Research on electricity consumption forecast in Anhui Province

Jingmin Wang[1], Yifei Yang[1,a] and Dongxuan Wang[2]

[1] School of Economic and Management, North China Electric Power University, 071000 Baoding, China

[2] Institute of Technology, Hebei Agricultural University, 061100 Huanghua, China

[a] Corresponding author: 360999473@qq.com

Abstract. Electricity consumption forecasting has drawn more and more attention after that China has entered a period of energy structure adjustment and economic transition. Therefore, forecasting electricity accurately is indispensable. In this paper, based on the analysis of Anhui province economic development and electric load, tendency fitting, cubic exponential smoothing and multiple linear regression models are employed to predict the electricity consumption from 2015 to 2020 in Anhui province.

1.Introduction

With the development of economy and technology, energy resource is absolutely essential in social life. At the same time electricity as the most significant energy resource became more and more important in everyone's daily life. Forecasting electricity demand scientifically promises the related decision-making correctly. The forecasting of electrical load plays an indispensable influence on the safe operation of the power system and the stable development of the national economy. Consequently, forecasting the electricity consumption precisely contributes to formulating the power planning reasonably.

Since the middle of the 20th century, scholars home and overseas have begun to study electricity consumption forecasting abroad, and now some advanced models and methods have been obtained. Based on prediction time electrical load forecasting can be divided into short, middle and long term prediction. Abroad, the electrical load consumption was first predicted via the Bayesian method [1]; then Julian Silk etc. [2] used co-integration test and its error correction model, introducing seasonal and economic factors, to predict the short-term electrical load demand in USA; Abdul [3] studied the impact of electricity prices in the Gulf countries, alternative energy prices and GDP on electrical load consumption; Erkan Erdogdu [4] combined co-integration and ARMA model to study the relationship between electricity prices, alternative energy prices, and electricity consumption in Turkey. Domestically, more scholars would like to forecast electricity consumption through various methods. Such as Niu dongxiao [5] proposed grey model optimized by particle swarm to forecast electricity consumption.

Nowadays, there are a lot of methods and models are proposed to forecast electricity consumption. However, there is not yet a general method can forecast accurately in all cases. All kind of models have their own advantages, and it is necessary to make comparative analysis of the characteristics of power market, economic development and data sources in the region.

2.The development situation of Anhui Province

At the end of 2012, the GDP of Anhui Province reached 17212 billion yuan, the population reached 6902 thousands, per capita GDP exceeded 3000 dollar, and the total fixed assets investment reached 15055 billion yuan. As we can see from the table 1, Anhui Province maintained double-digit GDP growth, more than 30% of annual investment growth, and more than 30% of annual investment fiscal growth.

Table 1. Statistics on National Economic and Social Development Indicators of Anhui Province.

Indicators	**1995**	**2000**	**2005**	**2010**	**2012**
Total population (thousand)	6000	6278	6516	6827	6902
GDP (billion yuan)	1811	2902	5350	12360	17212
total fixed assets investment (billion yuan)	532.5	866.7	2521	11850	15055
Fiscal revenue (billion yuan)	147	290	657	2064	3026

Since the 19th National People's Congress in 2017, China will enter a new era of socialism with Chinese characteristics, and its economic development also turns from high-speed growth stage to high-quality growth stage. As the main area of economic development in central and eastern China, Anhui's economic situation will closely follow the general trend of national economic development.

As a major energy province, the energy industry in Anhui Province has developed rapidly in recent years. The total energy production has increased year by year, and the proportion of clean energy has increased. Then electric power as a kind of clean energy has been effectively used in a wide rage, and the electricity consumption is growing year by year. From the perspective of the energy consumption structure of Anhui Province, raw coal is the main energy, but the proportion of electricity in the total energy consumption has also begun to increase significantly. At present, the energy policy of national energy conservation and efficiency has provided a good environment for the development of Anhui's energy industry. Anhui Province is expected to further adjust the energy consumption structure to achieve diversification and clean utilization of energy based on the implementation of energy conservation and efficiency strategy, thereby a healthier economic development system will be built.

3.Methodology

Three different forecasting models are selected in this paper to predict the total electricity consumption in Anhui Province.

3.1 Trend fitting model

The trend fitting method is the simplest and most time-saving forecasting method. Firstly, it is necessary to draw a scatter plot of the original data and observe the data trend. Then it can add a trend line to the data by means of the excel tool. Finally, by comparing the fitting effects of different trend lines, the most suitable fitting model is found.

3.2 Exponential smoothing model

This paper uses the second exponential smoothing method, the principle is as follows.

$$S_t^{(1)} = \alpha x_t + (1-\alpha) S_{t-1}^{(1)} \quad (1)$$

$$S_t^{(2)} = \alpha S_t^{(1)} + (1-\alpha) S_{t-1}^{(2)} \quad (2)$$

$$\hat{y}_{t+T} = a_t + b_t T \quad (3)$$

$$a_t = \alpha S_t^{(1)} - S_t^{(2)} \quad (4)$$

$$b_t = \alpha/2(1-\alpha)[S_t^{(1)} - S_t^{(2)}] \quad (5)$$

T is the t period from the T period, Y_{T+t} is the predicted value of the t-th period since the T period, a_t and b_t are the parameters of the model. $s_t^{(1)}$ and $s_t^{(2)}$ are the primary and secondary smoothing values of time t, respectively. x_t Is the real value of time t. α is smoothing constant and its range is (0,1).

3.3 Multiple linear regression model

Multiple linear regression is the linear regression analysis with two or more independent variables. It is expressed as below:

$$y = a_0 + a_1 x_1 + \ldots + a_n x_n \quad (6)$$

a0 is a constant, and a1, a2, ..., an are regression coefficients.

4.Forecasting electricity consumption of Anhui Province

4.1 Data sources

This article selected the total electricity consumption from 2006 to 2016 in Anhui Statistical Yearbook. According to the total electricity consumption curve in Anhui Province in recent years, multiple linear regression model, trend fitting model and exponential smoothing model are used to forecast the total electricity consumption during 2018-2020.

4.2 Trend fitting model

The electricity consumption data of the Anhui Province during 2006-2016 was obtained from the 2017 Statistical Yearbook of Anhui Province. Meanwhile, as shown in figure 1, the excel tool was used to plot the 11-year data trend graph.

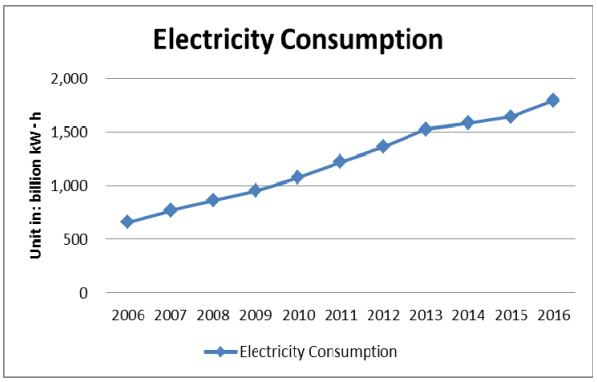

Figure 1. The electricity consumption during 2006-2016 in Anhui Province.

As we can see from the figure 1, in 2006-2016, the electricity consumption trend in Anhui Province was relatively flat and roughly linear or exponential. Then the linear and exponential function fittings were performed, and the fitting results are shown in figure 2 and figure 3.

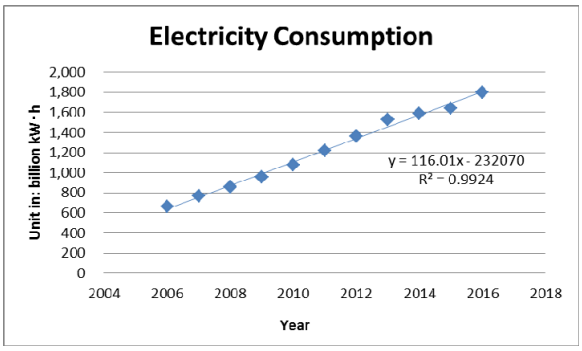

Figure 2. Linear fitting map.

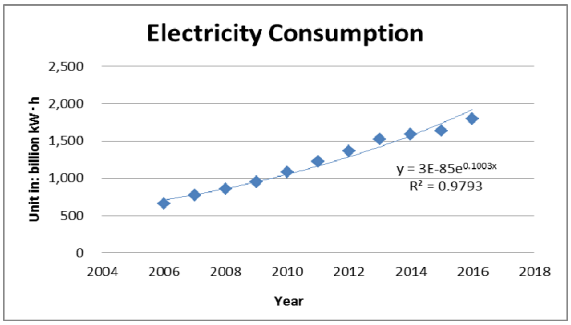

Figure 3. Exponential fitting map.

The final fitting formulas are:

$$y=16.01x+232070 \quad (7)$$

$$y=3^{E}\text{-}85\ e^{0.1003x} \quad (8)$$

R2 is the coefficient of determination, ranging from 0 to 1. The closer R2 is to 1, the better the fitting effect. The exponential fitting model is selected to predict the electricity consumption in Anhui Province during 2017-2020. The forecasting results are shown in Table 2.

Table 2. Exponential fitting model forecast the electricity consumption during 2017-2020 in Anhui Province.

Year	2017	2018	2019	2020
Electricity consumption	2125.0	2349.2	2597.1	2871.9

4.3 Exponential smoothing model

From figure 1, it can be seen that the Anhui Province's electricity consumption in 2006-2016 is not seasonal, relatively stable and showing a non-linear trend. Consequently, exponential smoothing model can be used to forecast the total electricity consumption in Anhui Province during 2017-2020. The forecasting results, obtained by Matlab software, are shown in Table 3, and the fitting map is listed in figure 4.

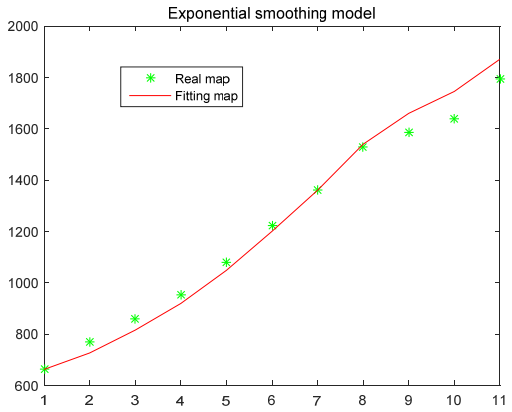

Figure 4. The fitting map of exponential smoothing model and real value.

Table 3. Exponential fitting model forecast the electricity consumption during 2017-2020 in Anhui Province.

Year	2017	2018	2019	2020
Electricity consumption	1930.5	2067.1	2203.6	2340.2

4.4 Multiple linear regression model

This section selects GDP and population as the variables of multiple linear regression for regression analysis. The regression equation is described as follows.

$$y=1047.97-0.1101x_1+0.0672x_2 \quad (9)$$

As shown in the results of the regression analysis, there is a clear relationship between "Gross National Product" and "Power Consumption" in this model. The forecasting results of multiple linear regression are shown in Table 4.

Table 4. Multiple linear regression model forecast the electricity consumption during 2017-2020 in Anhui Province.

Year	2017	2018	2019	2020
Electricity consumption	1907.5	2024.1	2140.9	2257.8

5.Results and conclusion

5.1 Results

Based on the situation analysis and the current status of electricity consumption, this paper selects three different models to forecast the total electricity consumption during 2017-2020 in Anhui Province, which include trend fitting, exponential smoothing and multiple linear regression models. The forecasting results of different models are listed in table 5.

Table 5. The forecasting results of different models during 2017-2020 in Anhui Province.

Model/Year	2017	2018	2019	2020
Trend fitting model	2125.0	2349.2	2597.1	2871.1
Exponential smoothing model	1930.5	2067.1	2203.6	2340.2
Multiple linear regression	1907.5	2024.1	2140.9	2257.8

Through comparative analysis, it can be found that the exponential fitting model has the largest prediction result, the exponential smoothing model has the second prediction result, and the multiple linear regression model has the smallest prediction result.

5.2 Conclusion

According to the actual situation of Anhui Province and the characteristics of original electrical data, this paper selects three different models to forecast electricity consumption. The electricity load forecasting models have the following problems:

(1) There is no clear connection between the accuracy of the prediction and the complexity of the model.

(2) The historical data of electricity forecasting is not as much as possible. Historical data that is too long has no reference value for future predictions. It should be 5-10 years to select historical data.

(3) By using regression model for electricity consumption forecasting, the amount of data in the regression model is too small and the practical significance of the regression equation is ignored.

In short, the application of any scientific methods must be based on a true and reliable data base, and at the same time, with the scientific ethics and rigorous scientific attitude of the responsible person, scientific and meaningful conclusions can be obtained.

References

[1] L Berlin, R Bell. J. Bus. and Econ Stats **12**, 221-231 (1992)
[2] J. 1. Silk,F. L. Joutz. Energ Econ. **19**, 493-513 (1997)
[3] A. R. F. Al-Faris. Energ Policy **30**, 117-124 (2002)
[4] E. Erdogdu. Energ Policy **15**, 107-114 (2006)
[5] D.X. Niu, J. Zhao, B. Zhang etc. Chin. J. Manage. Sci. **15**, 69-73 (2007)