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Public acceptance of household energy-saving measures in Beijing: Heterogeneous preferences and policy implications

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ABSTRACT

Residents have different acceptance levels of household energy-saving measures and heterogeneous preferences for energy-saving attributes. Using questionnaire method, this paper studies the residents' acceptance of and preferences for 24 energy-saving measures in Beijing, China. Conjoint and variance analysis are used to examine preferences for attribute levels of energy-saving measures and the heterogeneity in preferences, respectively. The results show that energy-saving measures are relatively highly acceptable overall, while technical energy-saving measures are almost the least acceptable. The energy-saving domain (home versus transport) is the most important attribute that determines the acceptance level. Home and behavioral energy-saving measures are preferred to transport and technical energy-saving measures, respectively. For households living within the fourth Ring Road in Beijing and for people with high environmental concern, their average acceptance levels of energy-saving measures are 65% and 80% higher than those of their counterparts, respectively. Home energy-saving measures are more favored by households without elders over 60 years old, individuals with low educational level, and residents with low environmental concern, compared with their counterparts. Currently, effective policy tools targeting at behavioral energy conservation are scarce. Publicity about energy-saving measures contributes to improving residents' familiarity with these measures and environmental concern. Customized incentive policies are needed.

1. Introduction

In recent years, the residential sector has become a worldwide focus of studies on energy conservation and public policies. It has been the second largest energy consumer, following the industry sector in China (Fig. 1), approximately accounting for 11% of the total consumption. Energy consumption in China's residential sector is expected to experience rapid growth in the foreseeable future although it had increased at an annual rate of 7.71% between 2000 and 2014, mainly due to two reasons. First, according to the "New Urbanization Plan (2014–2020)" released by the State Council in 2014, there will be 100 million new urban residents in 2014–2020. Residential energy consumption maintains fast growth with the rapid urbanization since urban residents consume 1.5 times more energy than rural residents on average annually. Second, the energy consumption per capita remains at a relatively low level. For example, the annual household electricity consumption per capita in China was 417 kWh in 2011, approximately accounting for 1/11, 1/5, and 1/4 of that in the US, Japan, and the European Union, respectively (International Energy Agency, 2011).

China's residential sector has tremendous energy-saving potential despite its huge energy consumption and relatively fast growth rate in energy consumption. As for the period of the 11th Five-Year Plan (2006–2010), the energy efficiency labeling system alone was estimated to save 79 million tons coal equivalent (TCE) (Price et al., 2011). Guo et al. (2016) estimated that up to 2020, the maximum achievable household energy-saving potential would be 8.3% of the business-as-usual baseline consumption in Xiamen City. Residential energy conservation is of significance for easing intense energy supply, reducing air pollutants such as NO_x and SO_2, and mitigating CO_2 emissions (Nie and Kemp, 2014). In practice, energy conservation is realized through adopting specific energy-saving measures, which commonly have three key attributes: the domain (home versus transport), the strategy (technical versus behavioral), and the amount of energy savings (small versus large). These attributes would affect residents' acceptance of energy-saving measures.

This study mainly investigates how three key attributes affect the residents' preferences for diversified energy-saving options and the heterogeneity in preferences among different household categories. The behavioral habit and characteristics of household energy consumption

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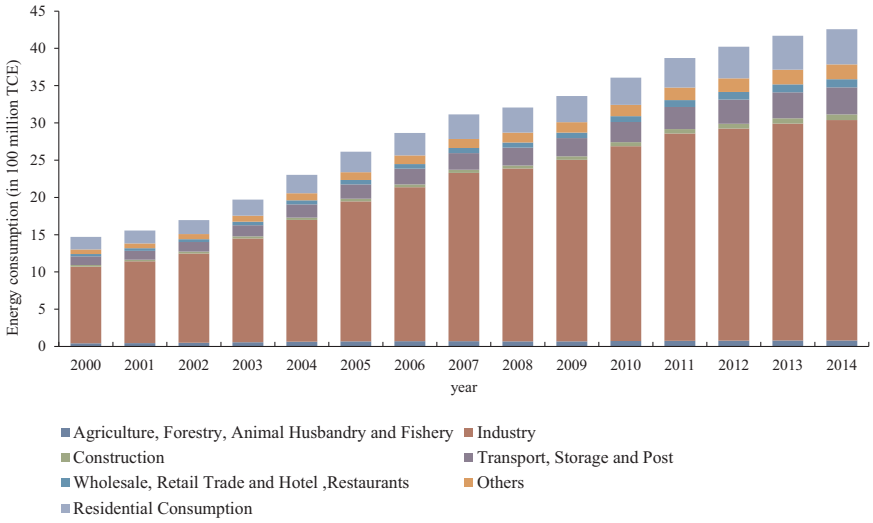

Fig. 1. Energy consumption distribution among different sectors in China (2000–2014).
Data sources: China Energy Statistical Yearbook (2014, 2015).

are further revealed to help promote energy conservation by nudging household energy-use behavior.

For energy efficiency, studies usually paid solely attention to energy supply in the 1970s, and attention was turned to the energy demand after the oil shocks in the 1980s, when the studies about household energy consumption have grown popularity in many sectors among researchers and policy makers (Xu et al., 2012, 2016; Peng et al., 2016). Mainstream studies focusing on energy-saving measures usually include three aspects, namely, identifying the determinants of purchasing energy-efficient endurable goods, the incentive mechanism for promoting behavioral energy-saving measures, and preferences for energy-saving measures.

Firstly, identifying the barriers to and determinants of the diffusion of energy-saving technologies has significant policy implications for promoting energy-efficient appliances and energy conservation. The study about the determinants of purchasing A-class efficient appliances in Germany found that housing characteristics and the electricity price would significantly impact the purchase decision, while socioeconomic variables had a weak effect (Mills and Schleich, 2010). Qiu et al. (2014) focused on the role of consumer risk preference in Arizona and California in the US. The results showed that the more risk-averse the consumers were, the less likely they were to buy energy-efficient appliances. In the case of Tunisian households, Jridi et al. (2015) found that villa owners were more likely to buy solar water heater compared with tenement residents; the smaller the price gap was between energy-efficient and energy-inefficient goods, the more likely the low-income households were to buy energy-efficient goods. In terms of the willingness to pay for energy-saving measures, Banfi et al. (2008) and Kwak et al. (2010) found that the willingness to pay outweighed the implementation costs of installing air cleaning system and sealing doors and windows in Switzerland, and was also higher than that of purchasing energy-efficient air conditioner and heating system in Korea respectively. When it comes to the study in China, Liu et al. (2015) analyzed three building energy-saving renovation projects and found that whether residents voluntarily participated in projects had an impact on the satisfaction in these projects but had no effect on the shift in household energy-use behavior. The stream of these studies mainly investigated the external factors that affect residents' preferences for energy-saving measures, without considering the role of own attributes of energy-saving measures, which will be considered in the study.

Secondly, in order to promote household behavioral energy-saving measures, searching effective incentive mechanisms constitute the focus of studies. Researches contended that residents have little knowledge about the relationship between daily activities and energy consumption since daily energy consumption is usually invisible (Burgess and Nye, 2008). Consequently, it is expected that energy savings could be achieved by providing feedback information on energy use to make energy consumption visible, which had been proven correct by a host of studies (Abrahamse et al., 2007; Darby, 2006; Faruqui et al., 2010; Hargreaves et al., 2010). Many other effective mechanisms of influencing household energy-consuming behavior and reducing energy use include individualized social marketing approaches (Daamen et al., 2001; Thøgersen, 2007), commitment strategies (Katzev and Johnson, 1983, 1984), eliciting implementation intentions (Bamberg, 2002; Jakobsson et al., 2002), and modelling and providing information about the behavior of others (Schultz et al., 2007). Furthermore, environmental concern laid a solid foundation for energy conservation, and raising environmental concern among the public was an effective means of fostering persistent energy-saving behavior (De Groot and Steg, 2009; Lindenberg and Steg, 2007; Steg et al., 2005). However, household preferences for energy-saving strategies had not been completely unveiled and were still under-researched for policy design to influence residents' energy-use behavior.

Thirdly, concerning studies on preferences for energy-saving measures, Poortinga et al. (2002) found that behavioral energy-saving measures and governmental laws and regulations on energy conservation were preferred by people with high environmental concern, while market-based energy-saving measures were favored by people with low environmental concern. By conducting a field experiment involving over 80,000 households in California, Costa and Kahn (2013) concluded that the electricity saving amount of liberal households was two to three times more than that of conservative households. Thus, it would be more effective to implement energy-saving measures in liberal communities. Liang et al. (2017) investigated consumers' attitudes toward extra payment for promoting energy efficiency in the US. They found that homeowners were more likely to prefer demand charges than renters and there was preference heterogeneity among consumers in terms of demographics and behavioral factors. Those studies focused mainly on public heterogeneous preferences for energy-saving measures and only Poortinga et al. (2003) further studied household preferences for different attributes of energy-saving measures and the heterogeneity in preferences in the Netherlands. Their results showed that the energy-saving strategy played the most important role in determining the acceptability of energy-saving measures, and home energy-saving measures were preferred to transport energy-saving measures.

This paper focuses on China, the largest energy consumer around the globe, and aims to unveil household energy-consuming habits and to evaluate household acceptance and preferences for energy-saving measures from three points of view, namely, the domain, the strategy, and the energy-saving amount. To this end, the paper first collects and summarizes 24 practical household energy-saving measures and calculates the average annual amount of energy savings for each measure. Second, energy-saving measures are presented to households by issuing