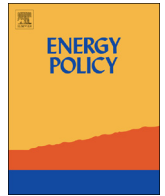


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# Energy Policy

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## Bioenergy consumption in rural China: Evidence from a survey in three provinces

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### HIGHLIGHTS

- Nearly 40 percent of rural households surveyed in 2010 and 2011 use bioenergy.
- Bioenergy accounts for nearly 20 percent of total energy used by rural households.
- Income growth of 5 percent results in less than 1 percent reduction in bioenergy use.
- The high opportunity cost of biomass collection reduces bioenergy use.
- Sustainable policy for bioenergy use must benefit local households.

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### ABSTRACT

Biomass in the form of crop residues and firewood is a major energy source for rural households in China. A survey conducted in the provinces of Shanxi, Zhejiang, and Guizhou shows that 37 percent of rural households use bioenergy for heating and cooking and that bioenergy accounts for 18 percent of their total energy consumption. Most of the biomass used for energy is burned in traditional stoves, contributing to indoor air pollution in rural homes. Crop residues also are commonly burned in the fields, contributing to the high level of outdoor air pollution in China. Our econometric analysis of the key determinants of bioenergy use shows that bioenergy consumption falls modestly with income growth, increased time required for biomass collection, and less farmland. Hence, open burning of some biomass is an optimal choice and is likely to become more of a problem without policy intervention. These findings suggest that a more sustainable use of biomass requires policies that promote cleaner, more efficient bioenergy combustion technologies and increase the economic value of biomass such that local households can benefit from biomass collection.

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### 1. Introduction

Biomass in the form of crop residues and firewood is one of the major energy sources for rural households in developing countries (Rosillo-Calle, 2007). In China, bioenergy in the form of biomass is still widely used by rural households in the traditional way. Based on a survey in 18 villages of 6 counties between 1987 and 1991, Wang and Fend (1996) showed that biomass was the main energy source, accounting for 60–90 percent of total energy used by rural households in China. In Gansu province, bioenergy still accounted for 60 percent of total energy used by rural households according

to a survey in 13 villages of two counties in 2006 (Li et al., 2009). In the present paper, we will study key determinants of bioenergy used by rural Chinese households based on a survey conducted in three provinces in 2010 and 2011.

Household survey data are typically adopted by previous studies on bioenergy use in rural China. Besides the two studies mentioned above, Démurger and Fournier (2011) adopted a sample including 273 households from 10 villages near Beijing in 2001 to study the effects of household characteristics on firewood use. Peng et al. (2010) used a sample including 401 households in 20 counties of Hubei province in 2004 to explore patterns of residential fuel switching. Liu et al. (2013b) studied the public acceptance of renewable energy deployment based on data collected from three villages in Shandong province in 2011. To provide an updated dataset on current situation of bioenergy

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use in a broader area of rural China, we organized a survey involving over 2000 households in 30 villages of the provinces of Shanxi, Zhejiang, and Guizhou in 2010 and 2011.

Our survey shows that bioenergy is no longer the dominant energy source for the surveyed rural households. On average, only 37 percent of the rural households use bioenergy, which accounts for just 18 percent of their total energy use. The main sources of bioenergy are crop residues and firewood from own farmland, suggesting that China's ban on deforestation may have had some effect. However, the survey also reveals that biomass would probably be open burned on farmland if it does not serve as bioenergy for daily life of the surveyed households. Hence, to understand why biomass is burned rather than used for bioenergy, we should identify key determinants of bioenergy used by rural households in China.

The Chinese government has promoted sustainable development since 2000 (Démurger and Fournier, 2011). Biomass combustion in rural China poses two challenges to this goal. First, the traditional method of burning firewood and crop residues in indoor stoves contributes to high levels of indoor air pollution in rural households. A second challenge is that crop residues also are commonly burned in the fields, indicating a surplus of biomass. This practice returns nutrients into the soil but also contributes to the increasingly serious air pollution problem in China. Along with coal combustion, open burning of biomass on farmland is considered a key polluting source. The government has announced policies to promote sustainable biomass use – such as renewable energy and forage to feed animals – in order to reduce field burning of biomass. However, the practice is still widely adopted by rural households as shown by our survey. To control air pollution and improve the living standard of rural residents, the Chinese government's pursuit of sustainable development would be aided by efforts that account for the broader set of management decisions that the rural households are taking. This also motivated us to identify and analyze the key determinants of bioenergy used by rural households in China based on our survey data.

Income is generally one of the key determinants of bioenergy use. Historically biomass has served as almost the only energy source for households until the Industrial Revolution when fossil fuels started to be widely used. The energy ladder model characterizes biomass as a traditional source of energy, which will eventually be abandoned by households with increasing income (Hosier and Dowd, 1987). Indeed, poor households tend to use more bioenergy than wealthy households do because biomass is cheap and easy to obtain, particularly for rural households. This is consistent with the poverty–environment hypothesis, which claims that poor people are more dependent on environmental resources (Cavendish, 2000; Zwane, 2007).

However, some empirical evidence shows that bioenergy is not completely abandoned even by the wealthiest rural households (e.g. Démurger and Fournier, 2011; Hiemstra-van der Horst and Hovorka, 2008). For example, Démurger and Fournier (2011) found that in the wealthiest household group in a town located in North China, bioenergy use may have stabilized at a level where income growth has only a modest negative effect on firewood use, based on a household survey conducted in 2001. Consequently, more households use a variety of energy types, as the energy-stacking model describes (Masera et al., 2000).

To better explain the phenomenon that wealthy rural households tend to reduce but seldom abandon the use of traditional bioenergy, the energy wave transition model assumes that any energy used by households has its own bell-shaped life cycle following five sequent stages – development, increase, ceiling, decline, and floor – that occur along with household income growth (Zhang et al., 2014).

Our econometric results show that bioenergy consumption of the surveyed rural households decreases only marginally

with income growth. Meanwhile, income growth leads to fewer bioenergy-using households and increasing consumption of commercial energy so that the share of bioenergy use in total energy use decreases with income growth. If a bell-shaped life cycle exists for bioenergy (Zhang et al., 2014), then bioenergy use has reached a floor stage for most of the households.

Another key determinant of bioenergy consumption is the necessary collection time per unit of biomass (Amacher et al., 1993). Our results show that a 1 percent increase in biomass collection time can lead to a 0.8 percent reduction in bioenergy use, indicating that bioenergy use is elastic to its collection time and that a high opportunity cost can markedly reduce bioenergy use.

These findings suggest that an effective policy to reduce field burning of biomass could be to encourage and promote the use of combustion technologies for burning biomass more efficiently and with less air pollution. At the same time, policies have to increase the economic value of biomass such that local households can benefit from biomass collection.

The remainder of the paper is organized as follows. The next section provides a description of rural energy use with a particular focus on bioenergy use of the surveyed households. Section 3 introduces the methods used to analyze the key determinants of bioenergy consumption. Section 4 reports and discusses the results on the key determinants of the bioenergy use. The last section provides conclusions and policy implications.

## 2. Survey data of rural energy consumption

### 2.1. Data collection

Regular official energy statistics in China have covered only commercial energy. Biomass in the form of crop residues and firewood is available almost everywhere in rural China, but because a biomass market practically does not exist, its use has been excluded from the regular official record.

Researchers outside the Chinese government have attempted to fill this gap. However, the available data on biomass and bioenergy are scarce due to at least two difficulties. One is the sheer amount of resources and coordination necessary to obtain a sample with a plausible number of observations covering a large region. Previous studies adopted samples of a small region of rural China. For example, Démurger and Fournier (2011) adopted a sample including 273 households from 10 villages near Beijing in 2001. Peng et al. (2010) used a sample including 401 households in 20 counties of Hubei province in 2004. Liu et al. (2013b) was based on data collected from three villages in Shandong province.

The other difficulty is associated with on-site investigation. Interviewers have to be familiar with local conditions so that respondents are willing to answer questions patiently and provide accurate information to prevent potential deficiencies.

To overcome both difficulties, we cooperated with the Office of China Rural Fixed Observation Points (CRFOP)<sup>1</sup> at the Ministry of Agriculture to administer our survey on household bioenergy consumption. CRFOP was founded in 1984 and has established a national longitudinal survey system whereby interviewers are recruited from local villages to survey rural households annually on production and consumption. About 350 villages in 30 provinces were covered by the CRFOP survey system in 2012.

Rural households differ considerably in energy consumption across regions due to regional characteristics such as climate, energy endowment, and lifestyle. To get a relatively accurate

<sup>1</sup> See <http://www.rcrc.moa.gov.cn/jizn/jgsz/ncgdgdc/> for a Chinese introduction of the office (Nongcun Guding Guanchadian—农村固定观察点).

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