The Application of Biomass Energy Analysis in Rural Energy Systems Based on a Linear Regression Model

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Abstract. With the development of energy economy, the use of biomass energy gradually into the public view, become more and more widely, the application of biomass energy greatly promoted the utilization of energy, this paper is based on the analysis of biomass energy data in Anhui province, through the linear regression model and time series model, analyzes the utilization of rural biomass energy in Anhui province and the future development prospects. First, this study defines the required model of X and Y variables, including X for total power generation, hydro power installed, thermal power, biomass power plant to total installed, power plant, installed, capacity, fuel consumption eight variables, Y for time, model of data needed from China association for the promotion of industrial development of biomass energy industry branch, with reliability and availability. This study makes a multiple linear regression model. The R-squared value of the regression model was 0.84, indicating a good model fit and a strong predictive power of the independent variables for the dependent variables. While the Prob> F value is 0.0784, indicating that the model is significant at a significance level of 0.1. According to the results, the biomass energy potential and all aspects of the benefits of Anhui Province are comprehensively analyzed.

Keywords: Biomass Energy Analysis, Rural Energy Systems, Linear Regression Model.

1. Introduction

Due to various aspects of limited fossil energy [1] and increasing environmental pollution problems [2], in response to the global energy blank, energy transformation to protect the earth environment [3], especially in 3d scenes [4, 5], the importance of the discovery of renewable energy, biomass energy is a key strategic development direction, energy agency biomass energy executive committee issued the 2021 IEA biomass energy national report shows that in the past decade, the proportion of renewable energy in the global energy consumption increased year by year. Biomass energy accounts for more than half of the renewable energy supply in most countries.

The Fifth Plenary Session of the 18th CPC Central Committee stressed the strategy of accelerating the sustainable energy development and the safe and efficient development of nuclear energy. It also proposed a two-carbon plan to peak carbon in 2035 and carbon-neutral [6] in 2060. Biomass energy, an energy derived from nature, has drawn attention to [7]. Its basic energy comes from the sun, and biomass energy exists in the organic matter of plant [8], animals and microorganisms, which can be broken down by microbial [9].The total supply of biomass energy in China is the first in the world, but the comprehensive utilization efficiency of biomass energy in China is low, which has a huge development potential of [10], among which the utilization of biomass energy in Anhui Province is relatively strong. In addition, Anhui province also has clear plans and policies for the future evaluation and development of biomass energy. The team decided to choose the rural areas in Anhui province as the carrier of the research content. On the basis of in-depth understanding of the current energy utilization structure, biomass energy ratio and biomass energy ratio, it is believed that the utilization of biomass energy in rural Anhui has full development potential. In this study, we hope to use linear regression models to optimize biomass energy utilization in rural energy systems to improve the utilization of biomass energy.

Low sulfur and nitrogen biomass combustion produces small amounts of sulfur and nitrogen oxides, greatly reducing photochemical pollution and effectively reducing the aggravation of

greenhouse effect; in terms of combustion emissions, less carbon dioxide emissions and less oxygen demand than fossil fuels.

The research question (RQ): How to predict the future biomass energy utilization rate from the time series through multivariate variables?

In order to solve this problem, the main contributions of this paper include: (1) the data on biomass energy utilization, involving energy, economic and cultural aspects; (2) based on the known data, the model based on the analysis of multiple linear regression. (3) This paper analyzes the results, and finds that the model fit is good, and the independent variables have a strong predictive ability to the dependent variables.

2. Literature Review

2.1. The research status and development status of biomass energy

With the increasing attention to the community with a shared future for mankind, the global search from biomass energy and other renewable energy sources has become a common action to solve environmental pollution. According to the Chinese Academy of Sciences, in 2017, the global bio-based materials and biomass energy industry scale exceeded us $1 trillion, with the United States accounting for more than 40 percent. The bio economy for 2030 released by the Organization for Global Economic Cooperation and Development (OECD) predicts that bio manufacturing will account for 35% of chemical industrial products; biomass energy is already a large proportion of renewable energy, 30% of 10 years will be replaced for vehicles and other vehicles within 20 years. The total supply of biomass energy in China is the first in the world, but the use of biomass energy is low and has great development potential.

2.2. Time-series model solution algorithm

Mobile averaging was proposed in the 19th to 20th centuries, smoothing the data by calculating the average within a particular window size in the time series and being used to predict future trends. Simple moving average (SMA) and index moving average (EMA) are commonly used moving average methods, which are often used in economic forecasting and stock market analysis.

The auto regression model was proposed by the British statistician G. U. Yule in 1927. The AR model uses the time series' own past values to predict future values. The model establishes an auto regressive equation by fitting the relationship between the lag term and the current value of the time series. It is often used in the fields of energy, social science and economics.

The auto regressive moving average model was proposed in the 1970s by American statisticians George Boas (George Box) and Away Jenkins (Wily Jenkins). The ARMA model combines the characteristics of AR and MA, considering both the auto regressive part of the time series and the moving average part. The ARMA model was built by fitting the auto regressive and moving mean terms of the time series. Often used to analyze and predict time-series data.

The auto regressive integration moving average model was proposed in the 1970s by American statisticians George Box (George Box) and Away Jenkins (Wily Jenkins). The ARIMA model is an extension of the ARMA model, combining auto regressive (AR), difference (I) and moving average (MA), which is used to process non-stationary time series data and predict its future value. It converts the non-stationary time series into stationary time series through differential operation, and then applies the ARMA model to fit.

The state-space model was first proposed by Aiken in 1975, and further developed by Menorah in 1979. The state-space model is a dynamic linear model suitable for processing time-series data. It makes models and predictions using the dynamic properties of state variables by splitting the time series into equations of state and equations of observation.

3. Methodological

3.1. Data profile

In studying the prediction of the future development of biomass energy, this paper follows the principle of data reliability and availability, mainly relying on the Biomass Energy Industry Branch of China Industrial Development Promotion Association, as an official data set, which provides comprehensive and detailed data on biomass energy and other energy sources. Eight sets of data were collected on total installed power capacity, total installed hydro power capacity, total installed thermal power capacity, total installed biomass power capacity, total installed power capacity, total installed power capacity, and fuel consumption in Anhui province from 2014 to 2016, and analyzed and predicted these data.

3.2. Data collection

As shown in Table 1, in evaluating the development of biomass energy and predict the future development trend, this study comprehensives past research, based on the linear relationship between influencing factors and time, set in Anhui province from 2014 to 2016, hydro power total installed, total thermal power, biomass power plant can total installed, power plant, total, capacity, fuel consumption for X, time for Y, linear regression model analysis.

Table 1. The description of data

Factors	Description	2014	2015	2016	Unit
X_1	Total installed power generation capacity	4326	5610.6	5863	Ten thousand kilowatts
X_2	Total installed hydro power capacity	287.9	291.2	293.9	Ten thousand kilowatts
X_3	Total installed thermal power capacity	3723.9	4613	4914	Ten thousand kilowatts
X_4	Total installed capacity of biomass power plant energy	44.6	57	60	Ten thousand kilowatts
X_5	Number of power plants	16	20	21	One
X_6	Total installed capacity	44.6	57	60	Ten thousand kilowatts
X_7	generating capacity	26.8	29.4	18.6	One hundred million kilowatt-hours
X_8	fuel consumption	396	440	278	Ten thousand tons

3.3. Model establishment and solution

Before constructing the model, this study sets the boundary for the biomass energy system in Anhui Province. This paper mainly studies the conversion efficiency of biomass energy to electric energy, and the development prospect of biomass energy conversion into electric energy. The linear regression model and time series model were constructed with Anhui biomass energy generation and time as variables. It has the practical significance of predicting the future development.

Time as variables. It has the practical significance of predicting the future development. Linear regression model is a simple but widely used statistical model for predicting the target variable of numerical type. In linear regression, the model assumes that the target variable (dependent variable) varies with a linear combination of one or more independent variables (explanatory variables). Linear regression models can be either a unary linear regression or a multiple linear regression, depending on the number of independent variables. The structure of the multiple linear regression model is described as follows.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \epsilon, \quad (1)$$

Among:

$X_1, X_2, \cdots, X_n$ are independent variables. $\beta_1, \beta_2, \cdots, \beta_n$ are the coefficients of the respective variables, indicating the degree of influence of each independent variable on the dependent variable. ϵ is the error term.

4. Result Analysis

An R-squared of 0.84 indicates that the model explained 84% of the variation in the dependent variable. Prob> F has a value of 0.933, This seems to be a relatively high p-value, meaning that at a significance level of 0.05, this study may be unable to reject the null hypothesis that the explanatory variable may have no significant effect on the dependent variable.

Table 2. The description of the results

R-squared	Prob > F
0.84	0.0784

As shown in Table 2, R-squared represents the percentage of variation in the dependent variable explained by the model. In this example, the R-squared was 0.84, meaning that the model explained 84% of the variation in the dependent variable. This is a relatively high value, and the model is generally considered to have a good fit when the R-squared is greater than 0.7. This means that the independent variables in the model have a strong predictive power for the dependent variable, and most of the variation in the model can be explained by the independent variables. The F statistic was used to test whether the regression model was significant, where at least one independent variable in the model had a significant effect on the dependent variable.

Prob> F is the p-value corresponding to the F statistic, which represents the probability of the observed F statistic or more extreme value under the null hypothesis (i. e., all independent variables have no effect on the dependent variable). Generally, if the p-value is less than a certain significance level (e. g. 0.05 or 0.1), the null hypothesis is rejected and the model is considered significant, meaning that at least one independent variable has a significant effect on the dependent variable. Prob> F is 0.0784, which means that if the significance level is set to 0.1, the model is significant (because 0.0784> 0.05, but not greater than 0.1). However, if the significance level is set to 0.05, the model may not be significant (because 0.0784> 0.05).

In conclusion, the R-squared value of this regression model was 0.84, indicating a good model fit and the independent variables had strong predictive power for the dependent variable. While the Prob> F value is 0.0784, indicating that the model is significant at the significance level of 0.1, but probably not significant at the significance level of 0.05. This means that the chosen significance level needs to be considered when interpreting the model results.

5. Discussion

As the key material basis for the survival and development of human society, the importance of energy is self-evident and irreplaceable. In particular, biomass energy, as a renewable energy, its position is increasingly prominent in the energy structure. Anhui Province, located in the hinterland of East China, has become a typical big agricultural province in China with its rich agricultural resources and a significant proportion of agricultural products. The total land area of Anhui province is 139,000 square kilometers, among which the cultivated land area is 4.22 million hectares, the woodland area is 3.29 million hectares, the water area is 1.05 million hectares, and the perennial crop planting area is 8 million hectares. Therefore, the biomass resources in Anhui province mainly cons the following three parts: 1. Agricultural resources, 2. Household waste, and 3. Forestry resources. Among them, straw is an important biomass resource in Anhui Province, and its total energy is the same as the total energy of corn and starch. Anhui province can produce about 46 million tons of all kinds of crop straw resources all the year round (relevant data in 2020).

The utilization of biomass energy in Anhui province started relatively early and has achieved certain economic benefits. Anhui province is rich in agricultural resources, and a large number of straw resources can be fully utilized. At present, straw is directly returned to the field and as fertilizer, as high-quality organic fertilizer; also used as feed, feed livestock; also as industrial raw material and rural fuel, on the basis of primary processing mode, the scale of straw industry, industrialization and assembly line production mode has gradually mature.

Chinese forestry biomass resources total about 900 million tons, at least a third can be used as energy utilization, according to the considerable heat equivalent conversion, processing 1.5t forest biomass can replace 0.45t, crude oil or 1 Ice, if the development and utilization of available forest biomass can replace 200 million Ice, equivalent of ten percent of fossil energy consumption in China.

Biomass carbon is a solid substance converted by biomass under the condition of air isolation and heat enhancement. The use of biomass carbon can improve the activity of soil enzymes and promote the increase and emission reduction of greenhouse gases in farmland. It can also influence the soil microbial community structure by its own properties and changing soil hemispherical properties. The influence of biomass energy on the soil in Anhui province is mainly manifested in the improvement of soil physical and chemical properties, the improvement of soil enzyme activity, and the influence of soil microbial community structure.

Biomass energy is a renewable energy source, and the carbon dioxide produced in the combustion process can be absorbed by plants, thus realizing the carbon cycle and reducing greenhouse gas emissions. This will help alleviate the trend of global warming and maintain the ecological environment of Anhui rivers. The use of biomass energy can reduce the dependence on traditional fossil fuels, thus reducing the consumption of water resources. To some extent, it can have a positive impact on the river water in Anhui.

Biomass energy is a renewable energy source that comes from organisms such as plants, animals and microorganisms, or from energy converted from waste from these organisms. Biomass energy can be converted into the energy that this study can use in a variety of ways, such as biomass classification, biomass liquefaction, biomass hydrolysis, etc. Because of its renewable, clean, low and carbon characteristics, it is possible to create a flywheel effect to promote the economic development of Anhui Province. On the one hand, the development of biomass energy industry can promote the development of agriculture, industry and services, increase farmers' income and promote employment; on the other hand, biomass energy can reduce the pollution to the environment, improve the ecological environment, thus attract more investment and talents, and further promote the economic development of Anhui Province.

Biomass energy has a positive impact on environmental protection. By saving energy and reducing carbon emissions, it can have a butterfly effect on the entire ecological environment of the whole earth, such as reducing the startup time of electronic equipment, reducing the brightness, etc., which can help slow down the global warming, weaken the greenhouse effect, and reduce ecological disasters, so as to reduce the possibility of biological extinction.

6. Conclusion

This paper is based on the Anhui power plant and biomass power plant data, studied the biomass development prospects and predict the biomass development situation, biomass capacity as the independent variable build time series, with time as the dependent variable, build a linear regression model with the help of stat linear regression model, and for the variables in the model and the results of the model analysis. It is concluded that the model has a good ability to predict the development trend of biomass energy. It is concluded that the development of biomass energy in Anhui province is rising in the future, which has practical reference significance for the use and development of biomass energy in Anhui Province. It is of great significance to the global energy gap and the energy transition. In the future, this study will go to the energy transformation efficiency of graduate material power plants and improve the conversion and utilization rate of biomass energy.

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