BIOMASS ANALYSIS OF RESOURCE UTILIZATION SYSTEM

by

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This paper uses the biomass of livestock, poultry manure and straw to study the resource utilization and integration technology by division and classification. The SPSS regression analysis and integration were applied to analyze the economic benefits of the base period (2018) and the audit period (2020). The analysis gives an opportunity in rural areas to reduce chemical fertilizers, pesticides, electricity and coal cost in planting, and this paper opens a novel window for utilizing renewable energy resources and reducing carbon dioxide emissions.

Key words: *biomass energy, resource utilization, application scheme, economy, technical model*

Introduction

With the aggravation of global warming [1], it has become the hottest topic in both the academic and industrial communities to utilize renewable energy resources and to reduce CO_2 emissions.

Livestock and poultry manure and straw are the widely accessible biomass, and much attention has been paid on the efficiency of the biomass resource utilization system. Herrero *et al*. [2] studied systematically biomass use, production, feed efficiencies, and GHG emissions from global livestock systems. Bridgeman *et al.* [3] found that torrefaction of straw can enhance solid fuel qualities and combustion properties. Binod *et al.* [4] discussed the available technologies for bioethanol production using rice straw. Castells *et al.* [5] studied the kinetic properties of biomass pyrolysis. Koul *et al.* [6] concluded that the microbial electrolysis cell (MEC) is an efficient method for waste-to-product conversion. Ferrone *et al.* [7] conducted research and related experiments on building material to maximize in situ resource utilization (ISRU).

Though energy harvesting technologies [8, 9] were widely used in engineering, now the interest was changed to biomass energy conservation and rational utilization of energy [2-7], and much achievement was obtained, however, there is still much space to further improve the conservation efficiency and optimize the utilization process.

This paper focuses itself on the biomass analysis in Longnan area of China to propose an effective application scheme of resource utilization and integration technology in partition and classification. Through SPSS regression analysis and data integration [10, 11], the economic benefits of the base period (2018) and the audit period (2020) were analyzed, and five in-situ and nearby resource utilization models (livestock and poultry manure + straw) were proposed. It

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was helpful for rural areas to promote the combination of planting and breeding and rural ecological revitalization, with a view to reducing air pollution and fossil energy consumption.

Application analysis of resource utilization

The SPSS regression analysis is used to study the biomass energy resource utilization in Longnan area of China, and the theoretical data were integrated to explore the scale of biogas digester construction (pool capacity), the optimal ratio of livestock and poultry manure to straw in the mixed fermentation raw materials, the composting time and other influencing factors, so that various biomass resources all over the rural areas can be fully utilized. The rational utilization of resources in situ and nearby is helpful to promote the combination of planting and breeding and rural ecological revitalization, and to reduce air pollution and fossil energy consumption. According to the actual situation of the integration of traditional energy and renewable energy in Longnan region, the characteristics of local resources and the need to use energy in a coordinated manner, a scheme for zoning and classification of resource utilization was proposed to analyze the difference in economic benefits between the base period (2018) and the audit period (2020) in Longnan region.

Considering the biogas pool construction scale in base period (2018), the pool capacity was small, the mixed fermentation raw material ratio was not clear, and neither partition, nor classification was applied; while the audit period (2020) followed the audit rectification plan to use local, nearby rational utilization of resources.

The audit period (2020) was to build the combination and deployment of biogas pool through partition, classification and comprehensive utilization as shown in fig. 1. Among them, CASE-1 and CASE-2 areas were agricultural picking gardens, CASE-3 and CASE-4 areas were walnut gardens, CASE-5 and CASE-6 areas were public bathrooms, CASE-7 and CASE-8 areas were vegetable greenhouses, CASE-9 and CASE-10 areas were used for farmers' daily life.

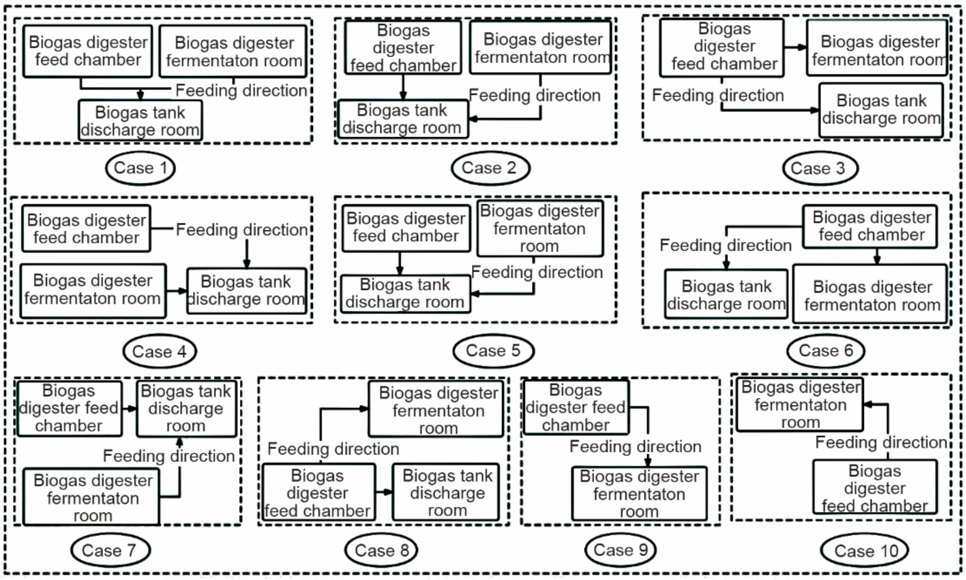

Figure 1. Case mode of partition, classification and comprehensive utilization of biogas pool construction

Annual gas production comparison

According to the field survey data of Longnan area, through SPSS analysis and integration, the comparison of the schemes of resource utilization in the audit period (2020) and the base period (2018) revealed that the gas production in the second and third quarters was significantly higher than that in the first quarter, while the gas production in the first quarter was slightly higher than that in the fourth quarter. In addition, the suitable demand for the end of the grid in Longnan area was studied and analyzed under two typical conditions.

The construction scale and capacity of the biogas digester were same, while the *livestock and poultry manure + straw* model was different. In the base period (2018), the *livestock and poultry manure + wheat straw* model was used in the second and third quarters for co-fermentation gas, while the *livestock and poultry manure + corn straw* model in the first and fourth quarters. In the audit period (2020), the *livestock and poultry manure + wheat straw* model was used in the first and fourth quarters, while the *livestock and poultry manure + corn straw* in the second and third quarters.

The comparative analysis of the average gas production and temperature of the four quarters (I, II, III, and IV) from the base period (2018) to the audit period (2020) is shown in fig. 2. In different seasons, the *livestock and poultry manure + straw* models were different, and the comparative analysis of co-fermentation gas production and biogas residue margin is shown in fig. 3.

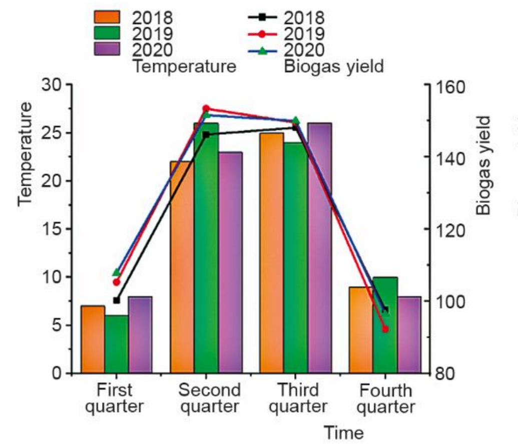

Figure 2. Comparative analysis of biogas digester fermentation temperature and gas production in the fourth quarter of 2018-2020

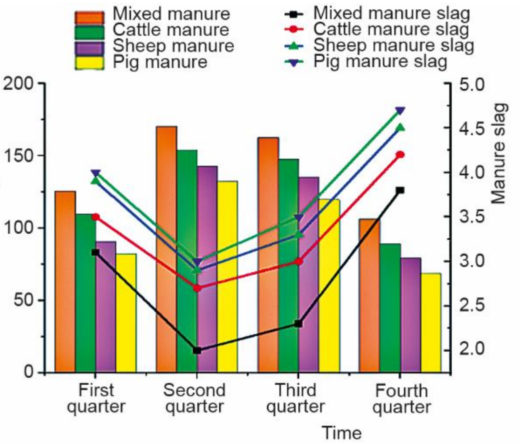

Figure 3. Different quarters, different types of *livestock and poultry manure + straw*, comparative analysis of co-fermentation gas production and biogas residue margin

According to fig. 2, temperature and gas production were roughly positively correlated. The higher the average temperature, the more gas production. The temperature in I and IV quarters was lower and the gas production was less. It can be seen from fig. 2 that when the temperature was lower than 10 °C, the minimum gas production during the integration period was only 69.5 m^3, accounting for 45.04% of the maximum gas production. With the gradual increase of the average temperature, the biogas production also increased rapidly, and the maximum gas production was about 154.3 m^3. When the temperature rose to more than 25 °C, the biogas production decreased slowly. Through SPSS regression analysis and data integration, the gas production in the first, second and fourth quarters increased by about 6.7%, 4.1%, and 2.5%, respectively, while the gas production in the third quarter was basically the same, with a slow increase of about 0.6%.

From fig. 3, it can be seen that at the same fermentation temperature, the mixed raw materials *livestock and poultry manure + straw* models were diverse, and the gas production effect is more obvious. The biogas residue margin gradually decreases with the increase of gas production. The results showed that the highest gas production in the same gas production cycle was about 153.2 m^3, and the gas production in the fourth quarter was low, about 86.3 m^3. Among the single *livestock and poultry manure + straw* model, the *cattle manure + straw* manner had better fermentation effect, The *sheep manure + straw* manner took second place, and the *pig manure + straw* manner had poor biogas production. In the audit period (2020), the mixed raw materials *livestock manure + straw* model were considered and the fermentation program was deployed, the second quarter saw the gas production peak of 175.6 m^3 and the biogas residue margin of only 1.9 m^3. Compared with the *cow manure + straw* manner, the *sheep manure + straw* manner and the *pig manure + straw* manner, the gas production showed an increasing trend, accounting, respectively, for 12%, 20%, and 30% of the total gas production, while the biogas residue showed a decreasing trend, accounting, respectively, for only 8%, 13%, and 21% of the total biogas residue.

Longnan regional economic benefit research

Farmers with a biogas digester construction scale and a pool capacity of 5.8 m^3 were studied. According to the field survey data in the audit period (2020), compared with the base period (2018), farmers' purchase of various energy was reduced by about 419.5 Yuan, and the direct income was about 795 Yuan. The annual expenditure of farmers in the base period (2018) and the audit period (2020) is shown in fig. 4. The case model application of farmers fruit and vegetable greenhouse can realize the increase of crop yield, improve the economic benefits of farmers. At the same time, the application of biogas fertilizer in vegetable greenhouses and agricultural industrial parks can not only reduce the soil pollution caused by chemical fertilizers, but also increase vegetable production, reduce the expenditure of coal and electricity costs and the input of chemical fertilizers and pesticides. Different biogas fertilizers on industrial park production are shown in fig. 5. Relative to the use of agricultural fertilizers, biogas fertilizers on fruit and vegetable production rate are shown in fig. 6.

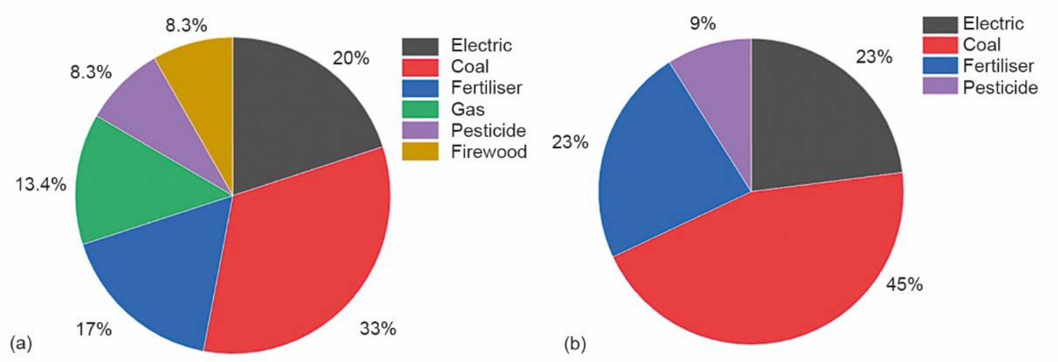

Figure 4. Annual expenditure of farmers in base period (2018) and audit period (2020); (a) base period (2018) annual expenditure and (b) audit period (2020) annual expenditure

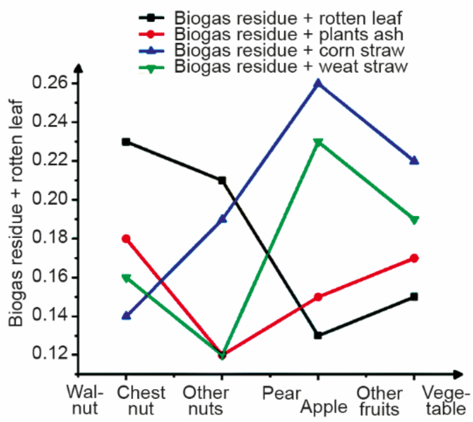

Figure 5. Increasing rate of fruits and vegetables in industrial park by different biogas manures

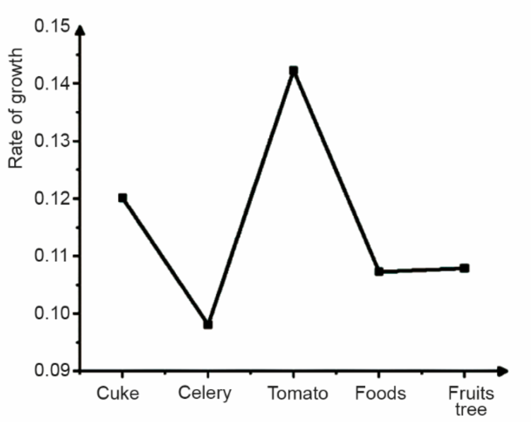

Figure 6. The yield increase rate of fruits and vegetables relative to agricultural chemical fertilizer and biogas fertilizer

Biogas pools are constructed for production of biogas, which can be used for everyday life use. While the biogas slurry and the biogas residue can be composted to field to increase fruit and vegetable production. From fig. 4, it can be seen that based on statistical data, during the audit period (2020), compared with the base period (2018), the energy costs purchased by farmers were reduced by about 419.5 Yuan, and the direct income was about 795 Yuan, saving fertilizer and pesticide by13.3%, electricity and coal cost by 28.3%, and gas and firewood cost by 21.7%.

It can be seen from fig. 5 that different biogas fertilizers have different effects on the growth rate of different fruit and vegetable gardens. For example, the biogas residue and the rotten leaf compost are more suitable for peach orchards and nut orchards, which can increase the yield of nuts such as walnuts and chestnuts by about 23%, and other nuts by about 21%. Research found that the biogas residue and the straw compost can make apples, pears and other fruits increased by about 24%, other fruits and vegetables increased by about 17%. According to fig. 6, the construction of the *livestock and poultry manure + straw* model can comprehensively utilize the biomass resources. According to local conditions, it was conducive to promoting fruit and vegetable production, and to change the mode of agricultural development, finally to increase farmers' income by a suitable planting and breeding combination, rational distribution, and construction of biogas. The results showed that the yield increase of fruits and vegetables in the audit period (2020) compared with the base period (2018) is as follows: 12.10% for cuke, 9.81% for celery, 14.23% for tomato, 10.73% for crops (wheat, corn) and 10.79% for other fruits and vegetables.

Construction of resource utilization system

According to the circular economy for sustainable development and externality [12], the *livestock and poultry manure and straw* model was used in Longnan area, and the resource utilization was carried out by division and classification, which is helpful to enrich the economy theory related to agricultural economic management and resource environmental economics, and to establish a dynamic economical model [13]. The resource utilization system of the *livestock and poultry manure and straw* model in Longnan area is shown in fig. 7.

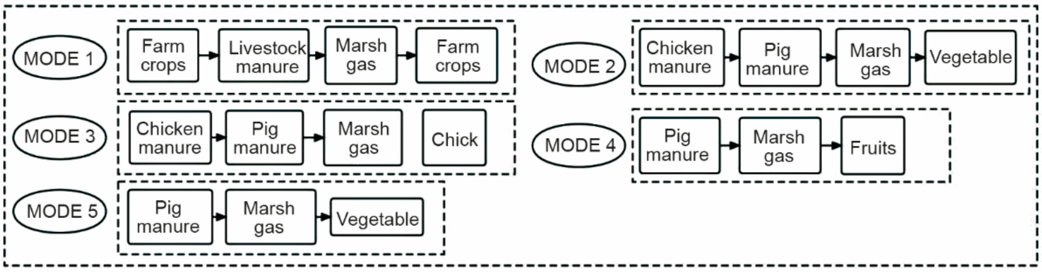

Figure 7. Resource utilization system of *livestock manure and straw*

Resource utilization mode 1. It is suitable for farmers who have been raising livestock and growing crops for many years. Crop straw is used as feed for livestock and poultry, and livestock and poultry manure are mixed with crop straw as raw material for biogas fermentation. The biogas produced by the biogas digester can be used for lighting, heating and cooking, while biogas slurry and biogas residue can be fertilized and returned to the field.

Resource utilization mode 2. Investment is relatively small, it is easy to manage and suitable for most farmers. The chicken house is built next to the pig pen, and a biogas digester is constructed near to the chicken house and the pig pen. The chicken manure and the pig manure can be used for biogas digester fermentation, biogas can maintain the daily life of farmers and the biogas fertilizer can be used for planting vegetables and other crops.

Resource utilization mode 3. This mode is suitable for farmers in chicken farms with simple construction and less investment. The biogas digester is built next to the chicken house and the pig pen. The chicken manure and the pig manure are used for fermentation in the biogas digester. After fermentation, the biogas residue and the biogas slurry can be used to fertilize crops, and the generated biogas can be heated to incubate chickens and provide farmers with normal life.

Resource utilization mode 4. It is suitable for farmers to grow fruit trees while raising pigs. The pig manure is used as raw material for biogas fermentation. The biogas can be used for heating and lighting. The biogas residue and the biogas slurry can be used as fertilizer for planting fruit trees.

Resource utilization mode 5. It is suitable for most farmers. The pig manure produced in the piggery is used as the raw material in the biogas fermentation process. The biogas can be for heating, cooking and illuminating. The biogas residue, the biogas slurry and the straw can be combined to make biogas fertilizer to plant crops.

The fermentation time plays a decisive role in the fermentation of biogas. Figures 8 and 9 show the comparison of the impact of the co-fermentation time of cow dung and wheat straw in the audit period (2020) and the base period (2018).

From figs. 8 and 9, it can be seen that biogas production increased with the increase of days, and the 25^{th} day sees the peak of 1.28 m^3. After the 25^{th} day, biogas production began to decline slowly, and the gas production on the 30^{th} day was 1.13m^3. The amount of biogas residue decreased with the increase of fermentation days. According to SPSS regression analysis and data integration, compared with the base period, the annual gas production increased by 80 m^3, and the gas production rate increased by about 20%, which brought economic benefits to farmers about 13%.

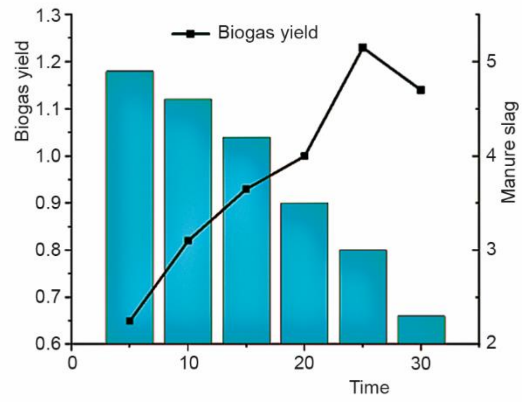

Figure 8. Co-fermentation of cow dung and wheat straw for 30 days (2020)

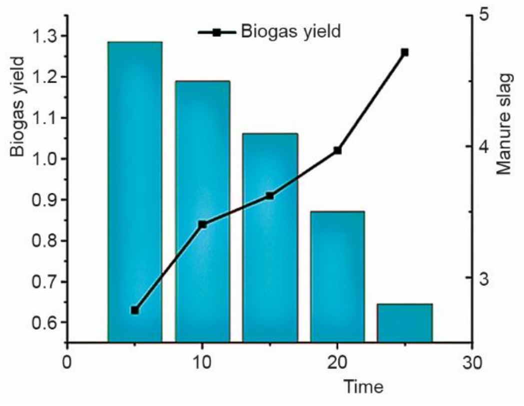

Figure 9. Co-fermentation of cow dung and wheat straw for 25 days (2018)

Conclusions

Based on the implementation of resource utilization in Longnan region of China, the comparative analysis was conducted between base period (2018) and audit period (2020). The results showed that chemical fertilizers and pesticides were reduced by 13.3%, electricity and coal costs were reduced by 28.3%, and gas and firewood costs were reduced by 21.7%. The yield increase of fruits and vegetables was as: 12.10% for cuke, 9.81% for celery, 14.23% for tomato, 10.73% for crops (wheat, corn), and 10.79% for other fruits and vegetables.

This study proposed 5 *livestock and poultry manure + straw* models for analysis of the in-situ and nearby resource utilization, it opens a total new window for reducing air pollution and fossil energy consumption in rural areas in China.

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