk et al., 2004; Haldenbilen and Ceylan, 2005; Ceylan et al., 2005a; Ceylan et al., 2005b; Ozturk et al., 2005; Canyurt et al., 2006; Ozturk et al., 2006
Artificial neural network (ANN)	Hamzaçebi, 2007; Görücü et al., 2004; Sözen et al., 2005a; Murat and Ceylan, 2006; Sözen and Arcaklıoğlu, 2007

ELECTRIC ENERGY IN TURKEY

The main indigenous energy resources of Turkey are hydro, mainly in the eastern part of the country, and lignite. It has no big oil and gas reserves. Almost all oil, natural gas and high quality coal are imported. On the other hand, it has large renewable energy potential (Yüksek et al., 2006). In Turkey, where there is no nuclear power, electricity is generated from thermal, hydro, wind and geothermal power plants. The installed capacity of Turkey between 1990 and 2007 is given in Table 2. The installed capacity of Turkey's electric power plants was 16.32 GW in 1990. In 1999, Turkey's installed electric power generation capacity reached 26.12 GW, and 99.9% of its population was connected to the electricity grid (IEA, 2001; Kıncay and Ozturk, 2003). In 2007, electricity installed capacity reached 40.78 GW. In this capacity, the share of thermal power plants was 66.73% (27.21 GW). Hydro power plants accounted for 32.85% (13.39 GW), geothermal and wind for 0.42% (0.17 GW).

Turkey's electricity generation is based on the solid-fired resources (hard coal, lignite and imported coal), the liquid-fired resources (fuel-oil, diesel oil, LPG, Naphtha), natural gas, hydro, and others such as renewable energy and wastes sources. The solid-fired and hydraulic resources being the basic; oil and natural gas resources are main primary energy resources of Turkey in electricity generation. The electricity generation of Turkey between 1990 and 2007 is given in Table 3. As reported by the TEIAS, Turkey's gross electricity generation was 191.24 TWh in 2007. Of the total electricity generation, 81.01% came from the thermal power plants, while 18.72% came from the hydro power plants. In addition, the wind and geothermal power plants met 0.27% of Turkey's electric power generation. In this year, 154.92 TWh of this energy was produced by operating the thermal power plants. On the other hand, the annual electricity productions of the hydro power plants, and the wind and geothermal power plants were 35.80 TWh and 0.52 TWh, respectively. According to the prediction of Kenisarin et al. (2006), the installed capacity of electric power plants is expected to reach 109.23 GW and the annual electricity production is going to be 623.84 TWh by the year 2025.

Electric energy is used in nearly all kinds of human activity, such as industrial production, residential, agriculture, transportation, lighting and heating. While net electricity consumption was 46.82 TWh in 1990, it increased to 155.14 TWh in 2007. For the total consumed electricity of 155.14 TWh, 75.42 TWh was used by residential sector, 73.80 TWh by industrial sector, 4.98 TWh by agriculture sector, and 0.94 TWh by transportation.

Table 2. Installed capacity of Turkey [GW] between 1990 and 2007 (TEIAS, 2008).

Year	Thermal	Hydro	Wind + Geothermal	Total
1990	9.54	6.76	0.02	16.32
1991	10.08	7.11	0.02	17.21
1992	10.32	8.38	0.02	18.72
1993	10.64	9.68	0.02	20.34
1994	10.98	9.86	0.02	20.86
1995	11.07	9.86	0.02	20.95
1996	11.30	9.93	0.02	21.25
1997	11.77	10.10	0.02	21.89
1998	13.02	10.31	0.03	23.35
1999	15.56	10.54	0.03	26.12
2000	16.05	11.18	0.04	27.26
2001	16.62	11.67	0.04	28.33
2002	19.57	12.24	0.04	31.85
2003	22.97	12.58	0.03	35.59
2004	24.14	12.65	0.03	36.82
2005	25.90	12.91	0.04	38.84
2006	27.42	13.06	0.08	40.56
2007	27.21	13.39	0.17	40.78

Table 3. Electricity generation of Turkey [TWh] between 1990 and 2007 (TEIAS, 2008).

Year	Thermal	Hydro	Wind + Geothermal	Total
1990	34.32	23.15	0.08	57.54
1991	37.48	22.68	0.08	60.25
1992	40.70	26.57	0.07	67.34
1993	39.78	33.95	0.08	73.81
1994	47.66	30.59	0.08	78.32
1995	50.62	35.54	0.09	86.25
1996	54.30	40.48	0.08	94.86
1997	63.40	39.82	0.08	103.30
1998	68.70	42.23	0.09	111.02
1999	81.66	34.68	0.10	116.44
2000	93.93	30.88	0.11	124.92
2001	98.56	24.01	0.15	122.72
2002	95.56	33.68	0.15	129.40
2003	105.10	35.33	0.15	140.58
2004	104.46	46.08	0.15	150.70
2005	122.24	39.56	0.15	161.96
2006	131.84	44.24	0.22	176.30
2007	154.92	35.80	0.52	191.24

MATERIALS AND METHODS

Linear and Nonlinear Regression Analysis

Regression analysis is one of the most widely used methodologies for expressing the dependence of a response variable on several independent variables (Abdul-Wahab et al., 2005). The first step in regression analysis is to select independent variables for constructing a model. Here, the important peculiarity is; i) to pick out adequate dependent variables, ii) to discover linear correlations of cause and effect between dependent and independent variables, and iii) to include only related independent variables to the model. If there are too many independent variables, those variables which provide substantial contribution to the interpretation of the variations of dependent variables must be selected (Sahinler, 2000).

In linear regression, the function is a linear equation, i.e. straight-line, in the form:

$$Y = \beta_1 + \beta_2 X_1 + \beta_3 X_2 + ... + \beta_{n+1} X_n \quad (1)$$

where Y is the dependent variable, β_1 to β_{n+1} are the equation parameters for the linear relation, and X_1 to X_n are the independent variables for this system (Özbayoğlu and Özbayoğlu, 2006). The general appearance of the nonlinear relation is assumed to be:

$$Y = \alpha_1 \left(X_1^{\alpha_2} \right) \left(X_2^{\alpha_3} \right) ... \left(X_3^{\alpha_{n+1}} \right) \quad (2)$$

where α_1 to α_{n+1} are the equation parameters for the nonlinear relation.

Artificial Neural Networks

Artificial neural networks (ANNs) are effective and reliable algorithms capable of performing functional input/output mappings. They are flexible mathematical structures that are capable of identifying complex non-linear relationships between input and output data sets. The main differences between the various types of ANNs are arrangement of network architecture. There are many methods to determine the weights and functions for inputs and training (Rajpal et al., 2006; Melesse and Hanley, 2005). Kalogirou (2001) stated that during past years there has been a substantial increase in interest of artificial neural networks. Researches have been applying the ANNs method successfully in various fields of mathematics, engineering, medicine, economics, meteorology, psychology, neurology, in the prediction of mineral exploration sites, in electrical and thermal load predictions and in adaptive and robotic control and many other subjects. This method learns from given examples by constructing an input-output mapping in order to perform predictions (Mohandes et al., 2004). In other words, to train and test a neural network, input data and corresponding output values are necessary (Çam et al., 2005). ANNs can be trained to overcome the limitations of the conventional approaches to solve complex problems that are difficult to model analytically (Sözen et al., 2005b).

The fundamental processing element of a neural network is a neuron. The network usually consists of an input layer, hidden layers and an output layer. A neuron j may be mathematically described with the following pair of equations (Haykin, 1994);

$$u_j = \sum_{i=0}^{p} w_{ji} y_i \quad (3)$$

and,

$$y_j = \varphi(u_j - \theta_j) \quad (4)$$

Where p equals the number of source nodes in the input layer or neurons in the output layer. The artificial neuron receives a set of inputs or signals (y) with weight (w), calculates a weighted average of them (u) using the summation function and then uses some activation function (φ) to produce an output (y). The use of threshold (θ) has the effect of applying *an affine transformation* to the output (u) of the linear combiner. The sigmoid logistic non-linear function is described with the following equation;

$$\varphi(x) = \frac{1}{1 + e^{-x}} \quad (5)$$

APPLICATION

In linear regression, nonlinear regression and artificial neural networks methods, the most significant point is to select the predictor variables that provide the best prediction equation for modelling of dependent variable. In addition, since the future predictor variables are unknown, the probability percentage of occurrence of these variables is substantially important. Furthermore, attention must be taken in selecting the independent variables. For this reason, firstly the independent variables were selected based on correlation coefficient analysis. There is a high rate of correlation coefficient between the variables. Secondly, those independent variables which were expected to be in the future year were investigated. For instance, installed capacity, gross electricity generation, population and total subscribership were selected as independent variables in order to obtain predictive equation for modelling of net electricity consumption. The values of net electricity consumption and predictor variables between 1990 and 2007 are given in Table 4.

Artificial neural network architecture used in this study is shown in Fig. 1. Computer program has been performed under MATLAB. The model is based on a feed-forward back-propagation (BP) network. Feed-forward networks often have one or more hidden layers of sigmoid neurons followed by an output layer of linear neurons. Installed capacity, gross electricity generation, population and total subscribership were used in the input layer of the network. On the other hand, net electricity consumption was used in the output layer of the network. After input and output variables were selected, the optimum number of neurons in the hidden layer was determined using the trial and error procedure by varying the number of hidden neurons from 2 to 16. By using trial and error method with different ANN configurations, it is decided to have the network consisting of one input layer with 4 neurons, one hidden layer with 8 neurons, and one output layer with 1 neuron.

Table 4. Values of net electricity consumption and predictor variables (TUIK, 2008; MENR, 2008; TEIAS, 2008; TEDAS, 2008).

Year	Installed capacity (GW)	Gross electricity generation (TWh)	Population (Million)	Total subscribership (Million)	Net electricity consumption (TWh)
1990	16.32	57.54	56.85	15.54	46.82
1991	17.21	60.25	57.77	16.28	49.28
1992	18.72	67.34	58.69	16.97	53.99
1993	20.34	73.81	59.61	17.77	59.24
1994	20.86	78.32	60.53	18.70	61.40
1995	20.95	86.25	61.45	19.47	67.39
1996	21.25	94.86	62.37	20.58	74.16
1997	21.89	103.30	63.29	21.12	81.88
1998	23.35	111.02	64.21	21.99	87.71
1999	26.12	116.44	65.13	22.94	91.20
2000	27.26	124.92	66.05	24.02	98.30
2001	28.33	122.72	66.97	24.81	97.07
2002	31.85	129.40	67.89	25.68	102.95
2003	35.59	140.58	68.81	26.62	111.77
2004	36.82	150.70	69.73	27.71	121.14
2005	38.84	161.96	70.65	28.44	130.26
2006	40.56	176.30	71.57	29.37	143.07
2007	40.78	191.24	72.49	30.02	155.14

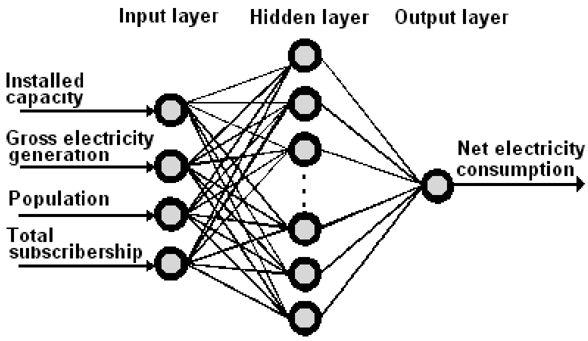

Figure 1. ANN architecture.

Variants of the learning algorithm used in the study are resilient propagation (RP), scale conjugate gradient (SCG) and Levenberg-Marquardt (LM) learning algorithms. However, the best results were found for the LM learning algorithm. For this reason, the LM learning algorithm was preferred for the present simulation. Neurons in the input layer have no transfer function. Logistic sigmoid transfer function (logsig) and linear transfer function (purelin) were used in the hidden layer and output layer of the network as an activation function, respectively. In each layer, every neuron is connected to a neuron of adjacent layer having different weights. Each neuron as indicated in Fig. 1, receives signals from the neurons of the previous layer weighted by the interconnect values between neurons except input layer. Neurons then produce an output signal by passing the summed signal through an activation function (Maqsood et al., 2005). During the training process, the weights of the connections between neurons are adjusted in order to achieve the desired input/output relation of the network. This procedure goes on until the difference between the actual output of the network and the desired output is equal with a specified remainder value. Here, the criterion is put forward as the network output which should be closer to the value of desired output. This training process has to be repeated for the rest of the input-output pairs existing in the training data.

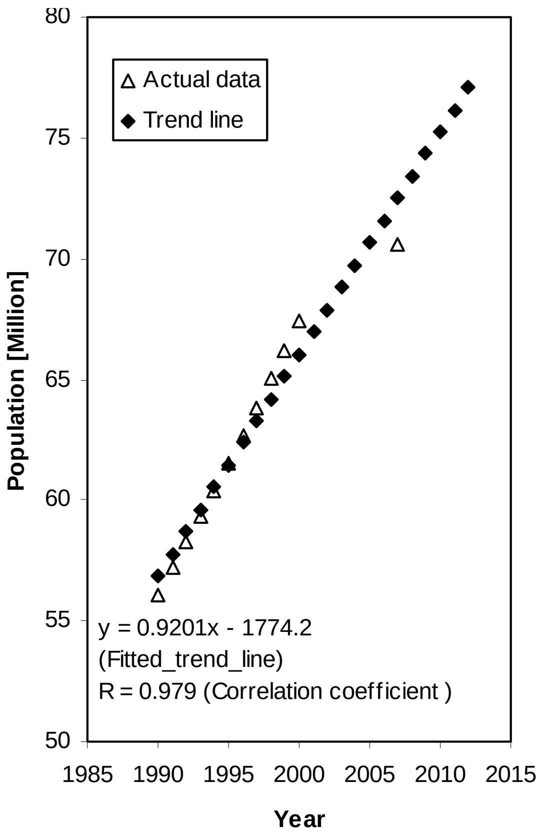

Figure 2. Population and its corresponding fitted linear trends.

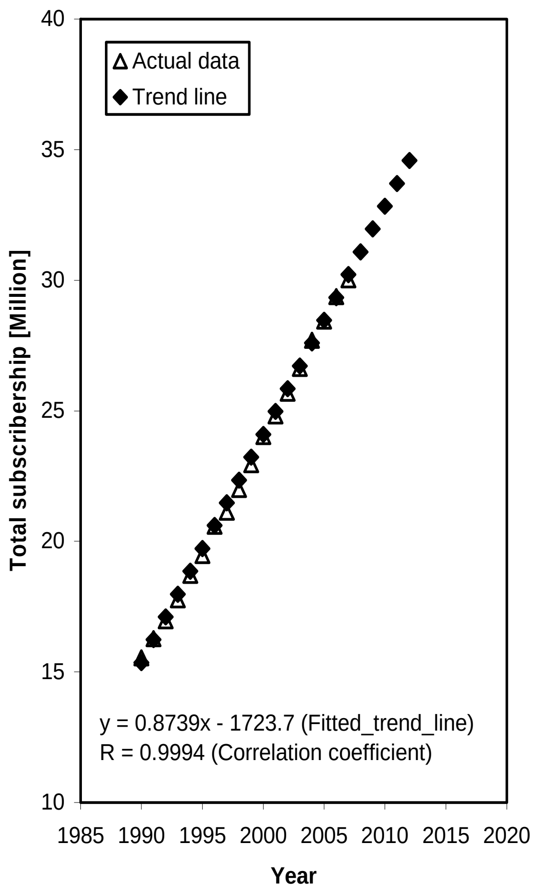

Figure 3. Total subscribership and its corresponding fitted linear trends.

Data from 1990 to 2007 were used for the training procedure. The data of three years (1995, 2000 and 2005) were used only as test data to confirm this method. In order to make future projections for the period of 2008-2012, installed capacity and gross electricity generation values were taken from the Turkish Electricity Generation Capacity Projection, which was prepared by the Turkish Electricity Transmission Corporation (TEIAS) (TEIAS, 2008). In addition, population and total subscribership values for the period of 2008-2012 may be estimated with forms of mathematical expression such as linear trend line equation. They are shown in Figs. 2 and 3, respectively.

RESULTS AND DISCUSSION

First, the training procedure was applied, and the LR, NLR and ANN models were used to obtain predictive equation. Then, the testing procedure was applied to evaluate the performance of the LR, NLR and ANN models. The performance values for net electricity consumption in the training and testing procedures are given in Table 5. According to the results obtained, errors are within acceptable limits. As seen in these tables, the performance values of the ANNs method are better than the performance values of the LR and NLR models.

TEIAS (2008) has planned two scenarios both for demand and resource projections, called the Turkish Electricity Generation Capacity Projection. In this capacity projection study, Turkey's future installed capacity and gross electricity generation values are calculated by considering the existing power plants, other projects which are currently under construction and new projects granted by licence by the end of January 2008. For the high and low scenarios, they are given in Table 6.

Table 5. Performance values for net electricity consumption.

Year	Actual (TWh)	LR (TWh)	Relative error	NLR (TWh)	Relative error	ANN (TWh)	Relative error
1990	46.82	46.96	0.142	46.51	-0.314	47.24	0.419
1991	49.28	48.39	-0.894	48.76	-0.521	49.08	-0.206
1992	53.99	53.90	-0.081	54.39	0.402	53.99	0.002
1993	59.24	59.00	-0.233	59.23	-0.003	58.58	-0.653
1994	61.40	62.15	0.748	62.29	0.890	61.83	0.427
***1995**	**67.39**	**68.07**	**0.672**	**68.48**	**1.085**	**67.67**	**0.281**
1996	74.16	75.02	0.861	73.76	-0.401	74.17	0.011
1997	81.88	81.32	-0.563	81.58	-0.308	81.37	-0.511
1998	87.71	87.58	-0.129	87.59	-0.111	87.55	-0.157
1999	91.20	92.24	1.036	91.76	0.556	91.98	0.780
***2000**	**98.30**	**99.29**	**0.998**	**97.53**	**-0.764**	**98.93**	**0.629**
2001	97.07	96.42	-0.649	97.56	0.490	97.14	0.070
2002	102.95	102.36	-0.583	103.39	0.442	102.76	-0.191
2003	111.77	112.50	0.731	112.21	0.442	112.23	0.461
2004	121.14	121.07	-0.075	119.67	-1.470	120.80	-0.343
***2005**	**130.26**	**130.53**	**0.266**	**130.04**	**-0.222**	**130.47**	**0.209**
2006	143.07	142.88	-0.189	141.73	-1.337	142.73	-0.341
2007	155.14	155.02	-0.120	155.87	0.736	155.37	0.231

*: Testing

Table 6. Turkey's installed capacity and gross electricity generation values for the period of 2008-2012 (TEIAS, 2008).

Year	Installed capacity (GW)		Gross electricity generation (TWh)	
	*High scenario	*Low scenario	*High scenario	*Low scenario
2008	42.43	42.23	212.18	211.65
2009	45.42	43.96	223.13	216.46
2010	51.57	44.47	250.37	221.49
2011	59.42	49.70	286.54	238.86
2012	66.69	55.59	333.87	278.74

*: Including existing, under construction, licenced power plants and new additional capacity

According to the high scenario, the total installed capacity and gross electricity generation will reach to 66.69 GW and 333.87 TWh by the year 2012, respectively. By utilizing the installed capacity and gross electricity generation values, Turkey's net electricity consumption for the period of 2008-2012 was estimated by the LR, NLR and ANN methods. Obtained forecast results are shown in Fig. 4. As seen from the figure, while the net electricity consumption is 172.59 TWh in 2008, it will increase to 251.10 TWh by the year 2012 for the ANN model. In addition, it is expected that Turkey's net electricity consumption will be 285.76 TWh by the year 2012 for the LR method.

According to the low scenario, the total installed capacity and gross electricity generation will reach to 55.59 GW and 278.74 TWh by the year 2012, respectively. For the low scenario, Turkey's net electricity consumption for the period of 2008-2012 was estimated by the LR, NLR and ANN methods. Obtained forecast results are shown in Fig. 5. As seen from the figure, while the net electricity consumption is 172.16 TWh in 2008, it will increase to 221.07 TWh by the year 2012 for the ANN model. In addition, it is expected that Turkey's net electricity consumption will be 232.78 TWh by the year 2012 for the LR method.

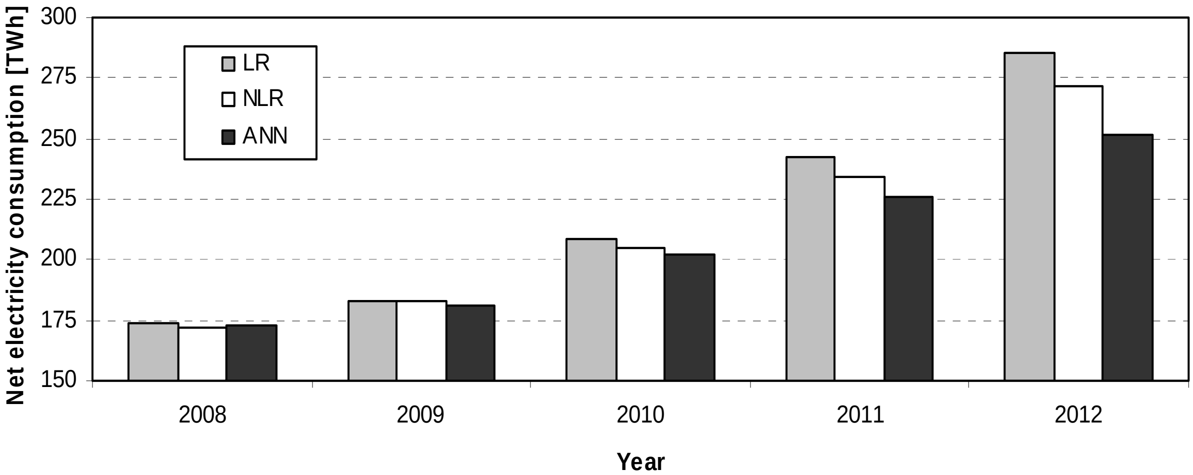

Figure 4. Turkey's net electricity consumption for the period of 2008-2012 according to the high scenario.

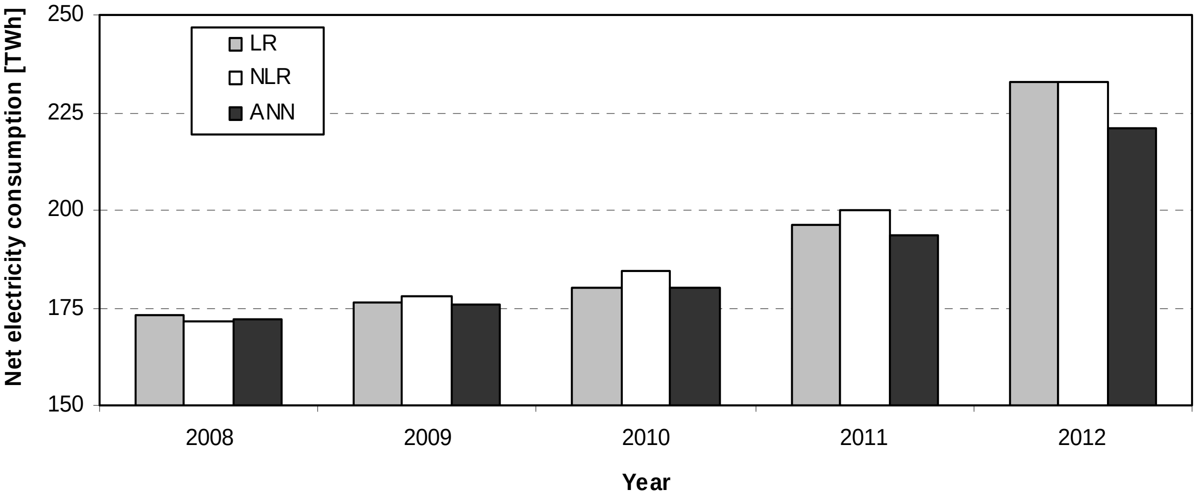

Figure 5. Turkey's net electricity consumption for the period of 2008-2012 according to the low scenario.

Table 7. Comparison of net electricity consumption (TWh) between the present study results and literature values.

Year	LR (High scenario)	ANN (High scenario)	Hamzaçebi'2007	MENR'2008	Erdogdu'2007
2008	173.42	172.59	173.59	168.60	146.37
2009	183.05	181.36	189.47	184.40	145.14
2010	208.30	201.93	206.83	201.65	155.67
2011	242.09	225.96	225.80	220.60	156.01
2012	285.76	251.10	246.52	240.70	158.15

In order to show performance of the present study, this projection results were compared with the published literature on similar studies that used ANN and other methods. Table 7 gives the comparison of net electricity consumption between the present study results and literature values. Hamzaçebi (2007) obtained the forecasts of Turkey's electricity consumptions on sectoral basis until 2020. In his study, artificial neural networks (ANNs) are preferred as forecasting tool. According to the Hamzaçebi's result, Turkey's net electricity consumption will increase to 285.76 TWh by the year 2012. Erdogdu (2007) developed and used an ARIMA model in order to forecast net electricity consumption in Turkey. As to forecasted net electricity consumption values in his study, the electric energy demand of Turkey will continue to increase at an annual average rate of 3.3% and will turn out to be 158.15 TWh in 2012. For the high scenario in the present study, the LR method gives higher forecasts of the energy demand than the MENR, Erdogdu and Hamzaçebi's results. On the other hand, the ANN method gives higher forecast than Erdogdu's result, but gives near forecast to MENR and Hamzaçebi's results.

CONCLUSION

Estimation of electricity consumption is of great importance for the future electricity policy of countries. Turkey's energy forecasting studies have been officially carried out by the Turkish Ministry of Energy and Natural Resources (MENR) by using Model for Analysis of Energy Demand (MAED) simulation technique. The ANN method can be applied in addition to this simulation technique. However, predictor variables must be selected carefully so that the model makes accurate predictions. It can be concluded that the ANN method looks promising in forecasting the net electricity consumption depending on the variables of installed capacity, gross electricity generation, population and total subscribership.

Results obtained from the present study show that Turkey's net electricity consumption will be between 285.76 TWh and 221.07 TWh by the year 2012. Unfortunately, Turkey is presently an energy-importing country. Excluding lignite; coal, oil and natural gas reserves in country are limited. However, Turkey has a substantial reserves of renewable energy resources such as hydro, wind and solar. In this regards, renewable energy resources appear to be one of the most efficient and effective solutions for the clean and sustainable energy sources. So, Turkey should use available renewable energy sources as much as possible.

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