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Biogas as a sustainable energy source in China: Regional development strategy application and decision making

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ABSTRACT

Biogas technology has brought benefits to health, the environment, the economy and energy conservation. Vast biomass resources, including organic waste, have the potential for use as feedstock for biogas production in China. This paper presents the development status of biogas application in China. The goal was to provide quantitative information about biogas use, from villages to large cities, to assess the major characteristics of biogas application. Analysis of the opportunities and constraints of the different biogas applications provided the basis for policies for the development of biogas plants and for the adjustment of the scale of biogas development to match local requirements. Based on the characteristics of different biogas plants and geographic regions, a fuzzy analytic hierarchy process model was used to provide a suitability evaluation for development of the regional biogas industry. Results from this model could provide decision support for development strategies for regional distribution plans and the scale of biogas system construction. The findings can also aid further research on balancing energy supply and demand, energy policy formation, and the regional eco-environment development in China.

Contents

1. Introduction

The harmful effects of the use of fossil fuels to the environment, health and society have spurred global interest in the search for cleaner sources of energy. In 2006, about 18% of the global energy consumption came from renewable energy sources, with 13%

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coming from biomass. China has a long history of using renewable energy sources, including biomass, solar, geothermal, ocean and wind energy [1] and with hydraulic biogas digesters being in use for nearly 100 years. With large biomass resources in China, biogas production potential is significant. By 2007, China had 26.5 million biogas plants, with an output of 10.5 billion m^3. By 2010 output increased to 248 billion m^3 (annually), with 2 billion m^3 produced from domestic waste, 6 billion m^3 from agricultural processing wastes, 150 billion m^3 from animal waste and 90 billion m^3 from crop residues.

Most of the research has focused on the development status of China's biogas industry, and the positive effects of biogas plant construction on the economy, society, ecology and environment [2–5], respectively. However, no research has been published on the systematic evaluation for different biogas applications, which is important to not only understanding the benefits but also to inform construction selection. Moreover, no attempt has been made to discuss regional needs, which takes into account the biogas application characteristics with regional suitability. Thus it is necessary to define the biogas potential at the regional level and conduct economic feasibility evaluations to guide the selection of methods for each region.

The development of sustainable biogas energy relies on the availability of local resources, environmental concerns, and the local societal and economic conditions. However, in China, poor biomass plant distribution has lead to insufficient supply of raw materials, limiting the development of the biogas industry. Appropriate and holistic planning is needed to achieve a favorable cost–benefit ratio to encourage industry stake-holders to make full use of the local natural resources. This planning would also seek to create favorable strategies for biogas industry development. Biogas application is urgently needed in China for systematic industrial development. The key is scientific distribution planning. Hence, a management plan for the biogas industry will provide a clear picture of the whole industry, including biogas plants development, regional differences and the degree of suitability.

This study had three objectives. First to give a holistic description of the present biogas development in China compared to other developed and developing countries. The second is to define why China lags in the application and industrialization of large-scale biogas facilities compared to developed countries. The third objective is to construct a regional suitability evaluation model to provide decision support for development of regional distribution plans, and the scale of biogas system construction.

2. Problem background

For a global review, biogas development and special market characteristics were examined for Europe, USA and Asia.

2.1. International comparisons

The interest in the potential of biogas arose because of the global concerns of energy security and climate change, which pointed to the inevitable end of the wholesale use of fossil fuels. As a result, the mission of the International Energy Agency (IEA) expanded to include extensive cooperation with the major energy consuming and producing countries, such as: China, India, Russia and Organization of Petroleum Exporting Countries (OPEC).

However, a large degree of geographical variability in biogas utilization and development was found between developed and developing countries. The biogas development conditions in representative developed and developing countries are shown in Fig. 1, which shows that biogas development in developed countries has a better, more extensive infrastructure, a mature industrial system, and a more highly educated labor force than in developing countries [6,7].

In developed countries, the biogas development characteristics are as follows: (i) importance is attached to developing the recovery and utilization of landfill gas (LFG). LFG represents around 85.5% and 75% of all biogas output in Britain and the

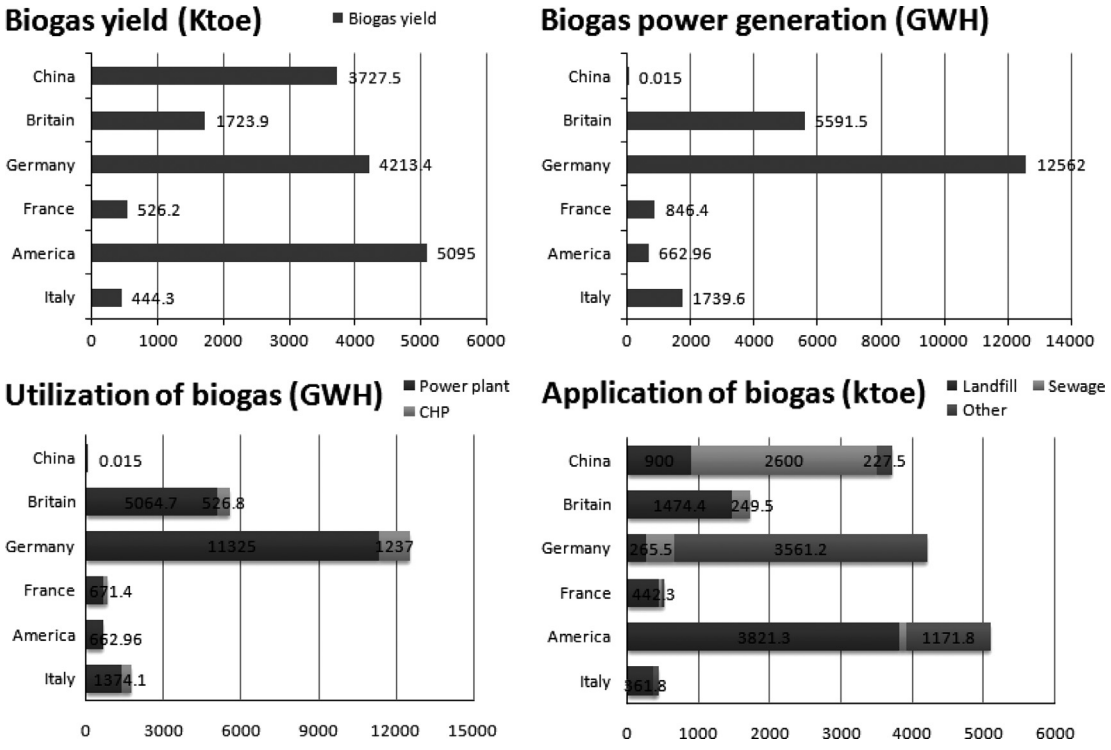

Fig. 1. Biogas development in developed and developing countries.