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Household biomass energy choice and its policy implications on improving rural livelihoods in Sichuan, China



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HIGHLIGHTS

- McFadden's choice model was applied to analyze household energy choice in Sichuan.
- We examined household revealed and stated preferences for different fuels.
- Household fuel switching is not a simple or unidirectional process.
- Households prefer to use fuel with lower cost, higher safety and lower indoor pollution.
- Household fuel choice is affected by interactions among multiple factors.

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ABSTRACT

It is widely known that a switch from traditional biomass energy to modern clean, safe and efficient energy could improve local rural livelihoods by enhancing the access to 'high quality' energy and reducing the negative impacts of traditional biomass energy on health, environment and living standards. Hence, in this paper, we used alternative-specific conditional logit model (ASCLM) to examine the rural household energy choice behaviors in Sichuan Province of China from the perspective of revealed and stated preferences. The results show that the fuel switching in our study region is not a simple unidirectional process from traditional biomass energy to modern fuels as incomes improve. Household energy choice behaviors could be not only affected by energy-specific characteristics such as fuel price, smoky level and safety risk, but also influenced by household-specific factors such as income level, age and educational level of the decision maker, household demographic structure, number of people frequently eating at home, distance to the nearest biomass collecting spot and household location, suggesting that government should attach more importance to simultaneously improve energy quality, control energy price and enhance household socio-economic status.

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1. Introduction

Biomass energy is one of the most important energy resources in developing countries, constituting about 35% of their energy supply (Demirbas and Demirbas, 2007). In the case of China, biomass energy occupies the predominant position in rural residential energy consumption over a long time (Zhang et al., 2010).

However, due to the limited access to advanced energy technologies and the low level of awareness among local farmers, a large share of rural population relies on direct combustion of biomass for domestic use. This has brought many serious problems to rural lives, for instance, resource waste, indoor air pollution, rural environmental deterioration and social inequalities (Zhang et al., 2010). Nevertheless, the clean, low-cost and high-efficient fuels based on modern biotechnologies could significantly improve rural living standards by providing huge environmental benefits and generating job opportunities in rural areas (Zhang et al., 2009). Therefore, it is vitally necessary for China to promote fuel switching from the use of traditional biomass energy to modern

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biofuels to optimize the contribution of biomass energy to rural sustainable development (Zhang et al., 2009).

Particularly in Sichuan Province, the current energy consumption at the household level still depends heavily on traditional biomass energy such as crop straws and firewood. By the end of 2013, the proportion of traditional biomass energy in rural energy consumption was 44% (SCREO, 2013). The long-term reliance on solid traditional biomass energy can be attributed to a rather slow energy transition process switching toward modern fuels (Gan and Yu, 2008; Démurger and Fournier, 2011). Nowadays, with the increasing pressure imposed by the stark conflict between rural economic growth and environmental protection, the energy transition is becoming more and more urgent. Notwithstanding Chinese government has been explicit about its objective to elicit household motivation of using high quality¹ energy by vigorously promoting the construction of biogas system and the electrification in rural Sichuan, the progress of energy transition is still slow there and needed to be sped up (Peng et al., 2010). More importantly, how to encourage households to make fuel substitutions has been one of the core tasks for policy making in recent years. Many previous studies (Reddy, 1995; An et al., 2002; IIED and ESPA, 2010; Lee et al., 2015) have demonstrated that how the energy transition takes place will determine its impacts on rural household livelihoods. Hence, the main purpose of this paper is to investigate the transition pathways of household energy choices, with a particular concern on cooking to find out the ways to propel the fuel switching from traditional biomass energy to modern cleaner energy at the household level. The focus of this paper is on the biomass energy, because it is the main type of energy used for cooking in rural Sichuan and the existing evidences regarding household preferences for it are usually insufficient to give a clear picture of current situation due to the lack of the market.

In Energy Economics, two main theoretical frameworks have been developed to analyze household energy choice behavior as well as its influencing factors. One is the 'energy ladder' model, which arranges an array of energy sources from the 'worst' to the 'best' in terms of cost, cleanliness, convenience, technological sophistication etc. (Hosier and Dowd, 1987; Reddy, 1995; Van der Kroon et al., 2013; Gosens et al., 2013). The basic assumption for this model is that with an improvement of the economic status, rural households can move up along the 'ladder' to the 'better' energy carriers (Reddy, 1995; Masera et al., 2000). Thus, income is the most important determinant of household energy choice (Leach, 1987, 1992). Another theoretical approach that has been widely used in analyzing household energy choice is 'energy stacking' model. This approach assumes that a household may consume a combination of several types of fuels, which simultaneously contains the traditional and modern energy sources at different levels along the 'energy ladder' (Van der Kroon et al., 2013). The household energy choice may also tend towards the high quality energy with the growth in their socio-economic status. Therefore household multiple fuel use patterns are determined by the complex interactions among various factors such as income (or wealth), local food and cooking habits, local tradition and institution, ethnicity and diet preferences (Masera et al., 2000; Heltberg, 2005; Ouedraogo, 2006; Takama et al., 2012). Both of the previously highlighted approaches have not only tried to explain the drivers of energy transition from traditional biomass to modern and clean energy sources, but also provided analytical tools to study biomass energy adoption of rural households. However, they are mainly tested using data of observed choice or consumption behaviors (Hosier and Dowd, 1987; Reddy, 1995;

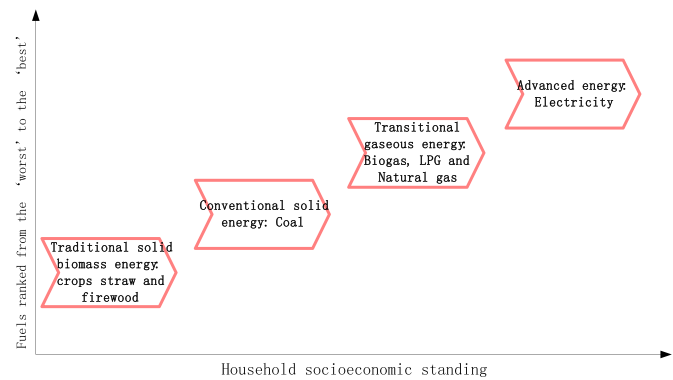


Fig. 1. Conceptualization of an 'energy ladder'. Source: adapted from WHO (2006); Wambua, (2011)

Heltberg, 2004, 2005; Ouedraogo, 2006; Gupta and Köhlin, 2006; Farsi et al., 2007). Despite the fact that, in many cases, data of some important potential influencing factors cannot be directly observed and effectively collected. Hence, this paper fills the gap and provides a holistic, systematic and in-depth analysis on household energy choice behaviors by comparing the revealed and stated preferences of the households for different fuels.

In this paper, we assume that a group of energy choices faced by the households can be ranked along an 'energy ladder' in terms of cost, cleanliness, efficiency and technological flexibility (see Fig. 1). Electricity is at the top of the list, whilst the traditional solid biomass energy such as crops straw and firewood is at the low end of the range. The process of fuel switching can be characterized by household switching from solid fuels, through gaseous fuels, to electricity for cooking. In order to better understand the energy choice behaviors of the households in energy transition, we want to clarify that how households make their choice decision towards modern cleaner fuels and to examine the determinants of these choice behaviors. The basic hypothesis of this paper is that with the increase in socioeconomic standing of the households, their energy use choices will 'move up' from traditional biomass energy to the energy carriers at higher levels. The structure of this paper is as follows. Section 2 reviews the existing literatures related to our research. The research methodology is given in Section 3 including the description of the data collection from our field survey and the model specification for econometric analysis. In Section 4, we present the estimation results of our empirical models and compare the revealed and stated preferences of the households for fuel alternatives. Section 5 concludes the main findings of our research and offers some policy implications for further rural energy development in China.

2. Literature review

In recent years, a large number of studies have tried to clarify the impacts of household energy use patterns on rural livelihoods (Gupta, 2003; Cherni et al., 2007; Byrne et al., 2007; Cherni and Hill, 2009; Lee et al., 2015; Biggs et al., 2015). These studies have shown that energy transition can change rural livelihoods in various ways. Conventional burning of biomass with low thermal efficiency usually causes waste of resource (Chen et al., 2006). It negatively impacts human health through indoor air pollution, and causes huge damages to environment and ecological system such as deforestation, land degradation, biodiversity decrease and soil erosion accompanying with increase in GHG emission (Fan et al., 2011). On the contrary, adopting modern fuels could bring positive effects on rural livelihoods by improving quality of life and enhancing environmental protection (Gosens et al., 2013).

¹ Here, the 'high quality' energy refers to low-cost, high-efficiency, clean energy sources.

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