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Household biogas development in rural China: On policy support and other macro sustainable conditions

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ABSTRACT

As a fuel, rural biogas is a promising renewable energy source. Policy support is a key initial impetus for industry development. This study explores household biogas development in rural China based on policy support found in literature. Relevant policies, which mainly include directive and guiding policies, economic inspiring policies, research policies, market policies, and other constructive policies, are gradually issued. Moreover, the National People's Congress has enacted five relevant laws, including the Agricultural Law, Renewable Energy Law, Animal Husbandry Law, Energy Conservation Law, and the Act on the Development of Circular Economy. The Energy Law is currently under revision. Relational rules and regulations have also been formed in response to the national policies and laws, which have already produced significant effects. The development of rural household biogas in China is growing steadily, and the technology standard projects have been established. The number of household biogas digesters and biogas annual output in 2010 was double of that in 2005. The offered financial incentive increased from 47 million dollars in 2002 to 760 million dollars in 2011. Policy supports play an important role in rural biogas development. And thus, additional national policy supports are necessary in the fields of scientific research, technological development, and biogas use model.

Contents

1. Introduction

The increasing negative effects of conventional energy sources and the limited stock of renewable energy have forced many

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countries, including China, to look into substitute energy sources [1]. The alternatives should be environment-friendly and renewable to sustain the increase in energy demands [1,2]. The use of renewable energy has become an important component of sustainable global energy strategies [3]. Biogas is a promising fuel, and its construction is an important part of new rural energy and sustainable development in China [4]. Biogas can be produced from a variety of organic raw materials and be used for various energy requirements [5]. Rural biogas construction can promote aquaculture, support production, and improve living conditions in rural areas. With the new countryside construction in China, the state and the farmers see rural household biogas development as an important approach to help solve environmental and rural energy problems [6].

In the 1980s, the central government proposed to set up the biogas industry in rural areas for the rational and effective utilization of agricultural natural resources. The impetus of the biogas industry was related to rural energy development, organic fertilizer development, environmental protection, and health development in rural areas. Therefore, biogas was envisioned to be an important element to achieve agricultural modernization [7]. The annual output of biogas in 2010 was approximately 1.55×10^{10} m^3, which was calculated to be equal to approximately 5.55×10^{11} MJ of heat (the heat of methane combustion is 35.822 MJ/m^3) [8], as shown in Table 1. Therefore, biogas should be regarded as one of the most promising renewable energy [9]. However, approximately only 19% of the potential of biogas has been utilized in rural China [4]. Energy policies play a vital role in mitigating the impact of global warming and in coping with challenge of energy shortage [1]. A biogas policy can promote and stimulate the development of biogas generation. A series of corresponding policies and laws that produced positive effects was issued during the different periods of rural biogas development in China.

China has made significant efforts to pursue energy and resource efficiencies and achieve sustainable development, but it still faces challenges. China should exert more effort in some key areas, especially in rural household biogas construction [10]. The infrastructure of rural China needs to be improved. The energy structure of some rural areas in China mainly focuses on fuel wood burning, which could lead to environmental pollution [11]. Coal price and electrovalence are high in rural and poor areas in China. The development of regional economies between urban and rural areas is uneven, where the popularization of new energies, such as natural gas and coal gas, is obstructive. The construction of rural household biogas, which is considered a livelihood project, could play an important role in countering the challenges above [12]. However, with the new countryside construction and urbanization promotion in China, rural biogas construction cannot keep pace with the social economic construction in rural areas [13]. The current paper presents a comprehensive overview of rural biogas development in China, mainly from the viewpoint of biogas digesters built. This study mainly aims to analyze policy support and law guarantees related to rural household biogas development and their effects.

Table 1
Number of household biogas digesters built and annual output of biogas in China.

Year	The number of biogas digesters (10^4)	Annual output of biogas (10^8 m^3)
1996	602.1	16.3
1997	638.2	17.7
1998	688.8	19.8
1999	763.5	22.5
2000	848.1	25.9
2001	956.8	29.8
2002	1109.9	37.0
2003	1288.9	45.8
2004	1541.0	55.7
2005	1800.0	69.0
2006	2200.0	85.0
2007	2650.0	102.0
2008	3050.0	122.0
2009	3507.0	124.0
2010	4118.0	155.0

2. General situation of household biogas development in rural China

2.1. Household biogas development and its characteristics

Biogas research and utilization in China have long histories, and hydraulic digesters have been used for nearly 100 years [14]. China is one of the pioneering countries in the world that developed anaerobic fermentation [6]. Biogas development in rural China has gone through three main stages since 1949, including types of energy demand, ecological demand, and ecological home development [15]. The nationwide implementation of the Eco-Household Project marked the milestone of the biogas industry in China [16]. Biogas costs approximately US$0.095 per m^3 [17], while the prices of nature gas and liquefied petroleum gas are approximately US$0.383 and US$1.037 per m^3, respectively [18], showing that biogas is much cheaper and easier to distribute in rural and poor areas in China. Rural biogas construction continuously consolidates and improves under policy support and legal protection. The characteristics of rural household biogas development are mainly reflected in the following aspects: (i) state funding continues to increase; (ii) household biogas scale grows steadily; (iii) various types of biogas projects are established; (iv) comprehensive utilization benefits of biogas improve; (v) service system construction is in full swing; (vi) technical standards system is formed; and (vii) the contribution to the energy saving of biogas development is significant. The effects above were obtained under policy encouragement and legal protection, but still with drawbacks. Domestic research on biogas power generation and the application markets are imperfect. Thus, higher technological demand is requested for researchers, and more studies related to scientific research and technological development are necessary.

2.2. Situation and characteristics of the built household biogas digesters

The number of biogas digesters built and the annual output of biogas continuously increase with the steady growth in household biogas scale. The large-scale development of household biogas in rural China began in the 1970s [4,19]. From 1973 to 1983, rural biogas development fluctuated dramatically [4]. The number of household biogas digesters built in the early 1970s was 6×10^6, which increased to more than 7×10^6 in the mid-1970s but fell to less than 4×10^6 in the early 1980s [20]. During this early stage, the challenges in household biogas production included poor management and the lack of secure and mature technologies to support the industry. From 1984 to 1994, the rural biogas construction remained in an adjustment period, with 8.27×10^5 new households using biogas [4]. This period focused on the scientific research of technological systems and repair of pathological digesters, and thus, the development pace slowed down. However, the pace of biogas development steadily increased annually from 1994 to 2000. During this period, biogas development picked up, and approximately 50,000 new biogas