Sustainable Development Strategies of Biomass Energy in Beijing

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Abstract. The development of biomass energy industry can effectively improve the rural environment and alleviate the shortage of living energy in rural areas, especially in mountain areas. In order to make clear the current situation of biomass energy industry development in Beijing, this paper analyzed the status of biomass resources and biomass energy utilization and discussed the factors hindering the development of biomass energy industry in Beijing. Based on the analysis, suggestions for promoting sustainable development of Biomass Energy Industry in Beijing are put forward.

1. Introduction

Renewable energy has become an important strategic solution for addressing climate change and energy crisis while achieving sustainable development [1]. Biomass energy, as one of humanity’s earliest sources of energy, can be produced from raw materials such as agricultural waste, manure, municipal waste, plant material, sewage, green waste or food waste. Countries around the world are becoming increasingly concerned about the development of biogas industry [2].

In China, alongside the rise in awareness of the importance of biogas, the government has realized that biogas is one of the best substitutes for fossil energy and traditional biomass energy, and thus, setting up the biogas system should be an inevitable strategic option for the sustainable development of rural economy and society [3]. The biogas system in rural China is composed of two patterns, that is, the decentralized household-based biogas digesters for scattered rural households and the centralized biogas plants for large-scaled biogas production [4]. Most of the decentralized and centralized systems have been supported by the Chinese government. Until to the end of 2010, 40 million household biogas digesters and more than 50 thousand medium and large-size biogas projects have been built. The total tank volume reached 7.15 million m³ and annual output of 917 million m³ of biogas [5].

In Beijing, a large number of household biogas digesters were constructed in rural areas in 1980s. By the late 1990s, medium and large biogas projects were began to implement, which is a key project of renewable energy development program in "Eleventh Five-Year Plans" period in Beijing. Most medium and large biogas projects in Beijing were constructed in 2006 to 2009. The plan of ‘New countryside construction in Beijing’ which was implemented from 2006 to 2012 was the main driving
force of the construction of large biogas projects. There were less than 10 large biogas projects in 2000, while more than 100 projects until the end of "Eleventh Five-Year Plans" period. At the same time, some of the existing large biogas projects were expanded. Biogas projects and straw gasification projects together constructed the renewable energy system in Beijing rural areas. In the “Twelfth Five-Year Plans” period, medium and large-size biogas projects provide high-quality, clean, renewable energy to farmers. Life convenience of local residents has been greatly improved. Meanwhile, biogas projects significantly improved the structure of energy consumption and utilization and played an increasingly important role in the development of circular economy and ecological environment construction in rural countryside in Beijing.

2. Biomass resources in Beijing

The total output of biomass resources in Beijing is nearly 30 million tons per year (Table 1). It is including 4.39 million tons of agricultural and forestry biomass, 4 million tons of garden waste, 7.42 million tons of livestock manure and 12.18 million tons of sewage produced by intensive farming and nearly two million tons of other types of biomass resources. The main ways of biomass utilization in Beijing are biogas projects (straw gasification projects, methane fermentation projects and the utility of biomass fuel by household biomass gasify stove), biomass briquette, biomass power generation, bio-ethanol and bio-diesel, cooking firewood and others. There are a large amount of biomass resources in Beijing, but only a small amount of biomass has been used.

| Amount of resources (million tons) | Utilization rate | Utilization patterns |
|-----------------------------------|------------------|----------------------|
| Straw that can be collected        | 2.26             | 70%                  |
| Firewood                          | 2.13             |                      |
| Livestock manure                  | 7.42             | 70%                  |
| Sewage produced by intensive farming | 12.18         | 50%                  |
| garden waste                      | 4.00             | <4.5%                |
| Rural domestic waste              | 0.65             |                      |
| Others                            | 1.00             |                      |
| Total                             | 29.64            |                      |

3. Development of biomass energy projects in Beijing

Biomass can be converted into bio-energy through three ways: physical conversion, biological
conversion and chemical conversion. The common technologies for the production of bio-energy from biomass are combustion, solidification, fermentation, liquefaction and pyrolysis gasification. To make clear the status of utilization and development of biomass energy, an investigation was conducted by Beijing Municipal Bureau of Agriculture in 2014. Results showed that straw gasification system and marsh gas system for centralized village cooking gas supply, biomass solid fuel and household biomass gasification furnace were the major ways of biomass energy utilization in Beijing.

Large and medium scale biogas project is the most important way of biomass energy utilization in Beijing. There are more than 200 biogas projects constructed in Beijing. But only 128 biogas projects are still running normally at the end of 2014 due to a variety of reasons (Table 2). In those 128 projects, 15 projects have the daily biogas production capacity of more than 500 m$^3$. Biogas supplied by these 128 stations can meet the needs of 30 thousand households in rural Beijing.

Table 2 Construction and operation of biogas projects in Beijing

| District  | Methane fermentation projects | Straw gasification projects |
|----------|------------------------------|----------------------------|
|          | Constructed (unit) | Running (unit) | Constructed (unit) | Running (unit) |
| Fangshan | 25 | 15 | 27 | 10 |
| Shunyi   | 13 | 11 | 10 | 5 |
| Daxing   | 13 | 11 | 12 | 3 |
| Yanqing  | 10 | 3 | 41 | 5 |
| Tongzhou | 10 | 2 | 9 | 0 |
| Pinggu   | 5 | 3 | 5 | 0 |
| Changping| 5 | 2 | 6 | 4 |
| Huairou  | 5 | 0 | 21 | 7 |
| Miyun    | 4 | 2 | 5 | 0 |
| Chaoyang | 3 | 2 | 0 | 0 |
| Haidian  | 0 | 0 | 1 | 1 |
| Total    | 93 | 51 | 137 | 35 |

Combustion of biomass solid fuel by biomass gasification furnace is another important pattern of biomass energy utilization in Beijing. There are 13 Large and medium biomass solid fuel production plants constructed in Beijing with annual output of biomass solid fuel for each plant between 5 thousand and 10 thousand tons. Almost 50 thousand household biomass gasification furnaces are used in mountain areas in Beijing now for cooking and winter heating. Despite the relatively high cost of using biomass solid fuels, it can greatly reduce the amount of coal usage and alleviate the difficulty of energy usage in daily life in mountain areas.

4. Factors hindering the development of biomass energy industry

The utilization of efficient energy conversion from biomass has changed the traditional way of life in rural areas. It not only reduces the air pollution caused by the direct burning of straw, protects the ecological environment, but also improves the quality of life of rural residents. However, due to the technical level, equipment performance and other factors, there are still many problems in the
utilization of biomass energy.

Firstly, in spite of the large output of biomass raw materials, it is difficult to collect the biomass in the rural areas, especially in mountain area. And generally, the cost of collecting biomass is too high to reduce its economic value. More than twenty biogas projects have been suspended because of inadequate of raw materials in Beijing.

Secondly, the application of biomass energy conversion technology and equipment needs to be improved. Large amount of tar can be produced in the process of straw pyrolysis in straw gasification centralized biogas supply project. If not handled properly, it will lead to serious environmental pollution. Half of the straw gasification projects have been suspended because of the tar treatment problem. The biomass cooking stove, biomass heating furnace and mixing furnace used in rural Beijing are not designed according to actual needs. It is hard to add biomass solid fuel to the stove and furnace. And the design of smoke exhaust system of stove and furnace is not reasonable too. A large amount of smoke and tar are produced when fuel burns.

Thirdly, faulty operation and management and high operation costs hinder the development of biogas industry in Beijing. Due to the high operation cost, large number of fermented liquid and residues and poor work condition, most biogas stations can’t be self-financing due to the restrictions on the scale of production. Half of the biogas stationmasters are not optimistic about the prospects for the development of biogas projects.

5. Suggestions for promoting sustainable development of Biomass energy Industry in Beijing
Under the constraint of development strategy of Beijing, the amount of available biomass resources are limited. Although biogas and biomass fuel are widely welcomed by residents in rural area, the total production of biomass energy in Beijing is difficult to increase in large scale, affected by insufficient supplies of raw materials. Thus, the future development of biomass energy industry is to improve production efficiency of existing projects. As to the biogas industry, production efficiency and resource utilization efficiency should be improved. The application of straw fermentation technology and multiple raw material fermentation technology can effectively promote the development of biogas industry. Taking the full advantage of existing biomass resources, the production of the biomass solid fuel industry could be moderately increased within policy permit. And the efficiency of biomass energy utilization should be promoted though technological innovation.

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