



Development process and probable future transformations of rural biogas in China



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ABSTRACT

In order to provide a clear guidance for biogas development in rural China, the progress and current status of rural biogas, critical factors influencing biogas development in rural areas, and probable biogas transformations are discussed in this paper. Rural biogas in China experiences rapid development in the past fifteen years and subsidies and policies from Chinese government are two main driving forces for promoting this development. For the recent days, the growth rate of household biogas decreased and that of Medium-to-large biogas projects (MLBPs) obviously increased. Several surveys showed that the utilization rate of household biogas greatly decreased and more and more digesters were discontinued. The underlying reasons for these changes come from the development of large-scale livestock farms, agricultural modernization and urbanization, which deeply affect the agricultural and social environment in rural China. The development of these agricultural and social factors all create positive conditions for MLBPs, but they negatively affect household biogas projects in terms of biomass supply and their participation in modern agricultural processes. Ongoing transformations and developments in local agriculture and rural society significantly influence the patterns of biogas projects. For future biogas development, MLBPs should be encouraged and the reduction of household biogas projects should be allowed to continue. However, recommendations on probable biogas development transformations suggest that the decision for expanding or abandoning the household projects in certain regions should be consistent with the developments and trends of local agriculture and society. For MLBPs, suitable developing models and reasonable operating mechanisms should be fully considered for assuring their benefits and continuous operation.

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1. Introduction

It has been widely accepted that biogas production using agricultural residues plays an important role in energy supply, environmental protection and the promotion of ecological agricultural development for rural areas. As the largest developing country in the world, China highly depends on agriculture to support its people. As a result, about 809 million tons of crop straw and 1629 million tons of animal manure are collected as biomass resources every year, with the biogas potential of $33.5 \times 10^{10} \text{ m}^3$ [1]. However, according to the National Bureau of Statistics of China, a total of only $1.67 \times 10^{10} \text{ m}^3$ of biogas in 2012 was generated through household and medium-to-large biogas projects (MLBPs) [2]. This means that only 5% of total agricultural waste was utilized for biogas production in rural areas.

To reduce the pollution from agricultural wastes and solve the shortage of energy consumption in rural areas, the Chinese government has made great progress in developing the biogas industry, especially since 2003. As a result, the Chinese biogas industry has experienced extremely rapid development over the past decade. However, many problems continue to hinder the further improvement of this industry. Studies related to biogas development in rural China mainly focus on the potentials, constraints, challenges and solutions of household biogas projects [3–6]. However, the construction of biogas projects should not only be consistent with the supply of biomass and/or the demand for bioenergy, but also should also accord with the agricultural and social environment. Previous research has not paid enough attention to the recent changes in rural areas and may therefore not sufficiently predict future trends of biogas development in rural China.

Therefore, this study describes the progress and current status of rural biogas in China, and analyzes several factors influencing biogas development in rural areas as well as discussing probable biogas transformations, with the aim to draw a clear picture for future development of rural biogas.

2. Progress and current status of rural biogas in China

2.1. Progress

China is a typical country carrying out the small-scale farming system in the world, which has witnessed household-based and scattered farming and operation. As such, household biogas projects are the main form of biomass energy generation in rural areas. Generally, biomass wastes produced by farming and livestock in each household are used for biogas production in 8–20 m^3 digesters. After digestion, the biogas product is used for cooking and lighting, and the residues are used as green fertilizers for planting. Although China has a long history of biogas utilization, rapid developments in the biogas production industry took place after the year 2000 (Fig. 1) [7,8]. From 1990 to 2000, household biogas plants increased from 4 million to approximately 8 million. However, from 2001 to 2010, the total number increased sharply up to 40 million, with an average annual rate of 17.6%. The growth

rate has clearly decreased as low as 2.1% after the year 2010 and the annual biogas yield has remained stable at around $1.67 \times 10^{10} \text{ m}^3$.

MLBPs are other sources for biomass utilization and biogas production (Fig. 1). Most projects of this kind are constructed based on medium or large livestock and poultry farms, which are a little far away from residential areas. So generally, biogas from MLBPs is used for cooking, heating and lighting within the farm regions, as well as for power generation. In some cases, MLBPs are built near the villages with centralized biogas supplements for local villagers as household energy consumption. Very few MLBPs existed throughout the country before 2000, but the number increased nearly 30 times from 2001 to 2010 (Fig. 1) [7,8]. By the end of 2012, more than 30 thousands MLBPs were built and $1.4 \times 10^9 \text{ m}^3$ biogas per year were generated by these projects.

2.2. Driving forces for rapid biogas development

The Chinese government recently proposed specific demands on the distribution of biogas, in consideration of improving the sanitation situation both in households and the village, supporting rural development, ameliorating clean energy, protecting the forest and improving the ecological environment of rural communities. To achieve its multiple goals, Chinese government played a direct and important role in promoting the biogas development in rural areas. Based on a survey with 1227 households from Guangxi, Hubei, Shandong and Gansu provinces, results of a binary Probit Model show that the governmental promotion of biogas has a significant effect on households' decision-making [9]. In this paper, the authors declared a fact that that knowing about biogas from the government will make farm households much more likely to construct a biogas digester, compared with other resources like friends, family, relatives or media.

Form some previous literature reviews, sufficient evidence has also linked the rapid growth of rural biogas production to Chinese governmental promotion programs of biogas, including biogas policies, laws, subsidies, rules and regulations (Table 1) [5,10,11]. The important role of policy supports in rural biogas development

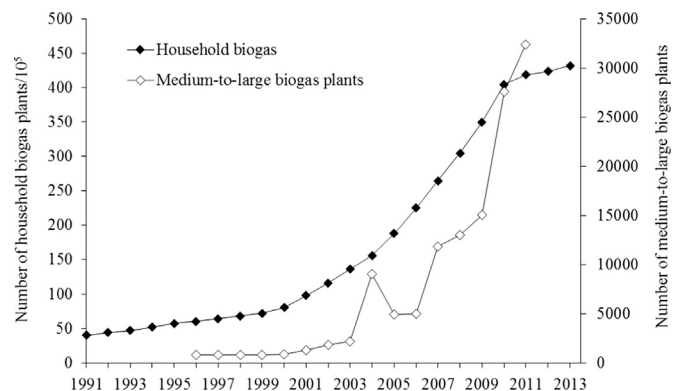


Fig. 1. The development in the number of rural biogas plants from 1990 to 2012 [7,8]. The number of medium-to-large biogas plants from 2011 to 2013 was not recorded in China livestock statistical yearbook.

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