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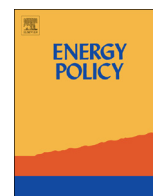
Which factors are effective for farmers' biogas use?–Evidence from a large-scale survey in China

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HIGHLIGHTS

- A binary Probit Model is used to test important factors of household biogas implementation in rural China.
- The analysis is based on a survey of 1227 households from four provinces.
- The promotion of government has very big and significant effects on household's decision-making.
- The agro-climatic conditions reveal to be decisive.
- Many household characteristics including the subjective discount rate are significant factors.

ARTICLE INFO

ABSTRACT

The Chinese government since 1995 has carried out programs for the construction of household biogas digesters in the Chinese countryside. Despite the large governmental spending in the building of household biogas digesters, only 12.16% of the households suitable to produce and use biogas, have built a digester (Li, 2009). This article asks which factors on the household level may be important for the decision whether or not to build a biogas digester. Based on a survey with 1227 households from Guangxi, Hubei, Shandong and Gansu provinces, results of a binary Probit Model show that the governmental promotion of biogas has a significant effect on households' decision. The question arises which households may, if governmental programs were to be running out, be most likely to construct a household biogas digester? The household head's age, the number of household members staying at home, the total household income and the subjective discount rate of the respondents are significant factors in a farm household's decision to build a biogas digester. However, also agro-climatic conditions reveal to be decisive, which is why technical solutions for tackling the low productivity of biogas digesters in cold regions may need to be further considered.

1. Introduction

In China, programs for renewable energy such as biogas have a rather long history, going back to as early as the 1960s. At that time rural renewable energy programs were generally not motivated by a shortage in energy supply or by environmental reasons, more often they were part of a political program (Ma et al., 2010). Since 1995, as a result of a series of guiding documents aiming at the promotion of rural biogas, capital input from the central government increased considerably (Hao, 2011). During the Ninth (1996–2000), Tenth (2001–2005) and Eleventh (2006–2010) Five-year Plan periods, 55.4 million Yuan, 3.5 billion Yuan and 21.2 billion Yuan were respectively invested in rural biogas development. Since the end of 2008, biogas received a wider role than just for energy provision. With its incorporation in a governmental program to counter the effects of the international financial crisis, biogas was made a further means of expanding domestic demand and revitalizing the rural economy. By the end of 2009, 35 million household biogas digesters have been built in the frame of 56,500 biogas projects (Hao, 2011).

Despite the large governmental spending in building biogas infrastructure, in 2006, only 0.2% of total primary energy consumption in China was covered by biogas (Zheng et al., 2006).

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Furthermore, only 12.16% of the households suitable to produce and use household biogas have adopted the technology (Li, 2009). According to Chen and colleagues, only about 20% of the biogas potential is utilized in rural China (Chen et al., 2010). After such a long time of governmental investment in biogas development, it is hence timely to ask whether the large amount of monetary input could reach its objective to provide momentum to the development of biogas in the rural areas of China.

We can assume that the government only reached out to certain households within the Chinese countryside. In this article, the characteristics of these households will be investigated, as well as what may have motivated them to build biogas digesters. From these results, we can gain insight into which factors will in future be important for the further diffusion of household biogas digesters in rural China.

In the analysis of factors, we distinguish four categories, i.e. agro-climatic conditions, socio-economic conditions of the household, some measures of the interviewees' foresightedness, as well as the influence of the government on households' decision to build a biogas digester. Each of these factors requires different conditions for the further diffusion of biogas. For example, if our research shows a large influence of agro-climatic conditions on the likelihood to build a biogas digester, this would mean that biogas may foremost further diffuse in certain regions of China. If, however, the government proves to be influential for the decision to build a biogas digester, the further diffusion of biogas digesters may fall short as soon as the government ends the biogas subsidy programs. By inquiring which factors on the household level are important for the building of biogas digesters, we can hence provide different policy recommendations and outlooks for the future success of biogas development in rural China.

This article focuses on household biogas digesters that are usually of the size of 8–10 m^3 and where feedstock is provided foremost by animal manure, and partly by agricultural residues. These systems have been extensively described by literature (Chen et al., 2010; Feng et al., 2009), which is why they will not be further treated in this study.

In the next section, further reasoning is provided for the selected parameters. In the subsequent section, the survey area and methodology are presented. Results in Section 4 show that the influence of the government on the decision whether to build a biogas digester should indeed not be underestimated. We discuss these results in Section 5 in the light of the other factors' influence. In the end, we conclude with some recommendations on how to further develop the momentum of biogas use in rural China.

2. Household variables that may influence the building of biogas digesters

From literature, four different groups of conditions can be identified which are assumed to be influential for the decision whether or not to build a household biogas digester (Li, 2009; Fan et al., 2011; Groenendaal and Wang, 2010; Sidh and Basu, 2011): the agro-climatic conditions, such as temperature, humidity and precipitation; the general socio-economic conditions of the household, such as income, age-structure, education; related to these, the foresightedness of those who are at home, i.e. the interviewees; and the influence of the Chinese government as the promoter of biogas.

An overview of the variables is given in Table 1. The variables in the last column are the names of the independent variables which are assumed to influence a household's decision of whether to build biogas infrastructure. In the following, these parameters are further explained.

2.1. Agro-climatic conditions

For biogas, agro-climatic conditions are crucial determinants for biogas yield, which is why they here are assumed to also play an important role in farm households' decision whether to build a biogas plant next to their house. While Gansu Province in the north-west of China, one of our survey locations, is a semi-arid to arid area with continental climate, including warm to hot summers and (very) cold winters, Guangxi Province in the south of China is located in a subtropical climate with hot and long summers and high annual rainfall. Hubei Province, a further survey site, also lies in a subtropical climate, however, the survey site is located in the mountainous areas with cooler summers and colder winters than in Guangxi Province. Shandong Province, the fourth survey site, is located in the east coast, has a temperate climate, in between a humid continental and humid subtropical climate, with winter temperatures below zero degree. These conditions are assumed to affect the general tendency of farm households to invest in biogas digesters. While a considerable amount of studies have been carried out on the implementation of household biogas digesters within a particular region (e.g. Zheng et al., 2006; Cheng et al., 2011; Tu et al., 2011), to the knowledge of the authors, no study has so far compared the effect of agro-climatic conditions on the decision whether to construct biogas infrastructure, in comparison to other, e.g. socio-economic factors.

Table 1
The variables used in the analysis.

Variable categories	Explanation of independent variables	Variable names
Agro-climatic conditions	Province dummy	Prov*
Socio-economic conditions	Total income of household (Yuan)	Inc
	Total area of agricultural land of household (mu)	Land
	Percentage off-farm income in total income (%)	Offinc
	Economic gains	Gains
	Number of members staying at home	Stay
	Is there a skilled person in the family? (1=yes, 0=no)	Skilled
	Gender of household head (0=female 1=male)	Sex
	Years of education of the household head	Edu
	Age of household head	Age
Foresightedness	Risk aversion	RiskA
	Interest in new technology (1-10 scale: 1=dislike 10=like a lot)	Newtech
	Discount rate	Discountrate
Governmental influence	Knowledge source for biogas? (1=from government, 0=others)	Knowsource
	Knowledge of the government's aim to promote biogas (1=yes 0=no)	Knowaim
	Household head the leader of village (1=yes, 0=no)	Cadre

1 mu = $\frac{1}{15}$ ha.

  * Prov: We have four provinces in total, so we can use three province dummy variables, Prov1, Prov2, Prov3.