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A time-geographical approach to biogas potential analysis of China

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ABSTRACT

Biogas is a renewable energy source by converting biomass energy into convenient, accessible and clean energy for diverse applications. In China, with vast grassland and arable land, the biogas potential is quite high, owing to tremendous amount of organic waste from agriculture and husbandry. Yet, without proper and timely treatment, the organic waste has been resulting in severe environmental hazards and health risks to take away the major part of economic achievements from agriculture and husbandry. It has been the important task to speed up the development of biogas industry and to fully extend the utilization of biogas for both central and local governments, with great efforts and enormous investment. In order to facilitate the development of biogas industry, to increase the exploitation and utilization of biogas, and to improve the return on investment on biogas production, the purpose of this research is to evaluate the biogas potential of crop straw and livestock manure through time-series analysis and geographical approach. Biogas potential of different crops and animals in various regions are estimated to learn the geographical characteristics and regional differences. In addition, actual biogas production and biogas production from large- and medium-scale biogas engineering projects are compared with biogas potential to learn the exploitation and utilization rate of biogas. Biogas potential density and biogas production density are also analyzed to learn the biogas potential efficiency and biogas production efficiency in various regions. Finally, some recommendations are provided for instituting corresponding policies and strategies to promote the development of biogas industry in China.

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1. Introduction

As energy demands sharply rising along with rapid economic development, energy security has been one of the major tasks for every country in the world, whilst fossil fuel energy sources are depleting fast due to excessive exploitation and utilization. Hence, exploring new, reliable, renewable and sustainable energy sources has become one of the key quests to tackle the crises of energy shortage, worldwide. In the meantime, energy conservation and emission reductions are set as two primary strategies and countermeasures in responding to climate change, which have imposed stringent restrictions and requirements on energy consumption and energy efficiency. Under such context, with great potential for energy conservation, biomass energy (bioenergy), the conventional, reliable, renewable, and clean energy source derived from plant or animal waste, has been recognized as the viable solution in resolving both energy and environmental issues, at the same time.

Biogas, an efficient and convenient method to recover energy from waste biomass for cooking, heating, fueling, power generation and various purposes, is the gas produced by microbial degradation of organic matter through anaerobic process. Biogas plays the significant role in improving energy structure, environmental quality and health conditions, reducing greenhouse gases emissions, and promoting economic and social sustainable development in rural areas. In Europe, the United States and other developed countries, biogas technology has been identified as an effective way of dealing with agricultural waste and livestock manure for waste resources recycling. Right now, the development of biogas technology in Europe is the most advanced and mature in the world, with extensive applications.

In China, the promotion of biogas applications was initiated in 1950s. The development of biogas industry was quite slow and backward before 1990s. Nevertheless, as the biggest agricultural country with about 800 million farmers, the construction and development of rural areas has always been one of the predominant tasks for the Chinese government. In 1982, the first official document of the year (the Central-1 document), issued by the State Council and the Central Committee of the Communist Party of China (the CCCPC), was regarding the promotion of village reform, which is the first Central-1 document concerning agriculture, village and farmers (the 3-Agros). It is important to realize that the Central-1 document is the most important outlines and guiding principles for the work plan of the year, nationwide, which indicates the emphasis of yearly work preferences for the governments. Furthermore, the 3-Agros has been the focus of the Central-1 document for the next four consecutive years, until 1986. Entering into the 21st century, once again, close attention has been paid to agricultural development and rural construction, where biogas development has acquired numerous considerations and great supports from both central and local governments. Since 2003, the 3-Agros has been re-elevated as the focal point of the Central-1 document for more than one decade, as shown in Table 1, in which the construction of village biogas engineering projects has been listed as one of the major tasks. Moreover, many laws, regulations, ordinances, plans and reports have put biogas development as one of the primary targets for the development of renewable energy, as shown in Table 2. And, the investment on biogas production from the Chinese government has been increasing considerably since the 21st century, as shown in Table 3·[1].

Indeed, with more than 1.2×10^6 km^2 of arable land and 3.9×10^6 km^2 of grassland, the biogas potential in China is huge. Through time-series analysis and geographical approach, the purpose of this study is to evaluate the biogas potential of both agricultural waste (straw) and livestock manure (excrement and urine) in various districts and provinces/municipalities, from 2007 to 2011. Biogas potential of different crops and livestock are also compared to learn the geographical characteristics and regional differences. The gaps between the theoretical biogas potential and actual biogas production are then analyzed to find out the exploitation rate of biogas potential. In addition, the biogas production from large- and medium-scale biogas engineering projects is compared with actual biogas production to assess the utilization rate. Furthermore, biogas production is compared with capital investment to discover the return on investment. At last, some recommendations are provided as references for instituting strategies and procedures to promote the development of biogas industry in China.