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Public preferences for biomass electricity in China

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ABSTRACT

The Chinese government has made significant effort to promote biomass based electricity generation in recent years. Yet, little is known about consumers' preferences for biomass electricity and associated environmental impacts. This paper uses discrete choice experiments (DCE) to investigate Chinese consumers' preference for electricity generated from various biomass sources. Based on 548 responses, the paper finds that Chinese households are willing to pay a premium of around 27 Yuan per month or 0.20 Yuan per kilowatt hour (kWh) to replace coal-fired electricity. Among the various biomass sources, electricity generated from agricultural and forestry biomass is most preferred, followed by biogas electricity and waste-to-energy. It is also found that respondents have a significant willingness to pay for reducing haze. Consumers' household structure and environmental awareness also affect their preference for biomass electricity. These results have significant implications for the prioritization, design and communication of biomass promoting schemes.

1. Introduction

The utilization of renewable energy is widely viewed as an effective way to resolve the conflict between increased energy consumption and mounting pressure for environmental protection. As one of the most important renewable energy resources, biomass energy is increasingly recognized due to its relative abundance and low levels of emissions of sulfur dioxide, nitrogen oxides and carbon dioxide [1–5]. Among the various forms of biomass energy consumption including direct consumption of biogas and biomass fuels, biomass electricity generation becomes increasingly popular. China is among the leading countries in promoting biomass electricity generation [6]. A series of regulatory arrangements have been introduced to facilitate the development of biomass electricity generation in the past decade, including the *Medium and Long-term Development Plan of Renewable Energy* (*MLDP*) [7], the *Twelfth Five-Year Plan of Biomass Energy Development* [8] the *Renewable Energy Law* [9], amended in 2009, the *Energy Saving Law* [10], amended in 2007 and 2016 and accompanying incentive instruments [11–13]. The last decade or so has witnessed a significant increase in China's biomass electricity generation (Fig. 1).

China has abundant biomass resources including agricultural residues (crop straw, agricultural processing residues etc.), forestry residues, energy plants, municipal solid waste and other organic wastes. The total amount of biomass energy resources in China is about 460 million tonnes of standard coal equivalent per year [8]. However, the nation has only tapped into less than 5% of this vast potential. Despite the rapid development in the last decade (Fig. 1), China's biomass electricity generation only accounts for less than one percent of the total electricity generation, and three and a half percent of the total electricity generated from renewable energy sources [14]. There remain issues with the implementation of biomass-promoting policies, and challenges facing the development of China's biomass electricity generation [11,12,15,16].

To further promote the development of biomass electricity generation, the Chinese government set a substantially higher feed-in tariff (0.75 Yuan/kWh) for biomass electricity generation than the yardstick on-grid prices. The yardstick prices for newly committed coal-fired electricity generation are typically in the range of 0.25–0.45 Yuan/kWh subject to periodical adjustments. Still, the feed-in subsidy turned out to be insufficient to make biomass electricity generation competitive due to higher costs of biomass collection, transportation, storage and electricity generation. Some provincial governments have also implemented top-up feed-in tariffs ranging from 1 to 8 cents/kWh in addition to the national feed-in tariff; however, the effect of these additional incentives is yet to be seen.

An alternative to these supply-side incentives for promoting biomass

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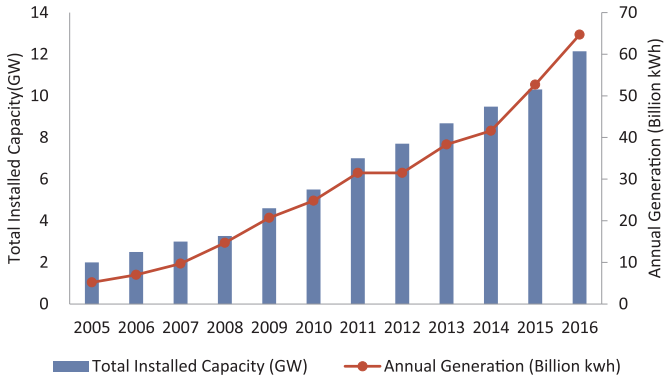

Fig. 1. Total installed biomass electricity capacity and electricity generation in China.
Sources: CNREC [14]

electricity generation is to tap into the voluntary demand for renewable energy from consumers. Studies from developed and developing countries using stated-preference approaches have consistently found consumers willing to pay notable premiums for electricity generated from biomass [17–24]. The voluntary demand is also confirmed by revealed preferences where consumers do have the options to purchase premium-priced electricity generated from renewable energy resources including biomass [25]. Voluntary premium willingness-to-pay (WTP) provides strong support for the promotion of green electricity products which in turn facilitates further development of biomass electricity generation. Except for the short-lived *Jade* program piloted in Shanghai [26,27], Chinese consumers typically do not have the options to buy alternative electricity products. However, green electricity options are much expected as China expands its ongoing reforms in the electricity sector to the retail electricity market. Information about consumers' preference for various biomass electricity options will be useful to assess the potential of promoting biomass electricity generation through the voluntary demand of Chinese electricity consumers, and to highlight areas where regulatory agencies may need to focus.

This paper makes the first empirical attempt to investigate Chinese consumers' preferences for electricity generated from biomass using discrete choice experiment (DCE). Specifically, the paper evaluates consumers' preferences for various technologies of biomass electricity generation. While all biomass electricity technologies mitigate air pollution by replacing coal-fired electricity generation, the different technologies differ in the net impact and present different trade-offs when other environmental and economic characteristics are also considered. Fig. 2 presents the distribution of biomass electricity generation capacity in China by four primary biomass electricity generation technologies: straw (i.e. agricultural and forest residue), waste to energy, biogas, and gasification. The first three biomass electricity generation technologies are most common in China, accounting for nearly 100% of the total biomass electricity generation capacity. This paper thus focuses on Chinese consumers' preferences for electricity generated from straw, waste to energy, and gasification.

The rest of the paper proceeds as follows. Section 2 reviews related literature on biomass electricity generation. Section 3 describes the survey design, data collection and models. Section 4 presents the findings. The last section concludes the paper with policy suggestions.

2. Literature review

Using biomass to generate electricity offers a wide range of benefits including timely cleanup of agricultural and forestry residues and thus reduced direct field burning of crop residues [28], lower risks of potential forest fires and pests [24,29,30], and reduced environmentally damaging landfills and associated emissions [21,31]. Biomass electricity generation is also thought to be beneficial for the reduction of GHGs and other airborne pollutants from the whole fuel cycle perspective (including the stages of cultivation, harvesting, transportation, and electricity generation). For example, electricity generation using forestry residues is considered to have a neutral impact on CO_2 emissions as the CO_2 released during the generation process is almost the same as that fixed by the harvested biomass [32,33]. Varela et al. [34] argued further that if the fixation of CO_2 in the roots that remain in the ground after the harvesting is concerned, biomass electricity generation in fact has a net CO_2 emission reduction. This is also confirmed by Belle [35] and Ruiz et al. [36] who found that the CO_2 emission in the collection and preparation of forestry residues for biomass electricity generation is much lower than that absorbed by plantations during their growth.

These desirable features of biomass electricity are shown to be valued by electricity consumers. There has been a rapidly emerging literature on consumers' preferences for electricity generated from renewable resources including biomass. A recent meta-analysis of this literature showed that people were willing to pay a premium for biomass electricity though the premium is lower than that for solar but not significantly different from other renewable sources [23,37]. Most previous studies of public preferences for biomass electricity investigated biomass among a number of renewable energy sources [e.g. 19,31,38–41]. The few studies that focused on biomass electricity either studied a single biomass technology or did not specify the generation technology at all. Using DCE, Lim [22] found that the WTP for a 1% reduction in GHG emissions through waste-to-energy in Korea was 1763 South Korean Won (KRW) per household per month. Soliño et al. [21] showed that the WTP for pollution improvement through the substitution of electricity generated from forest biomass for fossil fuel generated electricity was 52.04 Euros per household per year in the North-West region of Spain. Susaeta et al. [18] also found a premium WTP of $0.049/kWh for woody biomass based electricity in the Southern United States. More recently, Campbell et al. [24] also

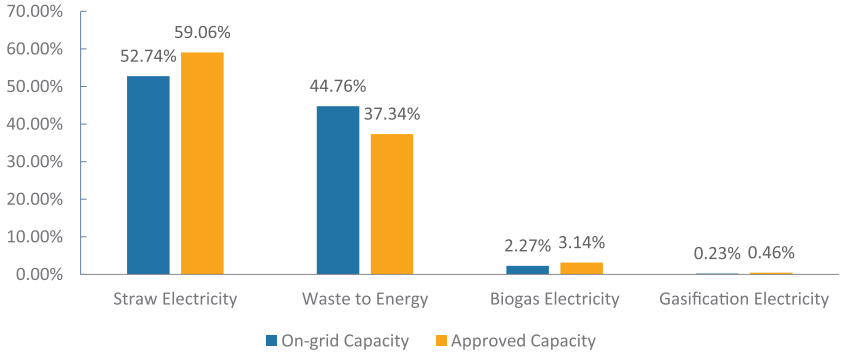

Fig. 2. Biomass electricity generation capacity by technology.
Source: CNREC [14]