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Factors underlying rural household energy transition: A case study of China

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ABSTRACT

This paper identifies factors underlying the energy transition of rural households in China. Based on province-level panel data for years of 1991–2014, it indicates that there exists the energy stacking process of rural household energy transition, characterized by the significant consumption inertia effects of traditional biomass energy (TBE), traditional commercial energy (TCE) and advanced commercial energy (ACE), respectively, the insignificant substitution effect of TCE and ACE for TBE, and the significant partial substitution of ACE for TCE. With regard to the factors underlying rural household energy transition: 1) per capita disposal income is negatively correlated with TBE, TCE and ACE consumption; 2) the number of motorcycles is positively correlated with TCE and ACE consumption; 3) the number of firewood-saving stoves and the price for ACE are positively correlated with TBE consumption; 4) household size and the number of motorcycles and the number of appliances are positively correlated with ACE consumption; 5) education level is positively correlated with TBE, but negatively with TCE consumption; 6) the number of rural energy management institutions is positively correlated with TBE, but negatively correlated ACE consumption; Therefore, some policy implications are discussed.

1. Introduction

In 2015, almost 40% of the global population in developing countries, approximately 2.7 billion people, relied on traditional biomass as a cooking fuel (IEA, 2016a) and, in some countries, the ratio reached as high as 80% (EUEI PDF, 2016). Although traditional biomass is renewable, its traditional use pattern of burning in open fires or simple stoves has led to enormous energy waste by utilizing only 5–10% of existing potential energy (Clark et al., 2009, 2010; Mehetre et al., 2017). It also presents major environmental and health issues (Heltberg, 2005; Bartington et al., 2017) arising from deforestation, forest and land degradation, as well as indoor and outdoor air pollution (IEA, 2006; Tonooka et al., 2006; Mekonnen and Köhlin, 2008). As a consequence, the WHO attributes 3.5 million premature deaths each year to indoor air pollution caused by combustion of traditional biomass for cooking (IEA, 2016b).

To eliminate these negative effects, factors underlying the transition from traditional biomass towards clean and efficient energy have attracted great interest from researchers. As early as the 1990s, the energy ladder theory was developed to depict the switching process of household fuel choices in developing countries (Baldwin, 1987; Smith, 1987; Hosier and Dowd, 1987; Leach, 1992). Since then, the energy switching process and its determinants have constituted a main focus of a large body of extant research. Even with consideration of demographics, infrastructure, and economic characteristics, a line of research has proven that the energy ladder model remains a linear and unidirectional progress in which household energy transits from traditional biomass fuels to modern fuels with the increase of income (Dowd, 1989; Fitzgerald et al., 1990; Barnes and Qian, 1992). In contrast, another line of investigators have argued that households consume a portfolio of both TBE (including straw, firewood, and biogas) and commercial fuels (including coal, oil, electricity, and liquefied petroleum gas (LPG)), and TBE are only partially substituted by commercial fuels (Hosier and Dowd, 1987; Leach, 1992; Schlag and Zuzarte, 2008; Horst and Hovorka, 2008). Furthermore, some households consuming more commercial energy have returned to TBE as a response to rising prices, and the unavailability and inaccessibility of commercial energy (Leach and Mearns, 1988; Leach, 1992; Schlag and Zuzarte, 2008). Understanding household fuel choices and their influencing factors is of great importance for policy-making contributions to energy transition processes (Kroon et al., 2013).

As the largest populous developing country, China has been the largest source of global energy demand growth since 2000, which will continue to exert an enormous impact on global energy trends (IEA, 2016a). In 2015, China's total energy consumption was 4174.94 Mtce, among which 5.13% was consumed by rural households. Energy

Abbreviations: TBE, traditional biomass energy; TCE, traditional commercial energy; ACE, advanced commercial energy

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consumption of farmers' production and life constitutes the fundamental issue of the overall development strategy (Yang et al., 2010; Tian, 2016). Although the market-oriented reform of coal and fuel oil supply, the country electric network transformation and the development of new energy have turned the major issue of rural energy from an insufficient supply to a structural contradiction of traditional and modern energies (Zhu, 2007; Chen, 2009; Wang et al., 2014), biomass is still the major source of energy consumption in rural China (MOA, 2016). Since rural energy had been excluded from the Chinese national commodity energy system as a subordinate entity in the overall development strategy (Zhang et al., 2009a, 2009b), the basic energy demand of the rural population has mainly relied on straw, firewood, and other traditional forms of biomass energy (Wang and Feng, 1997a; Chen and Chen, 2007). In addition, 90.11% of the coal used in rural China is raw coal of poor quality (Luo and Wang, 2015; Tian, 2016). Moreover, 27.29% of total energy consumption comprises crop straw, which has caused rural household energy consumption to be a source of $PM_{2.5}$ and haze shrouding China in the recent decade (Cheng et al., 2014; Yang et al., 2015; Sun et al., 2016). To fulfill its commitment to fighting climate change, household energy transition towards cleaner and more efficient fuels has been proposed by the Chinese government as an integrated component of a clean energy strategy (Zhu, 2007). This policy experiment provides a lens through which to elucidate the factors underlying household fuel choices, which is of critical importance for policy-making to facilitate the energy transition process in China, as well as the world, because of its central role in it (Kroon et al., 2013).

What are the factors underlying the process of rural household energy transition? Unfortunately, not enough focus has been given to the factors underlying such process both in developed and developing countries. The purpose of this paper is to investigate the energy transition process and its influencing factors in rural China. The paper contributes to the existing literatures in three ways. Firstly, while the majority of previous studies have focused on energy choice behaviors of rural residents by micro-level data and in local level, this paper investigates the national energy transition through macro-level data, which could be a help by providing a clear broad picture of energy transition in rural China and a well-grounded outlook for the future. Secondly, this study conducts an empirical analysis on factors underlying household energy transition in rural China that has attracted limited attention due to the lack of statistic data. Thirdly, specific attention is given to the effect of some Chinese government's efforts, such as the promotion of firewood-saving stoves and the establishment of rural energy management institutions, on rural energy transition.

The remainder of this paper is organized as follows. Beginning with an introduction of household energy transition and its corresponding policies in rural China, the second section also presents a literature review on energy ladder theory and energy staking theory. The third section discusses the methodology and data sources utilized in this study. The fourth section comprises the empirical results and a corresponding discussion. The study concludes with a discussion of the policy implications gained from the energy transition process and its influencing factors in rural China.

2. The present situation of rural household energy transition in China and its theoretical explanation

2.1. The pattern of rural household energy transition in China

Economic development implies a systematic change of economic structure (Chenery et al., 1988), and energy consumption structure refers to the composition of various energies consumed and their corresponding proportion to total energy (Liu et al., 2016). The structure of energy consumption changes over time as a response to economic development. At the stage of maintaining survival, the basic demand for energy is cooking and keeping warm, which largely depends on traditional biomass fuels. With the improvement of economic status,

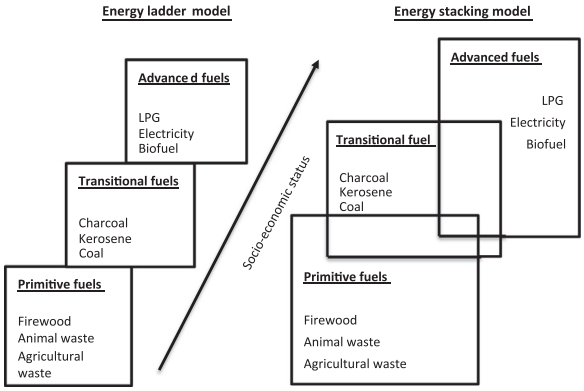

Fig. 1. The energy ladder model and energy stacking model (Hosier and Dowd, 1987).

however, more diverse energy sources are needed since households are able to afford various appliances. Biomass fuels are then only used to meet basic household demands, while advanced fuels function as a supplementary element (see Fig. 1).

In China, rural energy refers to energy used for both production and life in rural areas, and belongs to the category of energy construction and industry management (Yang, 1988), which is an essential component of China's Energy Strategy System and the equalization of basic public services in rural and urban areas (Tian, 2014). As defined by the National Energy Administration, rural energy includes straw, firewood, biogas, coal, oil, LPG, electricity, solar energy, wind power, geothermal energy, and ocean energy (NEA, 2015). The latter four energy sources are excluded in this study due to a severe absence of data and low consumption.

Fig. 2 illustrates the total energy consumption and the proportion of household energy consumption in rural China for the years of 1991–2014. Total energy consumption increased from 370.39 Mtce in 1991 to 379.09 Mtce in 2014, while the proportion of energy consumed by households decreased from 89.71% in 1991 to 84.92% in 2014, correspondingly. Despite the overall growth trend of total energy consumption and gradual declining proportion of household energy consumption, energy consumed by households still accounts for the majority of rural energy consumption, which was 85% in 2014, reflecting its significance to the rural energy revolution in China.

When considering household energy in rural China independently, its total consumption slightly decreased from 332.26 Mtce in 1991 to 321.94 Mtce in 2014, with an average annual growth rate of −0.14%, while household energy consumption per capita increased significantly from 399.99 Kgce in 1991 to 645.19 Kgce in 2014, with an annual growth rate of 2.62% (see Fig. 3) (NBS, 1992–2016a, 1992–2016b). The divergence of the two growth rates mainly attributes to the declining

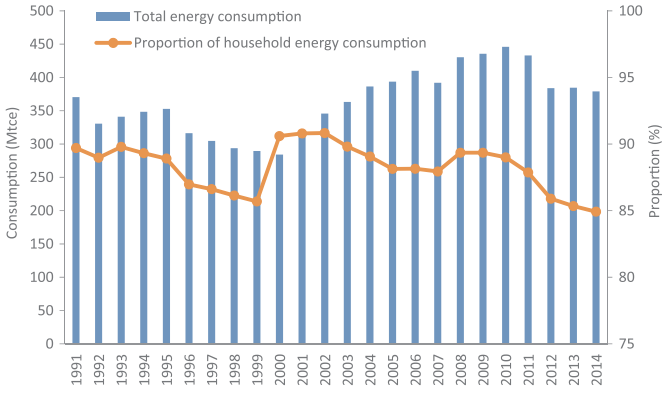

Fig. 2. Total energy consumption and the proportion of household energy consumption in rural China.