 DOI: 10.19601/j.cnki.issn1943 - 9903.2019.7.008

Application of Biogas in North China

Zhimin WEI[1,2,3], Shijia SONG[1,2,3], Xinyu WANG[1,2,3], Wei LU[4], Haiyan JIA[1,2,3]*, Shunguo LI[1,2,3]*

1. Institute of Millet Crops, Hebei Academy of Agricultural and Forestry Sciences, Shijiazhuang 050035, China; 2. Laboratory of Cereal Crop Research of Hebei Province, Shijiazhuang 050035, China; 3. National Millet Improvement Center, Shijiazhuang 050035, China; 4. National Engineering Research Center of Semi - arid Agriculture, Shijiazhuang 050000, China

Abstract Energy issues are an important part of the agricultural system, and they are closely related to rural production and peasant life. The state of rural energy development plays an important role in the development of rural ecology, economy and society in China, and is also an important indicator of the sustainable development capability of China's agriculture. This article analyzes the principle of the rural energy-ecology model in the north and its role in the sustainable development of agriculture, and puts forward some views on its existing problems.

Key words Four in one, Energy, Biogas, Agricultural sustainability

1 Introduction

Agricultural systems engineering is a complex system that includes multiple subsystems of agricultural production, management, energy, environment and education. Any change in the subsystem will cause a change in the entire system. Rural energy is a special field that not only affects other subsystems, and is also subjected to other subsystems. China's rural population accounts for about 56% of the total population, and their consumption for energy is very large. In order to reduce air pollution in recent years, most rural areas in North China have abandoned coal burning, which has been replaced by natural gas, but the use of natural gas for heating and cooking increases the cost of living for farmers. Therefore, studying rural energy construction is of great significance in solving rural energy shortages, protecting the ecological environment, improving the quality of life, and promoting the sustainable development of rural areas. In particular, it has good promotion significance for the "Northern Rural Energy-Ecology Model" (hereinafter referred to as the "four-in-one")[1].

2 Principle of "four-in-one"

The four-in-one model is the "two-high and one excellent" agricultural production model created by the unremitting research of agricultural science and technology personnel in Liaoning Province and the repeated practice of farmers in the past ten years. It is the growth point of the rural economy. It is a comprehensive utilization body that integrates livestock pen, toilet, solar greenhouse and biogas digester with solar energy as the driving force and biogas as the link, based on land resources (Fig. 1).

By building a solar greenhouse facing south, a 20-m^2 livestock pen, a toilet and an 8-m^2 biogas digester in the greenhouse, a closed system is formed. The four-in-one model makes full use of solar energy resources to provide suitable temperature conditions for plant growth and biogas fermentation in the greenhouse, and changes the defect of biogas in northern China that can only be used for half a year and is prone to breezing, thus ensuring gas production throughout the year. Hunan and animal manure enter the biogas digester in time, solving the problem of supply of biogas fermentation raw materials and purifying the environment. The biogas digester provides abundant organic fertilizer for the production of the greenhouse. The vegetable solar greenhouse and the connected livestock pens form a complement of oxygen and carbon dioxide. At the same time, the situation that livestock spend lots of energy on resisting cold in winter, leading to slow body weight gain is changed, and the cycle of production is shortened, improving economic efficiency. In this model, simultaneous production of gas and fertilizer and combination of planting and breeding is realized on the same piece of land, with sound biological chain structure and faster circulation of energy and materials.

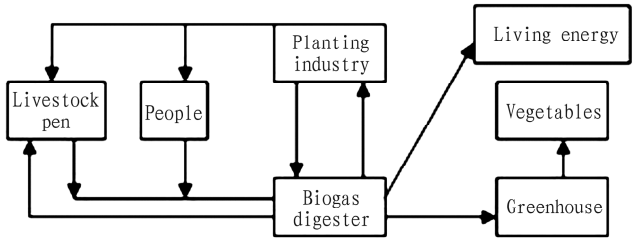

Fig. 1 Schematic diagram of four-in-one model

The system consists of four subsystems: primary producers (*i. e.* crop and vegetable producers), secondary producers (*i. e.* livestock and poultry), decomposers (*i. e.* purification and utilization of fecal sewage or biogas engineering) and consumers (*i. e.* farmers and the society). Biogas engineering is the central link of energy conversion material recycling of the system and comprehensive utilization of organic waste, and is the link between primary and secondary producers, decomposers and consumers, playing a key role in establishing the dynamic balance of the input and output of the ecological agricultural production system[2].

Received: March 19, 2019 Accepted: July 1, 2019
* Corresponding author. E-mail: lvwei91@126.com; 19667986@qq.com

3 Effectiveness of the "four in one" model in the sustainable development of agriculture

The promotion of the four-in-one model has achieved remarkable results in North China. It has played a positive role in the local ecological environment and promoted economic development (Fig. 2).

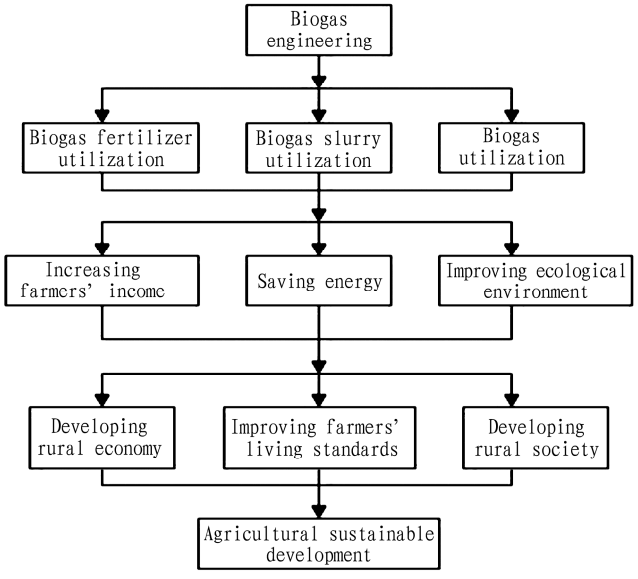

Fig. 2 Effectiveness of four-in-one model

3.1 Promoting a virtuous cycle of ecological environment and improving the quality of agricultural products Direct burning of firewood and straw not only destroys vegetation, causing soil erosion, but also produces a large amount of smoke due to insufficient combustion, polluting the environment and affecting human health. Biogas is a clean and hygienic fuel that burns completely at temperature up to 1 400℃. The remaining gases area H_2O and CO_2, and no harmful substances such as smoke are generated. Burning biogas also reduces deforestation of forests and promotes ecological protection and improvement[3].

Livestock and poultry manure sewage is both a serious source of pollution and a valuable resource. It is estimated that the volume of pollutants produced by a 10 000-pig farm is equivalent to that of a town with a population of 50 000. The harmless treatment of livestock and poultry manure sewage, that is, pouring them into the biogas digester for fermentation, not only removes organic pollution, purifying the environment but also clears many places where pests and diseases are born, greatly reducing the incidence of diseases. At the same time, biogas fermentation can kill most of the pathogens and their larvae.

The problem of pesticide residues in agricultural products has reached a panic level, seriously hindering the export of agricultural products. Although the relevant departments have been vigorously advocating the promotion and use of high-efficiency, low-toxicity and low-residue pesticides, due to various reasons, the promotion work is very difficult. Biogas slurry can kill pathogenic microorganisms on the surface of seeds to enhance the disease resistance of seeds. Biogas slurry contains antibiotics, which can be sprayed on the foliage of plants to prevent certain pests and diseases, and have strong disease resistance, thereby achieving the purpose of increasing production and improving quality. Thus, pollution-free vegetables and green food are produced[4].

The use of biogas fertilizer not only saves fertilizer but also reduces costs. Moreover, it has changed the physical and chemical properties of the soil, improved the soil fertility, and enhanced the stamina of agricultural development. The biogas digester in the solar greenhouse can produce gas all the year round, and farmers use biogas as living fuel, saving a lot of firewood and straw resources that can be converted into feed and used for returning to the field, further promoting the development of animal husbandry and increasing soil organic content.

3.2 Promoting economic development According to the survey, on average, each "four-in-one" model can produce 8 pigs, 900 kg of anti-season vegetables, 360 m^3 of biogas and 18 m^3 of biogas slurry per year, increasing the net income of farmers by 6 000 yuan. As natural gas is not used throughout the year, about 800 yuan of natural gas cost is saved. Biogas slurry and biogas residue can be used as green pesticides and high-quality organic fertilizers. They can reduce the pesticide use in vegetables, flowers and crops by 80% –90%. The amount of pesticides and chemical fertilizers reduced by biogas residue and biogas slurry is equivalent to saving 9 000 yuan of fertilizers and pesticides per hectare[5].

Biogas residue and biogas slurry are high-quality feed additives that promote the conversion of biogas, accelerate the accumulation of glycogen and muscle sugar in animals, reduce the incidence rate of diseases and increase the feed conversion rate. The fattening period of pigs has been shortened by 5 – 6 months from the past 10 months, and the feed conversion ratio has been reduced to 3.5∶1 from 5∶1 in the past. The biogas slurry produced by anaerobic fermentation of human and animal manure is rich in essential elements such as nitrogen, phosphorus and potassium necessary for plant growth. It also contains trace elements necessary for plant growth such as calcium, iron, copper, zinc, fierce and aluminum. Recently, it has been also detected that biogas slurry contains amino acids, auxin, gibberellin, hydrolase, monosaccharides, humic acid, B vitamins and certain antibiotics. These substances have important regulatory effects on crop growth and development. When applied to crop farming and aquaculture, agricultural investment and production costs can be reduced[6].

When biogas is used to grains storage, insects can be prevented. Biogas contains about 60% of methane, and about 35% of trace gases such as CO_2, H_2 and N_2. When the concentration of these gases is raised, an environment of hypoxia and suffocation will be formed. Therefore, inputting an appropriate amount of biogas into the grain storage device and keeping it closed for a certain period of time can make pests suffocated and died due to lack of oxygen. On average, each household can recover 50 kg of food per year.

3.3 Positive social benefits The construction of biogas digester in rural areas requires a large amount of cement, steel, bricks, biogas lamps, stoves and other products. This has stimulated domestic demand, increased employment channels and promoted social and economic development. When a biogas digester is built, human and animal waste and domestic sewage can be directly

poured into the biogas digester as raw fermentation materials to change the dirty, chaotic and poor conditions in the rural living environment and eliminate the breeding places of mosquitoes and flies, thereby greatly reducing mosquitoes and flies, and reducing the incidence of diseases, purifying the environment, and avoiding contamination of groundwater sources. The development of biogas and the combination of livestock and poultry pens, biogas digester, toilet and greenhouse are characterized by cleanness and hygiene and low incidence of diseases. The use of biogas for cooking frees rural women from the smog, and their life is more convenient, not only reducing the labor intensity but also improving the quality of life, not only bringing huge changes to village farmers in the economy but also bringing about certain improvements in spiritual civilization. The village appearance and the spirit of the masses have undergone fundamental changes[7].

4 Suggestions

Although the four-in-one model plays an important role in protecting the ecological environment and promoting rural economic and social development, there are still many shortcomings. Just like any technology, rural energy-ecology technology needs to be continuously improved. While doing the pilot demonstration work, it is still necessary for the majority of science and technology workers and farmers to continue to explore and achieve a new leap in this technology.

Due to the backwardness of rural areas in terms of transportation and information, it is difficult to promote and popularize new energy information and technologies in rural areas, making it difficult to effectively use the local abundant energy resources in rural areas. Governments at all levels should increase the propaganda of new rural energy technologies.

The current service system for rural energy construction cannot keep up. In some places, many farmers have begun to use biogas, but when it is necessary to repair and replace some accessories, they find it difficult to find the corresponding service points and service personnel. Training for technical construction personnel should be strengthened for this problem to improve the quality and technical level of the rural energy construction team, thus promoting employment and solving the difficulty in rural energy maintenance.

Rural energy-ecology technology is the integration of farming technology and energy technology. The vegetables, fruits and other agricultural products produced are all pollution-free green foods, the market demand for which is large. However, the transformation of individual farmers' production methods cannot form mass production, and it is also difficult to obtain good economic benefits through the mechanism of high quality and good price in the market. Therefore, the four-in-one model built in the courtyard should rely on the effect of one household leading neighbors, and neighbors leading the whole village, gradually forming a scale and grabbing the market by scale.

5 Discussion

Biogas ecological agriculture technology is an efficient agricultural technology with less investment, less risk, quick effect, far-reaching prospects and near-effectiveness, and is an effective way for farmers to get rid of poverty and accelerate rural energy construction, playing a great role in alleviating the shortage of energy used in rural areas, improving energy efficiency, and protecting rural resources and the environment. It is believed that the development of biogas not only has good economic benefits, but also has better ecological and social benefits. Biogas project is a project to enrich the people and benefit the people, and it is an effective means to promote agricultural efficiency, farmers' income, environmental improvement and social development.

References

[1] SHEN K. Suggestions on construction effect and rational utilization of rural methane[J]. New Countryside: Heilongjiang, 2017, 10(17): 17. (in Chinese).

[2] WAN J. Analysis on the effect of household biogas digester on improving rural ecological environment[J]. Agricultural Technology Service, 2015, 32(1): 176, 179. (in Chinese).

[3] LI SY. Research on rural energy construction under the framework of new countryside[J]. Agricultural Development & Equipments, 2018, 24(8): 29. (in Chinese).

[4] YUAN JZ. Studies on protective effect of rural infrastructure construction on rural ecological environment in China: Taking garbage chamber and biogas digester as an example[J]. Hubei Agricultural Sciences, 2013, 52(24): 6204 – 6206, 6221. (in Chinese).

[5] YU MH. Application technology of biogas fertilizer in the production of pollution-free vegetables[J]. Vegetables, 2013, 32(6): 64 – 65. (in Chinese).

[6] FU YL, SHI JH, QI LF, *et al.* Developing biogas construction to promoting the sustainable development of greenhouse vegetables[J]. Chinese Horticulture Abstract, 2015, 31(3): 168 – 169. (in Chinese).

[7] LIN XQ, ZHAO ZD. Practical significance and countermeasures of rural renewable energy development and utilization[J]. Jilin Vegetable, 2017, 44(11): 65 – 66. (in Chinese).

(From page 30)

[26] XU JX. Sediment flux into the sea as influenced by the changing human activities and precipitation: example of the Huanghe River, China[J]. Acta Oceanologica Sinica, 2003, 25(5): 125 – 135. (in Chinese).

[27] PENG J, CHEN SL. The variation process of water and sediment and its effect on the Yellow River Delta over the six decades[J]. Acta Geographica Sinica, 2009, 64(11): 1353 – 1362. (in Chinese).

[28] GROSSMAN GM, KRUEGER AB. Economic growth and the environment [J]. The Quarterly Journal of Economics, 1995, 110(2): 353 – 378.

[29] FAN J, QIAN QL. A comparative-study on the interactive relations between economic development and resource-environment in China's eastern coastal areas[J]. Journal of Natural Resources, 2004, 19(1): 96 – 105. (in Chinese).

[30] AN N, GAO NY, LIU CE. Wetland degradation in China: Causes, evaluation, and protection measures[J]. Chinese Journal of Ecology, 2008, 27(5): 821 – 828. (in Chinese).

[31] XU DX, ZHANG GX. Impact of human activities on coastal wetlands in China[J]. Wetland Science, 2007, 5(3): 282 – 288. (in Chinese).

[32] ZHANG CK, CHEN J, LIN K. Spatial layout of reclamation of coastal tidal flats in Jiangsu Province[J]. Journal of Hohai University(Natural Sciences), 2011, 39(2): 206 – 212. (in Chinese).

[33] XIAO JH, CHEN DJ, XU M. Evaluation of the loss values of the tidal wetlands ecosystem services by sea reclamation projects: A case of Jiangsu Province[J]. Transaction of Oceanology and Limnology, 2010, 22(4): 95 – 100. (in Chinese).