

Comparing centralized and decentralized bio-energy systems in rural China



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HIGHLIGHTS

- Biomass energy development has become part of the national energy strategy in China.
- The dis-/advantages of decentralized and centralized bio-energy systems are evaluated.
- Bio-energy systems should be selected based on the local circumstances.

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ABSTRACT

Under the dual pressures of an energy crisis and rising greenhouse gas emissions, biomass energy development and utilisation has become part of the national energy strategy in China. The last decade has witnessed a strong promotion of both centralised and decentralised bio-energy systems in rural China. The government seems to have a strong preference for centralised (village-based) bio-energy systems in recent years. However, these government-driven systems have not worked without difficulties, particularly regarding economic and technological viability and maintenance. Studies on the advantages and disadvantages of decentralised and centralised bio-energy systems are rare. This study aims to shed light on the performances of these two systems in terms of social, economic and environmental effects. Through interviewing local officials and village leaders and surveying farmers in 12 villages in Shandong Province, it was found that bio-energy systems should be selected based on the local circumstances. The diversity of the local natural, economic and social situations determines the size, place, technology and organisational model of the bio-energy system.

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1. Introduction

Bio-based energy is a highly controversial issue around the world, due to its potential conflicts with food security and environmental impacts (Cho, 2010; Jin et al., 2006; Kerr, 2010; Mol, 2007). Nevertheless, bio-based energy has been incorporated into national energy strategies in many countries, spurred by different driving forces. In China, bio-based energy in the form of bio-digesters in rural areas has been promoted by the government across the country since the 1950s, mainly with the intention of supplying gas for cooking in villages that had no access to other energy sources except firewood, straw residues or manure (China Biogas Society, 2011; Liu et al., 2008). The number of bio-digesters reached 7 million in 1976 but declined to 4 million in 1982 due to technical and management problems (Chen, 1981;

China Biogas Society, 2011). Since the early 1980s, the promotion of household bio-digesters in rural China has been integrated with efforts for improved sanitation and cleaner indoor environments. Consequently, technologies have been greatly upgraded to combine domestic energy production with the handling of waste from household toilets, kitchens, agriculture and livestock (Fan et al., 2011; Gan and Yu, 2008; He, 2010; MOA, 2007). More recently, household bio-energy systems have been complemented with more centralised bio-energy systems at the village level, often related to intensive livestock production.

Recent years have thus witnessed the further promotion of both centralised and decentralised bio-energy systems in rural China (Gosens et al., 2013; Jiang et al., 2011; Li et al., 2010; Zhou et al., 2006). Bio-digester systems have been recognised as an effective solution for increasing pollution from animal farms and agricultural residues. By the same token, bio-digester systems can be well integrated in on-going Chinese programs such as those on a rural circular economy, new countryside construction and eco-village construction. In 2003, the Ministry of Agriculture (MOA)

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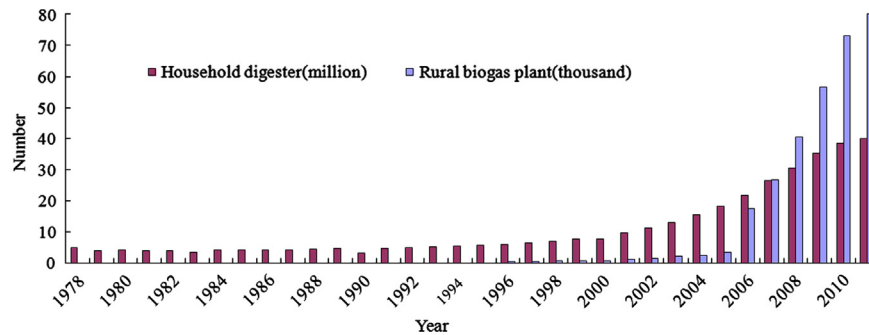


Fig. 1. The number of household biogas digesters and rural centralized bio-energy plants in China, 1978–2011.

Note: According to Article 7, Interim Measures for New Energy Construction Project Management 1997, medium and large biogas system have a biogas digester capacity of more than 5000 m³ per day. Otherwise the system is defined as a small-scale biogas system.

Sources: Based on [Chen et al. \(2010\)](#), [Li et al. \(2010\)](#), [MOA \(2008\)](#), and [Wang et al. \(2012\)](#).

issued “Measures for the Administration of National Debts for Construction of Biogas Projects in Rural Areas 2003 (Trial)”. The Measures insured financial support from the central government for biogas construction and development, and specified the subsidy criteria for household bio-digester construction. [Fig. 1](#) shows that the number of the household bio-digesters increased rapidly since 2004, as well as the centralised digesters since 2006. By the end of 2011, the number of households using biogas increased to nearly 40 million and approximately 33% of the suitable rural households had bio-digesters. Approximately 80,000 community-based biogas stations were established, which were mainly based on livestock and poultry farms.

A review of the existing Chinese laws and policies concerning rural development, rural energy and environmental protection shows that the current policy context is very favourable to the further development of bio-energy in rural areas ([Zhang et al., 2010](#); [Wang et al., 2010](#); [Zhang et al., 2009](#)). The Agricultural Law of 1973, the Electric Power Act of 1995 and the Energy Conservation Law of 1998 all recognised and emphasised the importance and strategic role of using renewable energy to contribute to the country's energy security, to reduce emissions and to protect the environment. The Renewable Energy Law of the Peoples' Republic of China, issued in 2005 and amended in 2009, is considered a milestone in China's development of a rural renewable energy policy. The Law aims to boost China's renewable energy capacity to 15% by the year 2020 and outlines a commitment to invest \$180 billion in renewable energy over this period. The recently (September 2011) issued “12th Five-Year Plan for Agricultural and Rural Economic Development in China” by the MOA proposes to have installed, by the end of 2015, bio-digesters for 50% of all suitable rural households across China. Recently, however, the Chinese central governments had a growing preference for centralised (village-based) bio-energy systems over household systems. Centralised systems better fit into the government's line of separating land use functions within villages, with raising livestock or energy production distinct from residential areas. Furthermore, with centralised systems, monitoring of their correct operation is more feasible.

Is this preference of the Chinese governments for centralised bio-energy systems in line with better performance of these centralised systems? Most of the existing studies on biogas digesters in China have focused on one of the two systems or on one aspect (economic, environmental performance, social preferences, etc.) of these two technologies ([Chen et al., 2010](#); [Gao et al., 2010](#); [Han et al., 2008](#); [Li et al., 2010](#); [Mangoyana and Smith, 2011](#); [Zhang et al., 2008](#)). Studies that give an overall assessment and comparison of the advantages and disadvantages of the two technologies are rare. A general preference for centralised bio-energy systems does not appear to be based on strong evidence yet. In addition, one can question whether a general preference for one type of system holds under all types of

circumstances. The choice between “centralised” and “decentralised” options for (bio-energy) systems lies at the core of many debates on environmental performances, economic benefits, and social effects of infrastructures, ever since the publication of Schumacher's “Small is Beautiful” ([Schumacher, 1973](#)). Increasingly, however, scholars argue that there is no one best system that fulfils our economic, environmental and social preference. Furthermore, as Grin argues, the answer may be found in the plural, as there is no single best solution, no “single truth” ([Voß et al., 2006](#)). At the same time, this does not mean that “anything might go” in the sustainable development of infrastructural systems. The recently emerged modernised mixtures school-of-thought has emphasised that socio-technical systems should be optimised against the specific context in which these systems are used ([Hegger, 2007](#); [Oosterveer and Mol, 2010](#); [Scheinberg and Mol, 2010](#)). To put it differently: good and sustainable performance of infrastructural systems is based on the context in which such systems are used. Hence, it depends on the local context whether infrastructural systems are preferably organised, designed and/or implemented in a centralised or decentralised mode. In the following this school-of-thought, the question thus should not be whether general centralised bio-energy systems should be preferred above decentralised ones; the question concerns under what circumstances centralised bio-energy systems should be preferred above decentralised ones in rural China and vice versa.

This paper aims to contribute to a more evidence-based governmental policy on stimulating centralised and decentralised bio-energy systems in rural China, by comparing the advantages and disadvantages of both bio-energy systems in rural China and concluding under which conditions each should be stimulated. To do so, the next section outlines the research methodology. Subsequently, the organisational modes and the strengths and weaknesses of both centralised and decentralised bio-energy systems are assessed with respect to environmental performance, economic performance and social preferences and effects. Finally, conclusions are formulated.

2. Research methodology

2.1. Performance evaluation

The performances of centralised and decentralised biogas systems are evaluated and compared with respect to three sets of criteria: economic performance, environmental performance and social effects and user preferences. For economic performance, the focus is on the costs and benefits of the two systems, both for the system as a whole and for rural households. Environmental performance is related to the degree in which the system influences the state of the environment (impact) with respect to energy

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