Study on Transformation and Utilization of Agricultural Straw Biomass under Green Development Concept

Yujie Wang

High School Affiliated to Nanjing Normal University, Nanjing, Jiangsu, 210003, China

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Abstract: The accumulation of straw is increasing, the technology of comprehensive development and utilization of straw in rural areas is relatively backward, and the speed and quantity of scientific transformation of straw are slow, which leads to the burning of a large number of straw in the field. With the further deepening of the concept of sustainable development in China, people's awareness of saving and utilizing energy resources is also increasing. In view of the surplus straw resources, farmers in many countries prepare for the next cultivation by burning in the field. Transforming straw into biomass energy for utilization is an important measure to turn waste into wealth, which closely conforms to the current concept of sustainable development and is an important measure to realize the economical utilization of energy resources. Straw conversion into biomass energy is an important way of sustainable development. In this paper, the status quo and influencing factors of straw to biomass energy utilization under the concept of green development were analyzed, and the utilization direction and development strategy of straw conversion into biomass energy were explored in detail, hoping to play a certain enlightenment role in the development of biomass energy utilization.

1. Introduction

A large number of crop straws have gradually evolved into wastes because they cannot be effectively utilized. The accumulation of straw is increasing, the technology of comprehensive development and utilization of straw in rural areas is relatively backward, and the speed and quantity of scientific transformation of straw are slow, which leads to a large number of straws being burned in the field [1]. It not only pollutes the environment and endangers people's health, but also is filled with smog, which affects land traffic and flight safety [2]. Crop straw is the main by-product of agricultural production and an important resource of industrial and agricultural production. To solve the present situation of straw development and utilization, it is necessary to fundamentally solve the problem of straw development and utilization [3]. In view of the surplus straw resources, it is a common practice for farmers in many countries to prepare for the next cultivation by burning in the field. Transforming straw into biomass energy for utilization is an important measure to turn waste into wealth, which closely conforms to the current concept of sustainable development and is an important measure to realize the economical utilization of energy resources [4]. Efficient transformation and utilization of agricultural straw can not only overcome the limitation of low utilization efficiency and serious environmental pollution caused by traditional utilization methods, but also replace the gradually decreasing fossil-based materials with its transformed biomass materials [5]. Conversion of straw into biomass energy can not only save resources and energy, but also avoid emission pollution and damage to ecological environment [6].

Resources and energy are the material basis for human survival. However, the traditional economic development model is a “one-time consumption” society which is closely dependent on mass production, mass consumption and mass abandonment of resources and energy, resulting in the rapid consumption of non-renewable resources such as coal, oil and natural gas, and also bringing irreparable damage to the ecological environment [7]. Agricultural straw biomass is rich in cellulose, hemicellulose and lignin, which can be converted into renewable biofuels and high value-added chemical products by biochemical transformation technology [8]. Grass-grain ratio of crops is an empirical value obtained by field observation or experimental analysis, which has great

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uncertainty and will be different due to different regions, crop varieties and measurement methods [9]. In order to alleviate the global energy crisis and solve the problem of environmental pollution, it is of great significance to make full and rational use of agricultural straw biomass and natural resources of crop straw for the development of contemporary agriculture and environmental protection, and to reduce the use of food and oil resources. In this paper, the utilization status and influencing factors of straw-to-biomass energy under the concept of green development were analyzed, and the utilization direction and development strategy of straw-to-biomass energy were explored in detail.

2. Current Situation and Influencing Factors of Biomass Energy Utilization by Straw Conversion

2.1 Current Situation of Biomass Energy Utilization by Straw Conversion

Straw, as a direct fuel, converts the heat energy of straw combustion into electric energy, thus promoting the continuous innovation of straw power generation technology. In order to make full use of and improve the efficiency of straw direct combustion, many combustion devices have been put into operation in some countries, which have gradually commercialized and greatly met the market demand. Straw biomass has various functions, and can be used as feed, fuel and biological base material. The utilization of straw biomass mainly includes comprehensive utilization of straw in the field of cultivation and planting, rapid decomposition and return of straw to field, production of high-quality feed and edible fungi, etc. Straw has greatly improved the benefit of industrial production because of its rich resources and low cost. However, due to the easy crystallization of cellulose in straw, the overall chemical activity of cellulose molecules is not high, and it is difficult to have chemical reaction [10]. Comprehensive utilization of straw is an important national policy measure. In order to speed up the comprehensive utilization of straw, our country has promulgated a series of policies and regulations in recent years, which promoted the rapid development of straw utilization. With the gradual reduction of fossil resources such as petroleum, it is becoming a new development trend to obtain new materials, chemical raw materials, energy, functional foods and medicines from renewable resources such as agricultural straw and supplement non-renewable resources such as fossils.

2.2 Influencing Factors of Biomass Energy Utilization by Straw Conversion

The special physical and chemical properties of straw inhibit its development and application as an industrial raw material, so it is necessary to properly pretreat straw. However, the high cost and high energy consumption brought by pretreatment make it lose its popularization value. The utilization and development of straw into biomass energy is greatly limited due to various factors. Supercritical fluid can be used for hydrolysis and saccharification of wood and cellulose materials. Under supercritical or subcritical conditions, water itself is highly ionized, which can be used as an acid catalyst to catalyze the conversion of cellulose. From the perspective of economic factors, although straw resources are abundant, it is very difficult to carry out centralized treatment, while the efficiency of decentralized treatment is relatively low and the cost is high, which is an important factor for the large-scale utilization of straw into biomass energy. The factors affecting carbon emissions are divided into four categories: energy structure, energy intensity, industrial structure and economic scale. The decomposition model can be expressed as:

$$C^t = \sum_{i=1}^{7} ES_i^t \times EE^n \times TG^t \times GDP^t \quad (1)$$

Among them, ES represents the share of various types of energy consumption each year, EE represents the energy consumption per unit output per year, YG represents the annual GDP percentage, and GDP represents the regional gross product.

Let C^0 represent the carbon emissions in the base period, and the change in the emissions in year

t relative to the base period is:

$$\Delta C_{tot} = C^t - C^0 = \Delta C_{ES} + \Delta C_{EE} + \Delta C_{YG} + \Delta C_{GDP} \quad (2)$$

Biomass raw materials are placed in microwave energy field. With the periodic oscillation of microwave frequency, these polar molecules are continuously and uniformly fused with other reactant molecules, during which violent collision and friction of various molecules are triggered, and the whole thermal movement is triggered by the mutual transmission of kinetic energy. Among the factors affecting the utilization of biomass energy from straw conversion, technical factors are more critical, and the lack of technology will inevitably directly affect the utilization of biomass energy. Straw cellulose content is high, and it is not easy to crush, which increases the difficulty of reuse. If it cannot be effectively broken through from the technical level, it will inevitably affect the utilization and development of straw into biomass energy.

3. Strategies of Agricultural Straw Biomass Conversion and Utilization

As a renewable energy, biomass energy is the fourth largest energy after coal, oil and natural gas, and occupies an important position in the whole energy system. There are several important directions for straw to transform biomass energy for utilization, and power generation through straw to transform biomass energy is an important development direction in the future. Compared with fossil energy, biomass has less environmental pollution in the combustion process, which belongs to clean energy and contributes to national environmental construction and CO2 emission reduction. CO2 emitted during biomass production and energy utilization can be incorporated into the natural carbon cycle, realizing zero CO2 emission, which is the most important way to reduce CO2 emission. Power generation by straw burning is carried out on the basis of no secondary pollution. After treatment, it is burned centrally, and heat energy is generated by straw burning [11]. This way can effectively alleviate the shortage of coal resources in China, and can also increase farmers' income in this way. In the preparation process, the early modification and hydrolysis of straw is an important link, and how to improve the conversion rate and reduce the cost are the main considerations. Pretreatment and hydrolysis must be carried out to destroy the entanglement of lignin and the crystalline structure of cellulose, so that it can be hydrolyzed under the action of solvent, catalyst or enzyme [12]. Semi-cellulose molecules with relatively complete structure can be separated under weakly oxidized and slightly alkaline environment, and the separation process is clean. Although the yield of each component after separation needs to be further improved, it is possible to realize effective separation of components.

The government conducts carbon verification for enterprises participating in the carbon trading mechanism. In time period t, the calculation formula of CO2 emission of enterprise j in department I is as follows:

$$E^c_{i,j,t} = \frac{11}{3}\sum_{n=1}^{6} a_n b_n c_n F_{n,i,j,t} \quad (3)$$

Among them, $E^c_{i,j,t}$ is the carbon emission of enterprise j in the production sector i during the t period, and a_n, b_n, c_n and $F_{n,i,j,t}$ are the conversion factor of energy n used by the enterprise, the oxidation rate of carbon emission factor and the consumption.

Higher emission reduction targets encourage companies to increase their emission reduction efforts, increase the demand for carbon allowances, and increase the total amount of carbon allowances that can be allocated to the market, thereby reducing the market clearing carbon price. Calculate the total industrial energy consumption in each province. Calculated as follows:

$$MIEC_{it} = \frac{MIAV_{it} \times EC_{it}}{GDP_{it}} \quad (4)$$

Among them, i and t are provinces and years respectively, $MIEC_{it}$ is the total industrial energy consumption, $MIAV_{it}$ is the sum of industrial added value, GDP_{it} is the regional GDP, and EC_{it} is the total regional energy consumption.

$$C_{it} = MIEC_{it} \times UC_{it} \quad (5)$$

The development of straw into biomass energy and gas is more important. The principle of straw gas is to use biogas technology and pyrolysis gasification technology to convert it into combustible gas and become green and clean energy. The utilization and development of straw-transformed biomass energy needs corresponding strategic support and policy support [13]. At present, the country has formulated a series of laws and policies for the comprehensive utilization of straw, which has promoted the rapid development of straw utilization. Because of its cost and technical factors, the preparation of biodiesel from straw cannot completely replace petroleum fuel. Therefore, more efforts should be put into in-depth research on the reaction mechanism, reaction equipment and application technology of bio-oil.

4. Conclusions

With the gradual reduction of fossil resources such as petroleum, it is becoming a new development trend to obtain new materials, chemical raw materials, energy, functional foods and medicines from renewable resources such as agricultural straw and supplement non-renewable resources such as fossils. China's abundant crop straw biomass resources contain huge energy, and the non-renewable and scarce resources such as oil provide necessary development conditions for the research and utilization of straw. Using abundant agricultural straw biomass to produce energy and high value-added chemicals to supplement or replace petroleum chemicals can turn waste into wealth, reduce environmental pollution and bring considerable economic benefits. Among the factors affecting the utilization of biomass energy from straw conversion, the technical factor is the key, and the lack of technology will inevitably directly affect the utilization of biomass energy. At present, there are still many aspects to be strengthened in the utilization of straw into biomass energy in China, and it is necessary to increase support from technical and economic aspects. While continuously improving the process and equipment for preparing combustible gas and combustible liquid from straw and improving the utilization rate, pushing biomass straw to industrial raw materials with high added value is the inevitable direction of new organic material synthesis industry in the future.

References

[1] Ma Xiaoxuan, Cai Hongzhen, Fu Peng, et al. Analysis of resource disposal approaches of agricultural solid waste straw in China[J]. Journal of Ecological Environment, vol.25, no.001, pp.168-174, 2016.

[2] Asomaning J, Haupt S, Chae M, et al. Recent developments in microwave-assisted thermal conversion of biomass for fuels and chemicals[J]. Renewable & Sustainable Energy Reviews, vol.92, no.9, pp.642-657, 2018.

[3] Zhang Yixuan, Fu Tongcheng, Zhou Fangyuan, et al. Evaluation of Economic Benefits of Waste Biomass Energy Utilization in China[J]. Progress in Electric Power and Energy, vol.008, no.002, pp.38-47, 2020.

[4] Song Yuyao, Li Xianchun, Arash Tahmasebi, et al. Experimental study on co-pyrolysis of bituminous coal and biomass in a fixed bed[J]. Coal Conversion. vol.38, no.004, pp.16-21, 2015.

[5] Hemsworth G R, Johnston E M, Davies G J, et al. Lytic Polysaccharide Monooxygenases in Biomass Conversion[J]. Trends in Biotechnology. vol.33, no.12, pp.747-761, 2015.

[6] Ma Bobo, Huang Ruilin, Zhang Na, et al. Effects of straw biomass charcoal on the molecular ecological network of rhizosphere soil bacteria-fungi communities[J]. Acta Pedologica Sinica. vol.56, no.004, pp.964-974, 2019.

[7] Zhang Ting, Wang Xudong, Pang Mengwen, et al. The effect of combined application of biomass charcoal and straw on the conversion of soil organic carbon[J]. Environmental Science.

vol.3, no.006, pp.2298-2303, 2016.

[8] Heroguel F, Rozmyslowicz B, Luterbacher J S. Improving Heterogeneous Catalyst Stability for Liquid-phase Biomass Conversion and Reforming[J]. Chimia. vol.69, no.10, pp.582-591, 2015.

[9] Xu Luwei, Wang Xudong. The effect of biomass charcoal on nitrogen transformation during vegetable waste composting[J]. Journal of Agricultural Resources and Environment. no.35, pp.1160-1166, 2016.

[10] Xu Renzhi, Zhao Baowei, Ma Fengfeng, et al. The effect of different biomass charcoal on the properties of lead-contaminated light gray calcite soil and the change of lead form[J]. Journal of Agro-Environmental Sciences, vol.35, no.03, pp.455-462, 2016.

[11] Xu Renzhi, Zhao Baowei, Ma Fengfeng, et al. The effect of different biomass charcoal on the properties of lead-contaminated light gray calcite soil and the change of lead form[J]. Journal of Agricultural Environment Sciences, vol.035, no.003, pp.455- 462, 2016.

[12] Liu Guohua, Zhuo Yuxin, Zhang Tao, et al. Process conditions optimization of ethanol production from biomass based on acid catalysis[J]. Environmental Engineering Science. vol.14, no.06, pp.244-253, 2020.

[13] Tang Qingjie, Lian Jiajia, Chen Ruiping, et al. Research on the co-carbonization process of biomass and coal[J]. Coal Conversion. vol.38, no.001, pp.79-81, 2015.