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Forecasting of electricity capacity and suggestions of future industrial economy adjustment based on electricity-economy production function

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Abstract. It is of great importance to make critical adjustments on industrial structure, which can provide a positive influence on the development of economy. However, due to the strong relationship between society electricity capacity and industrial economy, traditional electricity capacity prediction algorithms are too complicated to be applied. Therefore, this paper proposes a production-function-based electricity capacity prediction algorithm, considering the interaction between output value of three major industries/38 industries and electricity capacity. As the secondary industry takes a significant part in society economy and electricity capacity, this paper divides the secondary industry into 38 industries to make further analysis. With the help of predicted economy growth of three major industries and 38 industries obtained by expert analysis, the future industries electricity capacity of Zhejiang province can be calculated by production functions. Considering the impact of future industrial electricity capacity, this paper makes some suggestions on adjustment measures of three major industries and 38 industries structure.

1. Introduction

Economy is one of the key factors that determine the growth of electricity capacity. Especially with the dramatic development of economy, the promotion of power system is more and more dependent on economy [1] [2]. Therefore, taking a deep analysis of the interaction between total output value and electricity capacity is of great importance to the precisely prediction of electricity capacity. Moreover, this analysis can promote the environmental and sustainable development of economy by proposing rational adjustment measures on three major industries and 38 industries. In this paper, we consider the electricity capacity as the end-user status of the electricity consumed by society.

There are lots of researches on electricity capacity prediction. The frequently applied prediction algorithms are regression analysis [3], grey prediction [4] and time series prediction [5]. The function that can reflect the relationship between the input and output in the process of production is named as production function. Usually the different input factors have a certain connection between the other production factors including labor, materials, capital and goods, etc [6]. To efficiently and reasonably evaluate the relationship between economy and electricity capacity, this paper applies production function to forecast the future electricity capacity. [6] is mentioned that production function is a



clearly and convenient method to demonstrate the relationship between economic and production input, thus this paper applies production function to predicate. The production function is written with output as a function of inputs. Moreover, the production function is a modified type of a linear function. [6] claimed that there is a strong linear relationship between the electricity input and production output value. This algorithm is built on the consideration of contribution of production factors to the economy growth, instead of relying on the statistical data of history data in forecasting [7].

Different type of electricity has different relationship with economy, thus, the classification of electricity is essential in prediction. To fully and precisely analyze the correction between society economy and electricity capacity, this paper divides the society electricity capacity into four types, which are the end-user status of the electricity consumed by the primary industry, the secondary industry, the tertiary industry and the residential area, according to the state grid and government department. Therefore, this paper analyses the relationship between society economy and society electricity capacity from these four aspects. Moreover, as the secondary industry takes a significant part in the society, this paper deeply analyses the relationship of secondary industry from the perspective of 38 industries.

Concerning the strong relationship between society economy and electricity capacity, this paper proposes a production-function-based electricity capacity prediction algorithm to analyze the interaction between electricity capacity and economy. In this paper, the electricity capacity is the consumed electricity. Firstly, this paper divides the electricity capacity into four parts, and deeply divides the secondary industry into 38 industries. Based on the history data of electricity capacity and economy output value of three major industries and 38 industries, the production function of each type can be achieved. Secondly, with the help of future economy requirement of three major industries and 38 industries from policy, the future electricity capacity can be calculated by production-function-based electricity capacity prediction algorithm. Finally, according to the predicated economy value and electricity capacity, this paper proposes related suggestions on the adjustment of three major industries and 38 industries, which is beneficial for the green and scientific development and sustainable development requirement of society economy.

2. Electricity capacity forecasting algorithm based on the correction between society economy and industries electricity

2.1. Enterprise production function

The function that can reflect the relationship between the input and output in the process of production is named as production function. Usually the different input factors have a certain connection between the other production factors including labor, materials, capital and goods, etc [6]. Moreover, the electricity capacity has a fixed proportion relationship with the other factors of production inputs, which means that all changes in factors of production inputs can be equivalent into the change of electricity capacity. Therefore, the input-output of the production function can be equivalent as the electricity capacity-output production function. [6] claimed that there is a strong linear relationship between the electricity input and production output value. Thus, the production function of enterprise is a linear function, which can be shown in (1)

$$f_i = A_i \times x_i + B_i \quad (1)$$

Where f_i is the production function of enterprise i , x_i is the electricity capacity of enterprise i , A_i is the change of production output value when adding per unit of electricity capacity and B_i is the fixed electricity capacity

2.2. Three major industries and 38 industries production functions

As three major industries and 38 industries are made up of different enterprises, their production functions can be considered as linear functions as well [6].

$$F_j = C_j \times x_j + D_j \quad (2)$$

Where F_j is the production function of industry j , x_j is the electricity capacity of industry j , c_j is the change of production output value when adding per unit of electricity capacity of industry j , which is named as per unit added value parameter. D_j is the fixed electricity capacity.

2.3. Residential electricity capacity

The residential electricity capacity has no influence on the society economic output value. Thus, this paper assumes that the residential electricity capacity rises by an average growth of 10% per year.

2.4. The electricity capacity forecasting algorithm

Concerning the strong relationship between society economy and the divided electricity capacity, this paper proposes a production-function-based electricity capacity prediction algorithm to detailed analysis the interaction between electricity capacity and economy.

Step 1): Based on the history data of electricity capacity and economic output value of three major industries and 38 industries, calculate the production function of every industry.

Step 2): Based on the investigation of several government departments, they gave their opinion on the economic and electric growth of industries. Moreover, together with the history data of growth of industries, the economic growth of industries from 2018 to 2020 are found by expert analysis. Then with the help of production functions, we can predicate the economic output value of three major industries and 38 industries from 2018 to 2020.

Step 3): According to the prediction of economic output values from step 2 and the production functions from step 1, predicate the electricity capacity of three major industries and 38 industries from 2018 to 2020.

3. The suggestions of future Industrial Structure adjustment measures based on Electricity-Economy Production Function

Electricity capacity is an important influence factor of industrial output value, and the change of electricity capacity will greatly affect the change of industrial production, leading to the adjustment of industrial structure. Based on the development of industry production and forecasting of electricity capacity from 2018 to 2020, this paper proposes related adjustment advice for Zhejiang province industrial structure.

4. Case studies

In this section, we forecast the electricity capacity of Zhejiang province from 2018 to 2020. Moreover, we propose some suggestions on industrial structure adjustment.

4.1. Case study in three major industries: take Zhejiang province as an example

Table 1. The electricity capacity and total output of secondary industry in Zhejiang province

| Year | Electricity capacity / billion kWh | Output value /billion RMB |
|------|------------------------------------|---------------------------|
| 2010 | 2 206.47 | 14 187.36 |
| 2011 | 2 427.20 | 16 331.27 |
| 2012 | 2 448.75 | 17 000.09 |
| 2013 | 2 598.20 | 18 047.52 |
| 2014 | 2 652.53 | 19 175.06 |
| 2015 | 2 638.11 | 19 711.67 |
| 2016 | 2 815.13 | 20 517.83 |

Based on the analysis of history data, we found that the tendency of electricity capacity and total output of secondary industry in Zhejiang province before 2010 is different from the tendency after

2010, thus, in this paper we only choose the past 7 years to predict results. Based on the history data of three major industries listed in table 1 provided by government departments and state grid of Zhejiang Province. The production functions of major industries can be calculated.

$$F_1 = 53.667x_1 + 531.65 \quad (3)$$

$$F_2 = 8.5306x_2 - 3932 \quad (4)$$

$$F_3 = 51.417x_3 - 2067.8 \quad (5)$$

If the fitting precision in a production function is larger than 0.9, then this function has highly prediction accuracy. In this case, the fitting precisions of these three functions is 0.9867, 0.9784, 0.9953, respectively. Thus, the production functions in this case have highly prediction accuracy.

We assume the average growth of society economic output value is 6% per year according to government department, the proportion of primary industry will decrease by 0.2% per year, the secondary industry will decrease by 1.8% per year, while the tertiary industry will increase 2% per year. These assumptions are made by the analysing to history tendency of industries. Then the prediction of society electricity capacity can be seen in table 2.

Table 2. The electricity capacity for three industries Zhejiang province (/billion kWh)

| | Primary industry | Secondary industry | Tertiary industry | Residential | Society capacity |
|------|------------------|--------------------|-------------------|-------------|------------------|
| 2018 | 29.24 | 3 067.37 | 633.63 | 601.56 | 4 331.80 |
| 2019 | 30.39 | 3 165.84 | 707.83 | 661.72 | 4 565.77 |
| 2020 | 31.44 | 3 261.96 | 790.41 | 727.89 | 4 811.70 |

From table 2 and production functions, we can conclude that the average growth of primary industry electricity capacity is 4%, which is close to the secondary industry. However, the average growth of tertiary industry is much bigger than the other industries, resulting to the growth of 12% per year. The per unit added value parameter of primary industry is larger than the secondary and tertiary industry, which means the primary industry will go through a more dramatic change of output value. As the secondary industry has the smallest per unit added value parameter, therefore the relationship between its electricity capacity and output value is more vulnerable than the others, and the electricity growth is much less than the others.

From the analysis above, this paper gives five related suggestions on the adjustment measures of industries structure.

- 1) We can see from tables that if the economic percentage of primary industry is decreasing, then the electric growth is smaller than the growth of society. Thus to decrease the production output proportion of primary industry, we should improve the electricity capacity of primary industry, which can encourage the changing tendency of industry structure.
- 2) We can see from tables that if the economic percentage of secondary industry is decreasing, then the electric growth is smaller than the growth of society. Thus to decrease the production output proportion of secondary industry, we should improve the electricity capacity of secondary industry, which can encourage the changing tendency of industry structure.
- 3) We can see from tables that if the economic percentage of tertiary industry is increasing, then the electric growth is larger than the growth of society. Thus to increase the production output proportion of tertiary industry, we should improve the electricity capacity of tertiary industry, which can encourage the changing tendency of industry structure.
- 4) As the electricity capacity of secondary industry takes a greatest percentage of society electricity capacity, the growth of secondary industry electricity capacity should be the smallest to effectively decrease the production output proportion of secondary industry.
- 5) To effectively increase the production output proportion of tertiary industry, the growth of tertiary industry electricity capacity should be the largest.

4.2. Case study in 38 industries: take Zhejiang province as an example

Table 3. The electricity capacity and added value of industries from 2014 to 2016

| Industries | Data | 2016 | 2015 | 2014 |
|-----------------------------------|------------------------------------|------|------|------|
| Coal mining and washing industry | Electricity capacity / billion kWh | 0.01 | 0.02 | 0.01 |
| Coal mining and washing industry | Output value/ billion RMB | 0.25 | 0.30 | 0.33 |
| Black metal mining industry. | Electricity capacity / billion kWh | 0.30 | 0.60 | 0.76 |
| Black metal mining industry. | Output value/ billion RMB | 0.83 | 1.27 | 1.31 |
| Non-ferrous metal mining industry | Electricity capacity / billion kWh | 0.64 | 0.70 | 0.62 |
| Non-ferrous metal mining industry | Output value/ billion RMB | 5.89 | 6.79 | 6.99 |

Based on the history data of 38 industries list in table 3, the production functions of industries can be calculated.

$$F_{sum} = 14.451x_{sum} - 12635 \quad (6)$$

Based on the expert analyses of the growth of 38 industries, we can calculate the future production output value of 38 industries. Then the sum of future electricity capacity of 38 industries can be evaluated by (6), whose result can be seen in table 4

Table 4. The total output value of industries from 2018 to 2020

| year | Output value/ billion RMB | Electricity capacity / billion kWh |
|------|---------------------------|------------------------------------|
| 2018 | 15590.42 | 1953.18 |
| 2019 | 16862.51 | 2041.21 |
| 2020 | 18270.72 | 2138.66 |

Based on table 4, we can see that the growth of electricity capacity from 2017 to 2018 is 7.97%, from 2018 to 2019 is 8.16%, from 2019 to 2020 is 8.35%. To construct a green and economic industries structure, we should make better use of the industries which have higher per unit added value parameter. Three related suggestions on the adjustment of industries structure of Zhejiang province are given below.

- 1) As these industries have higher per unit added value parameters, thus we should make better use of Agricultural and sideline food processing industry, furniture Manufacturing Industry, Medicine manufacturing industry, Metal product industry, Manufacturing of computers, communications and other electronic equipment industry, Instrumentation manufacturing industry, Fuel gas production and supply industry, General equipment industry, Education, industry, Transportation equipment manufacturing industry, Electrical machinery and equipment manufacturing industry and Special equipment industry. The State Grid Zhejiang Electric Power Corporation should provide enough electricity for these industries, as these industries have large per unit added value parameter.
- 2) As these industries have middle per unit added value parameters, thus we should encourage the development of Non-metallic mineral processing industry, Food manufacturing industry, Textile industry, Paper and paper products industry, Printing and recording media reproduction industry, Petroleum processing, Coking and nuclear fuel processing industry, Chemical raw materials and chemical products manufacturing industry, Chemical fiber manufacturing industry and Water production and supply industry.
- 3) As these industries have lower per unit added value parameters, thus we should reconstruct or take control of the development of Coal mining and washing industry, Non-ferrous metal smelting and rolling processing industry, Ferrous metal smelting and rolling processing industry, Black metal mining industry and Non-ferrous metal mining industry, s these

industries have smaller per unit added value parameter, These industries require more electricity to achieve the same growth of economy compared with other industries, which are not beneficial for the economic development of Zhejiang province.

5. Conclusions

The traditional electricity capacity forecasting algorithms is complicated and time-consuming when considering the impact of society economy. Concerning the strong relationship between society economy and electricity capacity, this paper proposes a production-function-based electricity capacity prediction algorithm to detailed analyze the interaction between electricity capacity and economy. This paper divides the electricity capacity into four parts, and deeply divides the secondary industry into 38 industries. Based on the history data of electricity capacity and the economic output values of three major industries and 38 industries, the production functions can be achieved. With the help of future economic output values of three major industries and 38 industries from expert analysis, the future electricity capacity of each electricity type can be calculated. Finally, this paper proposes five related suggestions on the adjustment measures of three major industries structure and three suggestions of 38 industries structure, which is beneficial for the scientific and sustainable development of society economy.

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Reference

- [1] Kuizhong W 2013 Impact analysis of Jilin province's economic and social development on the power company's electricity demand *Jilin University*
- [2] Dan H, Bohong Z, Yong J 2009 Analysis and forecasting for effect of economic factor on electricity consumption *Jilin Electric Power* **37** 16-19
- [3] Kaytez F, Taplamacioglu M C, Cam E, et al. 2015 Forecasting electricity capacity: A comparison of regression analysis, neural networks and least squares support vector machines *Electrical Power and Energy Systems* **67** 431-38
- [4] Shuang Liu, Lixia Tian 2013 The study of long-term electricity load forecasting based on improved grey prediction model *Proc. Int. Conf. on Machine Learning and Computing* (China:Tianjin) 14-8
- [5] Bikcora C, Verheijen L, Weiland S 2018 Density forecasting of daily electricity demand with ARMA-GARCH, CAViaR, and CARE econometric models *Sustainable Energy Grids and Networks* **13** 148–56
- [6] Zhaoguang Hu 2013 Electricity economics *Tsinghua University Press*
- [7] Hui S, Dalin Z, Hongjin L 2010 The estimation of provincial TFP based on production function approach: 1990-2008 *South Economy* **5** 10-3