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# Characteristics of residential energy consumption in China: Findings from a household survey



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## HIGHLIGHTS

- We develop the first comprehensive survey of residential energy consumption in China.
- A typical Chinese household in 2012 consumed 1426 kilograms coal equivalent.
- Space heating accounts for half of energy demand.
- A large rural–urban gap exists in terms of energy sources and end-use activities.
- Results reveal challenges and opportunities for China's energy policy.

## ARTICLE INFO

### Article history:

Received 17 April 2014

Received in revised form

14 July 2014

Accepted 15 July 2014

Available online 5 August 2014

### Keywords:

Household survey

Energy consumption

China

## ABSTRACT

A comprehensive survey of 1450 households in 26 Chinese provinces was undertaken in 2012 to identify the characteristics and potential driving forces of residential energy consumption in China. The survey covers six areas: household characteristics, dwelling characteristics, kitchen and home appliances, space heating and cooling, residential transportation, and electricity billing, metering, and pricing options. The results show that a typical Chinese household in 2012 consumed 1426 kilograms standard coal equivalent, which is approximately 44 percent of the 2009 level in the United States and 38 percent of the 2008 level in the EU-27. District heating, natural gas, and electricity are three major residential energy sources, while space heating, cooking, and water heating are three major end-use activities. Moreover, the results suggest a large urban–rural gap in terms of energy sources and purpose of usage. Commercial energy is used mainly for space heating in urban areas, while biomass dominates mainly for cooking purpose in rural areas. The survey results can help decision makers and scholars identify energy conservation opportunities, and evaluate the effectiveness of energy policies.

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## 1. Introduction

With accelerating urbanization and rising income levels in China, residential energy consumption has grown rapidly over the last two decades, with an annual growth rate of 8 percent. The growth in demand for electricity, in particular, is even higher, with an annual average growth rate of 12.35 percent (NBS, 2012). This rapid increase mirrors the growth of major durable consumer goods, such as air conditioners, computers, shower heaters, and microwave ovens. In the near future of 2020, with 60 percent of the population expected to live in cities, residential energy consumption is likely to continue its rapid growth. The strong energy demand, on one hand, reflects the improvement of people's

quality of life and the nation's development level (Niu et al., 2012). On the other hand, it may conflict with China's efforts toward energy conservation and greenhouse gas emissions abatement. As part of its national low-carbon plan, China is considering setting a cap on energy use (Reuters, 2011). Therefore, it is essential for decision makers and the public to understand the patterns, determinants, and implications of households' demand for energy and its consequences for climate change.

Surveys of household residential energy are conducted regularly by government agencies in many developed countries and some developing countries and have become a fundamental source of energy data. For example, the US Energy Information Administration started to survey US households' energy use in 1978, based on which several informative studies have been conducted. A similar and comprehensive survey of its kind, however, does not exist in China. Currently, only partial information about residential energy can be gleaned from the literature and national statistics. For example, Wang and Feng (2003)

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investigate the utilization ratio of energy as well as serious pollution caused by energy consumption in the Jiangsu province. Based on 200 randomly selected households in Xi'an, the capital of the Shaanxi province, [Tonooka et al. \(2006\)](#) clarify the status of energy consumption, and estimate emissions of greenhouse gases and air pollution from the residential sector. [Feng et al. \(2010\)](#) investigate the barriers to energy efficiency at the residential sector and explore patterns of household electricity consumption in Liaoning province. [Zhou and Teng \(2013\)](#) use annual household survey data from Sichuan province to estimate the income and price elasticities of residential electricity demand from 2007 to 2009. While all these local studies focus on residential household energy consumption, they do not capture regional differences in energy use.

To fill this gap, we developed a China Residential Energy Consumption Survey (CRECS) questionnaire and used it in 26 provinces of China. The survey is heavily based on the US Department of Energy and Energy Information Administration Residential Energy Consumption Survey. It covers six areas: household demographics, dwelling characteristics, household appliances, space heating and cooling, patterns of private transportation, and electricity billing, metering, and pricing options.

The survey makes three important contributions. First, to the best of our knowledge, this is the first attempt to develop a comprehensive survey and provide an overview of residential energy consumption in China. The information revealed from CRECS will inform policy makers and the public about changes in energy usage patterns in Chinese households. This also will help to develop more credible projections of energy demand through a better understanding of crucial determinants, such as significant changes in age structure, accelerating urbanization, and household income growth.

Second, our study provides the basis for evaluating the effectiveness of various efforts in China to promote energy efficiency, such as programs promoting efficient lighting and energy efficiency product labeling. The comprehensive data allows us to examine the degree to which households are actually participating in these programs and their attitudes and behavior in practice at a national level.

Third, surveys of this kind will form an important database for evaluating China's residential energy conservation policy. China implemented an increasing block electricity tariff on July 1, 2012, and will implement a progressive water pricing scheme before 2015 ([Xinhua, 2012](#)) and multitier household natural gas pricing by the end of 2015 ([Reuters, 2014](#)). To evaluate the effectiveness of these policies and understand how households respond to these pricing schemes will require detailed electricity and natural gas consumption and price data at a micro level.

The main objective of this survey is to understand the characteristics and possible driving forces of residential energy consumption and therefore identify the underlying challenges, opportunities, and possible policy measures. We have several major findings. First, a typical household consumed 1426 kgce in 2012 and annual per capita energy use was 612 kgce.<sup>1</sup> District heating<sup>2</sup> is the major fuel source, followed by natural gas and electricity. In both urban and rural households, most energy is used for space heating, followed by cooking and water heating.

Second, large urban–rural gaps exist in terms of fuel choice and end-use activities. An urban household consumed 1.4 times more

energy than a rural household. Commercial energy is widely used in urban areas, while biomass still dominates in rural areas.

Third, household energy consumption in China is still lower than in developed countries. However, driven by a rich culinary culture, China's households consume 23 percent of their energy for cooking, which is generally higher than in other countries.

The remainder of this paper is organized as follows. In [Section 2](#), we provide a detailed description of the survey. In [Section 3](#), we present the main statistical results. Our energy flow chart analysis is described in [Section 4](#). We discuss policy implications in our concluding remarks in [Section 5](#).

## 2. Description of the survey

The CRECS survey was administrated by the Department of Energy Economics at Renmin University of China during February 2013. The questionnaire was designed with the aid of a few pilots and on the basis of the US Residential Energy Consumption Survey 2009. The questionnaire covered six main areas with 324 questions in total: household demographics, dwelling characteristics, household appliances, space heating and cooling, patterns of private transportation, and electricity billing, metering, and pricing options. To have a clear picture of household energy mix, for each section we collected detailed energy relevant information, such as appliance type, frequency and duration of appliance use, different types of energy costs, and electricity bill information.

In December 2012, approximately 120 undergraduate and graduate students from Renmin University were recruited to administer the CRECS survey in their hometowns, representing 26 provinces, where they were going to spend their winter holiday in February 2013.<sup>3</sup> To guarantee the survey quality, all interviewers were required to attend a half-day training lecture. During the lecture they received intensive training regarding properly understanding each question, conducting interviews, and using smart phones or GPS services to locate household addresses.

Households that met four criteria were invited to participate in the survey. First, a household had to be able to provide its electricity bills or electricity consumption records for 2012. Second, a household had to have used energy only for consumption purposes, rather than for production purposes. Third, the respondents must have lived in their home for more than six months in 2012. Fourth, the household had to be the only one from a defined community to participate. To incentivize participation, each household would get a mobile phone prepaid card worth 50 RMB as a payoff after they finished the survey. A total of 1640 households<sup>4</sup> were initially invited to take the survey, while 1542 eventually enrolled in the study (a high response rate of 94 percent). After validity and consistency checks, 1450 total observations remained for the final analysis, with 80 percent from urban areas and 20 percent from rural areas.<sup>5</sup>

<sup>3</sup> The distribution of the samples among province is based on household population in the 6th National Population Census in 2010. The official statistics show that the percentage of the population in eastern, middle, and western China is 40.61 percent, 31.7 percent, and 27.69 percent, respectively ([NBS, 2010](#)). Our samples' geographic distribution for eastern, middle, and western provinces is 38.28 percent, 43.24 percent, and 18.48 percent, respectively.

<sup>4</sup> Since this is the first attempt to conduct a comprehensive household energy survey, we focused more on questionnaire and questions design than on survey protocol. The interviewers were therefore allowed to randomly contact the families in their social networks and invite them for the survey, conditional on these families meeting the four criteria discussed above.

<sup>5</sup> According to the National Bureau of Statistics' definition, the urban area includes city and town ([NBS \(National Bureau of Statistics\), 2006](#)). There are 64 percent surveyed household in cities, 16 percent in towns and 20 percent in rural areas. To facilitate the comparison, we combine the city and town groups into the urban category.

<sup>1</sup> Standard coal is a metric widely used in China. The heat value of 1 kilogram standard coal is 29,307 kJ, or 7000 kcal.

<sup>2</sup> District heating is a system for distributing heat for centralized residential and commercial buildings. Compared with traditional individual heating system, district heating systems consume less energy and emit less pollution ([Keçebaş et al., 2013](#)). Fuels used for various district heating systems include natural gas and coal in China. However, it is difficult to distinguish the source. Therefore, we treat district heating as one particular fuel source in our study.

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