Chapter 2
A Survey Analysis of Energy Use and Conservation Opportunities in Chinese Households

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Abstract Based on the detailed CRECS-2012 dataset with 1,450 surveyed households, this study provides a brief overview of Chinese energy consumption at the household level in 2012. Furthermore, this study investigates the various types of household energy conservation behaviour. We have several major findings. First, our results show that a representative Chinese household in 2012 consumed 1,426 kgce (standard coal equivalent), which is approximately 44 % of that in the US in 2009, and 38 % of that in the EU 27 in 2008. Space heating is the most energy-intensive activity in a household, accounting for over half of the consumption. Second, the barrier to energy efficiency in space heating lies in the current pricing system of district heating. In order to improve the individual incentive to conserve energy, the reform should be carried out so that heating charges are made according to the actual usage. Third, although there are various government programmes to subsidise energy-efficient appliances, the purchase rate for less energy-intensive appliances, such as TVs, water heaters and computers, is still low. This calls for more research to understand the determinants of household energy conservation behaviour.

Keywords Household survey · Energy consumption · China

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2.1 Introduction

China's huge energy demand and its related CO_2 emissions have attracted a lot of attention both internationally and domestically. In 2010, China overtook the United States and became the largest consumer of energy products in the world (EIA 2014). The energy demand of the residential sector, as shown in Fig. 2.1, is continuously increasing and is the second largest user among all sectors. In 2011, the residential sector (excluding private transportation) consumed 374.1 Mtce, accounting for 11 % of national total consumption (NBS 2012).

There are two reasons behind the prediction that China's residential energy demand will continue to grow rapidly in the near future. First, there is still a vast gap in energy consumption per capita between China and other developed countries. As shown in Fig. 2.2, China's per capita household electricity usage is far

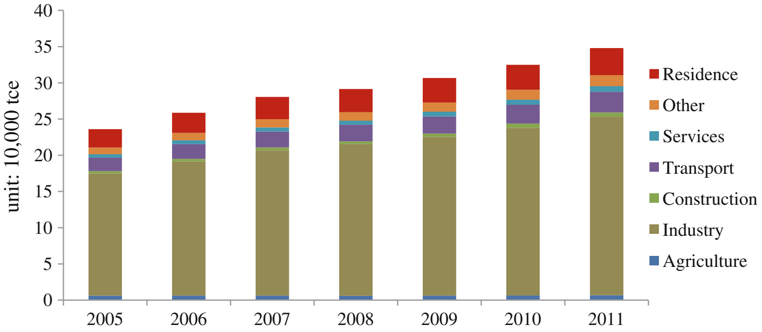

Fig. 2.1 Total energy consumption by sector in China (2005–11, unit: 10,000 tce). *Source* NBS, *China Statistical Yearbook*, various years

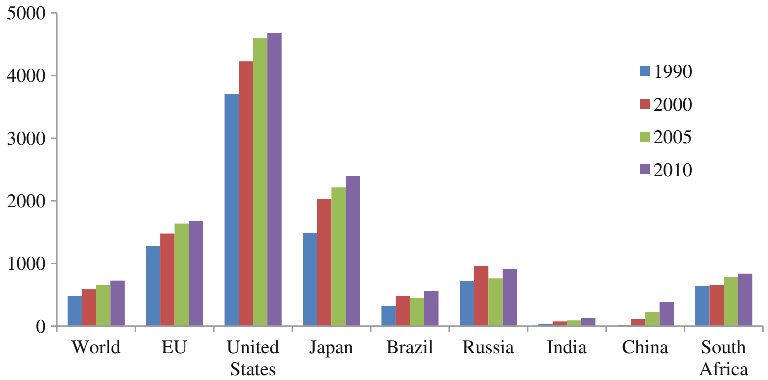

Fig. 2.2 Average electricity consumption of households per capita (unit: kWh/person). *Source* World Energy Council (2014)

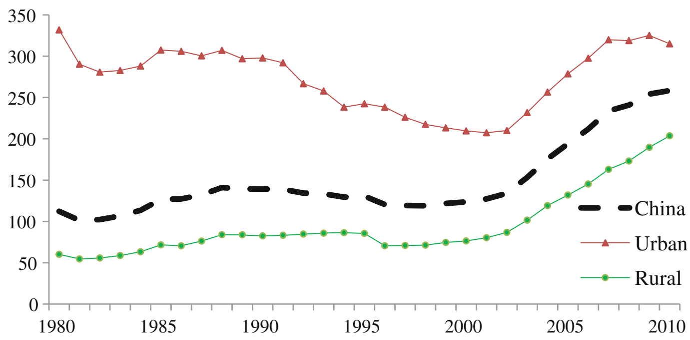

Fig. 2.3 Per capita household energy consumption in urban and rural area (1980–2010, unit: kgce). *Source* NBS (2012)

lower than that of developed countries, most transition countries and the world average. China is now on the industrialisation track. The catch-up process, accompanied by the people's need to improve their living standards, will inevitably generate rapid energy demand.

Another reason for the surging energy demand is the giant urban-rural gap within the country and the accelerating urbanisation process. In the 1980s, per capita energy consumption in the urban areas was five times that in the rural areas (see Fig. 2.3). Although this ratio is narrowing, the city-dweller still consumed 50 % more than in the rural resident in 2010.[1] Meanwhile, around 100 million rural residents are expected to urbanise by 2020, raising the urbanisation rate from 52.6 % in 2013 to 60 % (China daily 2013). This vast population migration and resettlement will lead to not only an increase in energy demand but also the energy transition from biomass to modern commercial energy.

On one hand, this strong energy demand reflects the improvement in people's quality of life and economic development level (Niu et al. 2012). On the other hand, it places increasingly tight constraints on resources and the environment. More importantly, it may conflict with, rather than contribute to, China's efforts towards energy conservation and GHG abatement. Among all energy conservation and climate change mitigation options, the improvement in energy efficiency played a vital role and was the most effective way to manage and restrain the growth in energy consumption, and reduce emissions globally (Ürge-Vorsatz/Metz 2009). It is important for both decision-makers and the public to understand the actual situation and characteristics of household energy efficiency, and then identify the underlying opportunities, policy measures, as well as challenges to conserve energy in China's residential sector. However, existing studies on household energy

[1]The narrowing urban-rural gap is due to the wide use of commercial energy (i.e. natural gas in the cities) and a broader statistical coverage (i.e. biomass usage in rural areas).

consumption are not sufficiently in-depth. One reason is that more attention has been paid to the industrial sector—the largest energy user. Another reason is the lack of household-level data.

To fill his gap, Renmin University conducted the first Chinese Residential Energy Consumption Survey (CRECS) from December 2012 to March 2013, during which 1,450 surveyed households were surveyed. Based on the detailed data from the CRECS, this study provides a brief overview of Chinese energy consumption at the household level in 2012, and allows us to have a better understanding of household energy conservation behaviour.

The remainder of this chapter is organised as follows. Section 2.2 reviews the energy conservation policies in the residential sector. Section 2.3 introduces the survey and presents the estimation of household energy consumption. Section 2.4 discusses the energy conservation opportunities and challenges. The conclusions and policy implications are given in the final section.

2.2 Energy Conservation Policies in the Residential Sector

The Chinese government has carried out a series of projects to promote energy efficiency and curb excessive energy consumption, including various policies introduced in the residential sector. In order to improve both consumer awareness about energy efficiency and minimise the use of less efficient appliances, in August 2004 the Chinese government began an energy efficiency labelling and product identification programme. This labelling management system, also known as the China Energy Label, is a type of information tag attached to the product, which indicates the energy efficiency grade, energy consumption and other indices of energy-using products. Labelling is done on a scale of one to five, with one being the most efficient and five the least. The programme initially covered only three appliances: air-conditioners, refrigerators, and washing machines. However, the mandatory energy efficiency labelling programme presently includes personal computer monitors, light LCD TVs, plasma TVs, electric rice cookers, induction cookers, washing machines, refrigerators, electric heaters, printers, copy machines, compact fluorescent lamps, high pressure sodium lamps, and electric fans.

To further improve energy efficiency in the residential sector, in 2009 the government launched a project to promote 10 different types of energy-efficient products through the issuance of financial subsidies for products such as high-efficiency illumination products and energy-efficient motors. Energy-efficient products refer to those with energy efficiency labels of 1 and 2. To promote the use of these products and benefits to the consumer, financial subsidies are provided at various levels based on the types of products as well as labels. For example, a customer who purchases an air conditioner unit with an energy efficiency label of 2 will enjoy a subsidy of RMB 300–650, while products labelled with an energy efficiency label of 1 will come with a subsidy of RMB 500–850. In that year, in order to reduce vehicle-related fuel use and air pollution, the government also initiated a project called "replace old automobiles with new ones". According to this regulation, owners who retired their old or yellow-label[2] vehicles early were entitled to government subsidies at various levels from RMB 3,000–6,000.

To change consumers' behaviour and make them more responsive to resource and energy prices, the government has made comprehensive plans to carry out pricing reforms for electricity, water, oil, and natural gas. The first pricing reform was conducted in the electricity sector. Pilot experiments of electricity pricing reform were carried out in three provinces, namely Sichuan, Fujian and Zhejiang. With the lessons and experiences learned, on 1 July 2012, the National Development and Reform Commission (NDRC) introduced a nationwide progressive pricing reform for residential electricity use. According to the NDRC draft, electricity prices would follow a three-tiered residential rate structure for power usage. Taking Zhejiang province as one example, if a household consumes less than 2,760 kWh per year, the price is set at 0.538 RMB per kWh. If consumption is increased to 2,761–4,80 kWh, the price will increase by RMB 0.05 per kWh. The price could increase by RMB 0.30 per kWh if electricity consumption exceeds 4,800 kWh. The government expects that 70–80 % of Chinese households consume no more than the baseline level (110 or 140 kWh per month) and are charged the first-tier price for marginal consumption.

Resources such as water are usually underpriced to protect citizens and industries from inflation. However, such a pricing policy will not encourage efficient use of resources as a result of low cost. The government is increasingly aware of the need to charge higher water prices for the heaviest urban consumers to conserve diminishing resources and spur investment. After a few trials in some regions, the reform plan is expected take place nationwide by the end of 2015. Similar to the electricity price reform, the water price reform plan will also include a three-tiered pricing structure, based on water usage for households in all cities and some towns. Under the plan made by NDRC, the heaviest consumers—or top 5 % of households —will pay at least three times the base rate of water. The second tier will pay 1.5 times the base rate, while the lowest tier—roughly 80 % of urban households—would not be affected by the changes.

In the next section, we use the household data set to provide an overview of residential energy consumption. This is followed by a detailed analysis of household energy conservation behaviour.

[2]Yellow-label vehicles refer to those that fail to meet the European No.1 standard for exhaust emissions.

2.3 An Overview of CRECS 2012

2.3.1 Survey Design

The Department of Energy Economics at Renmin University of China (hereinafter referred to Renmin University) organised the first Chinese Residential Energy Consumption Survey (CRECS) from December 2012 to March 2013. Based on the Residential Energy Consumption Survey 2009 in the US (RECS-2009) and a few pilot surveys, a comprehensive questionnaire was designed to gather the energy and related information from individual households in reference year 2012. It comprised 324 questions and covered six main parts: household demographic characteristics; housing unit characteristics; kitchen and home appliances; space heating and cooling; transportation; energy consumption and expenditures. Each part includes detailed specific issues related to energy equipment, frequency of use, expenditure as well as energy use preference/attitudes.

As the investigators needed detailed parameters/information about various energy equipment and face-to-face interviews can take over one hour, we adopted a simple but effective sampling strategy to enhance data quality/reliability and lower refusal rate. In December 2012, around 120 undergraduate and graduate students from Renmin University were recruited to participate in the CRECS survey. These students were first requested to contact up to 20 candidate families within their local social network. The households that met the following criteria were surveyed. The households: (i) had to be able to provide electricity bills or records for 2012; (ii) were detached and individual households, rather than a collective or tenant family; (iii) used energy only for consumption purposes, rather than for production; and (iv) consisted of respondents who lived in their homes for more than six months in 2012. In addition, we did not select two or more families who lived in the same community to avoid homogeneity. Each respondent received a mobile phone with a prepaid card worth 50 RMB after they finished the survey. Each investigator received 50 RMB for one valid questionnaire as a payoff. At the end of the first stage, a total of 1,640 households were contacted to participate in this survey.

In January 2013, all students participating in the survey underwent a one-day training session to understand each question, grasp interviewing skills, and learn how to gather the geographic information via an equipped GPS device. The survey was implemented in the winter holiday from January to February 2013. The investigators communicated directly with the representative of the household or his/her spouse and filled out the questionnaire. The well-established personal relationships between respondents and investigators allowed for the double-checking of detailed information, such as the power of home appliances. A total of 1,542 households were enrolled with a high response rate of 94 % by the end of March 2013.

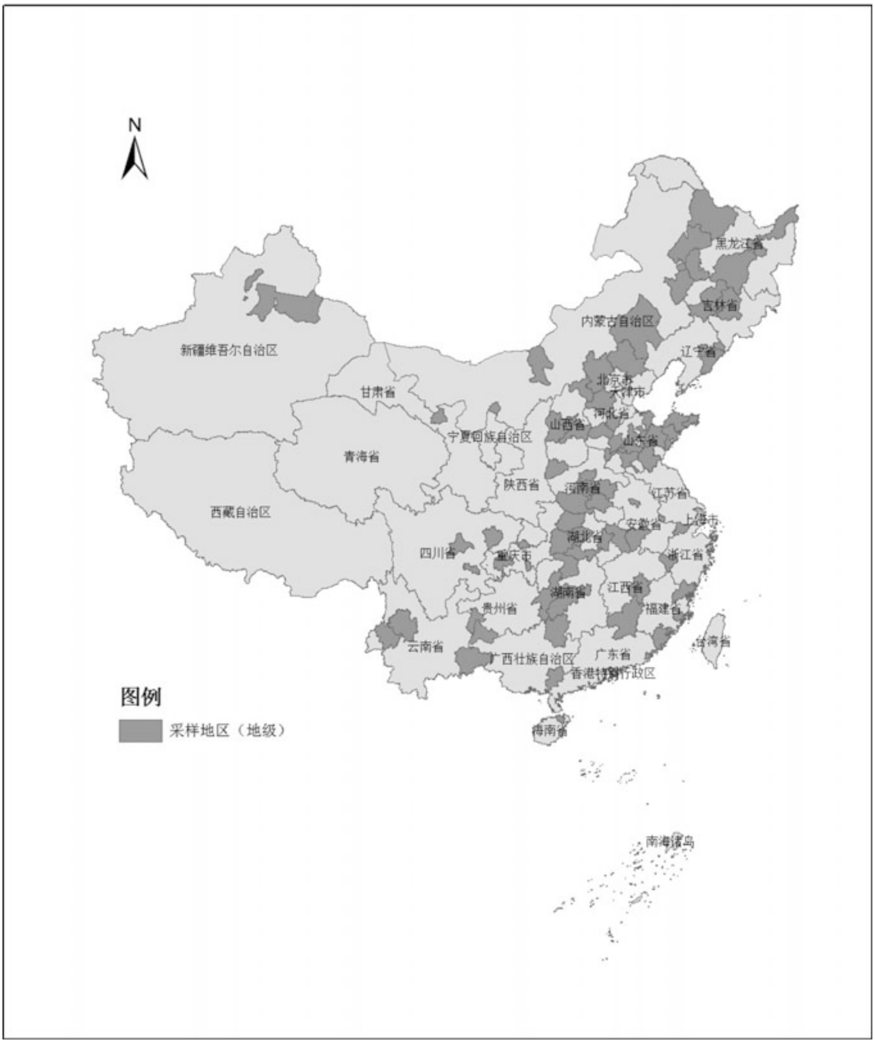

Fig. 2.4 Geographical distribution of sample coverage at the prefecture level. *Source* Authors' calculation

Random telephone interviews were conducted to examine the validity and consistency in the responses. This checking procedure left 1,450 observations for final analysis. As Fig. 2.4 shows, our sampled households covered 114 prefecture cities in

Table 2.1 Profile of household characteristics

Variables	Unit	CRECS-2012			NBS 2013[a]		
		Total	Urban	Rural	Total	Urban	Rural
Household size	Number of persons	2.65	2.57	2.95	3.02[b]	2.86	3.88
Male percentage	%	48.5	48.2	49.5	51.3[b]	50.6[b]	51.5[b]
Average age	Years	40.6	40.4	41.4	–	–	–
Proportion of employment per household	%	65.3	64.9	66.2	–	52.1	71.1
Schooling year	Years	10.2	11.2	6.8	8.8[b]	10.4[b]	7.6[b]
Income	10,000 Yuan	9.78	10.98	4.90	–	7.71	4.26
Expenditure	10,000 Yuan	5.28	5.50	4.33	–	6.39	3.73
Dwelling area	m^2	103.73	96.15	134.98	–	94.1	143.9

Source Zheng et al. (2014: Table 1)
Note CRECS China Residential Energy Consumption Survey; *NBS* National Bureau of Statistics; m^2 square metres
[a]NBS, *China Statistical Yearbook* (2013)
[b]NBS, *China Population and Employment Statistical Yearbook* (2012)

26 provinces in mainland China,[3] of which 80 % are in urban areas and 20 % in rural areas.[4]

Table 2.1 compares our sample with the official records. For household demographic characteristics, the average household size (2.65 people) was slightly less than the official number (3.02 people). The average age of family members was 40.6 years, of which 48.5 % were male and 65 % were employed. The average schooling was 10.2 years for all members, which is higher than the official statistics. In 2012, a typical household earned 97,800 yuan and the annual expenditure was 52,800 yuan. Moreover, the average living space for urban and rural households in our sample was 96 and 135 m^2, respectively. This is much closer to the NBS's number. Detailed information on the energy usage pattern is described in the later sections.

[3]The distribution is as follows: Anhui (42), Beijing (72), Fujian (47), Gansu (20), Guangdong (6), Guangxi (43), Guizhou (21), Hainan (2), Hebei (65), Henan (134), Heilongjiang (43), Hubei (138), Hunan (119), Jilin (76), Jiangxi (20), Liaoning (23), Inner Mongolia (40), Ningxia (20), Shandong (222), Shanxi (55), Shanghai (66), Sichuan (37), Tianjin (20), Xinjiang (26), Yunnan (29), Zhejiang (34), Chongqing (30).

[4]64 % in cities, 16 % in towns and 20 % in rural areas. To facilitate the comparison, we combined the cities and towns.

2.3.2 Measuring Household Energy Efficiency

There is no consensus on measurement of household energy efficiency. In the EU's comprehensive ODYSSEE programme, the indicator of household energy efficiency is defined as the unit consumption of households per dwelling, or per square metre. Depending on various research purposes, other detailed issue indicators can be defined for various end-use activities or appliances. In 1990, an overall index, ODEX, was established by weighting the energy efficiency of heating, water heating, cooking, refrigerators, freezers, washing machines, dishwashers and TVs. ODEX and its sub-index can be used to monitor and trace the energy efficiency progress for EU households (Lapillonne/Pollier 2014).

Acknowledging that energy efficiency is subject to the availability of data and is mixed with non-efficiency factors (i.e. structural, behavioural and economic differences), the USA's Energy Information Administration (EIA) has developed different indicators to meet various constraints and policy objectives. It further distinguishes between site energy and primary energy intensity. Primary energy is the amount of energy delivered to an end-user (e.g. residential housing unit) adjusted to account for the energy that is lost in the generation, transmission, or distribution of the energy. Site energy is the amount of energy delivered to an end-user without adjusting for the energy lost in the generation, transmission, and distribution of the energy (EIA 2000). Both types of energy intensity can be adapted to households, household members and converted to square feet.

We adopted energy intensity, that is, energy consumption per household, to measure energy efficiency. Households usually consume various types of energy for different end-use activities. Suppose there are i surveyed households, m types of energy activities and n types of energy. For the i-th family, $e_{i,m,n}$ is the amount of the n-th energy for m-th purpose. In our survey, we had seven types of energy: coal, natural gas, LPG, electricity, fuelwood, district heat, and solar power. The energy end-use activities included: cooking, space heating, space cooling, use of home appliances, and water heating.[5] Estimation of a household's energy consumption consists of two steps.

First, the consumption of various types of energy is estimated by the end-use activities. For example, for an electrical appliance, $e_{i,m,n}$ is determined by the output power, usage frequency and duration. The energy efficiency level and other technical characteristics (i.e. inverter air-conditioner) are taken into account by multiplying by a coefficient that is adjusted according to various national energy efficiency standards.[6] The calculation of energy for heating depends on the heating type. For the distributed heating systems, it is determined by two parameters. One is the heating period, which was collected from the questionnaires; the other is the average power

[5]Personal transportation is excluded to make our result comparable with other studies.

[6]For the energy efficiency standard of refrigerators, washing machines, televisions, computers, air-conditioners and electrical water heaters refer to GB 12021.2-2008, GB 12021.4-2004, GB 24850-2010, GB 28380-2012, GB 12021.3-2004 and GB 21519-2008, respectively.

or consumption rate, which can be obtained from the survey or related literature (Chen et al. 2013; Saidur et al. 2007). District heating is treated as one of the fuel sources for the central heating system user. Because fuel and technology information about the heating sources was not available, reference values (energy consumption per m^2 per heating season) were set up based on relevant energy efficiency standards for residential construction.[7] This was adjusted in accordance with the age of the building, window frame type, and insulation measures.

Second, various types of energy with different heat values need to be converted into a standard unit for comparison purposes. One can convert them into the standard coal equivalent (kgce) by multiplying by the conversion coefficient $coef_n$ for the n-th energy. Then the annual energy consumption for the i-th household can be measured as follows (Niu et al. 2012).

$$E_i = \sum_{m=1}^{M} \sum_{n=1}^{N} e_{i,m,n} \cdot coef_n \tag{2.1}$$

Also, the total energy consumption of n-th energy is

$$E_{i,n} = \sum_{m=1}^{M} e_{i,m,n} \cdot coef_n \tag{2.2}$$

Similarly, the total energy consumption for m-th activities is

$$E_{i,m} = \sum_{n=1}^{N} e_{i,m,n} \cdot coef_n \tag{2.3}$$

Based on Eq. (2.1), individual household energy consumption is first estimated. Energy usage by various type and purpose is computed from Eqs. (2.2) and (2.3), respectively.

As shown in Table 2.2, China's total household energy consumption was 1,426 kgce in 2012, which was less than several OECD (Organization for Economic Co-operation and Development) or economically developed countries. For instance,

[7]The energy conservation programme in the construction sector started in 1986. In the first stage, according to the energy conservation standard (heating residential buildings) (JGJ 26-86), it was required that energy consumption in residential construction be cut by 30 % on the basis of the 1980–81 level. In the second stage, the energy conservation standard (heating residential buildings) (JGJ 26-95), required that energy consumption in new construction be cut by 50 % on the basis of the 1980s level. In the third stage, China announced an energy efficiency standard for residential buildings in the hot summer and cold winter zones (JGJ134-2010) and other standards. The goal in this period was to attain 30 % energy savings on the basis of the second stage.

Table 2.2 Country comparison of household energy consumption

Country	Household energy consumption (kgce per household)
USA (2009)	3,227
Canada (2010)	3,287
EU27 (2008)	3,717
Germany (2008)	2,288
France (2008)	2,244
United Kingdom (2008)	2,353
China (2012)	1,426

Source USA (2009) comes from *U.S. EIA: 2009 RECS Survey Data*, at http://www.eia.gov/consumption/residential/data/2009/index.cfm?view=consumption; Canada (2010) comes from Natural Resources Canada: Statistics Canada's Report on Energy Supply-Demand in Canada (RESD), at http://data.gc.ca/data/en/dataset/27155507-0644-4077-9a97-7b268dfd8e58; EU 27 (2008) and member states' data comes from EU-ODYSSEE: Household Energy consumption, at http://www.indicators.odyssee-mure.eu/online-indicators.html; China (2012) is estimated by authors

the total household energy consumption in China in 2012 was approximately 44 % of that in the US in 2009, and 38 % of that in the EU 27 in 2008.[8]

2.3.3 Fuel Sources and End-Use Activities

The energy balance table of Chinese households in 2012 is shown in Table 2.3. In general, Chinese residents obtain energy mainly from seven types of sources, including district heating, electricity, fuelwood, gas, LPG, coal, and solar. District heating supplies 45 % of total energy needs, followed by natural gas and LPG. Electricity accounts for 15 % of the total energy supply, used for diverse purposes, e.g. household appliances (including lights), cooking, cooling, and water heating. Fuelwood, solar and coal are less important energy sources. Fuelwood is used for cooking and space heating. Solar is only used for water heating.

For the end-use purpose, space heating is the most energy-intensive, followed by cooking, and they account for 54 and 23 % of total energy consumption, respectively. Residents employ various types of energy for cooking, mostly gas, LNG and electricity; less so from fuelwood and coal. Water heating is the third largest energy user (14 % of total energy consumption). Almost 70 % of water heating uses gas and LNP, while the rest comes from electricity and solar energy. The energy demand from household appliances and space cooling was not as much as expected,

[8]The EU 27 includes: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, The Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and United Kingdom.

Table 2.3 Energy balance of Chinese households in 2012 (unit: kgce)

	Coal	Natural gas	LPG	Electricity	District heating	Fuel wood	Solar	Total
Cooking	16	135	56	51	–	69	–	327
Home appliance	–	–	–	102	–	–	–	102
Space heating	–	7	–	11	647	98	–	764
Water heating	–	111	29	27	–	–	38	205
Space cooling	–	–	–	28	–	–	–	28
Total	16	254	85	220	647	167	38	1426

Source: Authors' calculation

accounting for only 9 % of total consumption, which comes exclusively from electricity.

2.3.4 Comparison of Urban and Rural Residential Energy Consumption

There was a dramatic difference in energy consumption levels between urban and rural households (Table 2.4). The average household energy consumption in an urban household was 1,503 kgce/year, and per capita consumption was 651 kgce/year. In rural households, average total energy consumption was 1,097 kgce/year, and per capita consumption was 445 kgce/year. Energy consumption in urban households was about 1.4 times that of rural households.

Energy sources for urban and rural households were quite different: urban households obtain more energy from district heating, gas and electricity, and less from fuelwood, coal, LNG and solar. District heating accounted for 56 % of total energy consumed in urban households, but only 2 % in rural households. By contrast, rural households use fuelwood (used for space heating and cooking), accounting for as much as 59 % of total energy consumption. The share of electricity consumption was similar in urban and rural households: around 15 %.

Table 2.4 Comparison of urban and rural residential energy consumption by fuel type (unit: Kgce)

	Coal	Natural gas	LPG	Electricity	District heating	Fuel wood	Solar	Total
Urban	5	310	78	228	800	51	31	1503
Rural	62	22	115	165	21	648	65	1097

Source Authors' calculation

Natural gas was used much more in urban areas (20 vs. 2 %), reflecting the better network infrastructure, while LPG was used more in rural areas for cooking (5 vs. 10 %). Solar was used more often in rural households than urban households (2 vs. 6 %), reflecting the higher adoption rate of solar water heaters in rural areas.

2.4 Household Energy Conservation Opportunities and Challenges in China

2.4.1 Energy Efficiency for Space Heating

Since heating is the most energy-intensive end use for an average Chinese household, as shown in Table 2.3, it is naturally seen as a key area for energy conservation. We now look more closely at the energy efficiency of space heating.

China is a huge country with vast geographical and climatic variations. These result in different regional space heating systems. Since the 1950s, the urban areas in northern China have been supplied with central heating systems, but these were never made available in southern China. As shown in Table 2.5, 40 % of the surveyed households used central heating systems while another 39 % of households were not able to access central heating systems resorted to distributed heating. The average reported use area was 103.7 m^2 for the interviewed households, of which more than 80 % lived in apartment buildings. The use area of the living room, bedroom and study room was 28, 38 and 6 m^2, respectively. The proportion of households that installed plastic-steel windows frames and double glazing was 82 and 33 %, respectively.

Table 2.5 also shows that households with district heating had a much longer heating time (in terms of both length of heating season and heating time per day).

Table 2.5 Characteristics of space heating

	District heating	Distributed heating
Number of observations (%)	575 (40 %)	560 (39 %)
Sources or devices	Municipal network (63 %)	Portable electric heaters (35 %)
	Local boiler (21 %)	Air-conditioners (28 %)
	–	Heating stoves (28 %)
Fuel types	Not known	Electricity (67 %)
	–	Coal/fuelwood (29 %)
Average length of heating season	3.9 months	2.1 months
Heating time every day	All day long	4.3 h
Thermostat settings	No control	23 °C with people in door
	–	19 °C without people in door

Source Authors' calculation

Table 2.6 Average heating energy consumption per household in 2012 (kgce)

	Average	Median	S.D	Min	Max
District heating	1646.72	1423.53	1106.13	316.11	11380.05
Distributed heating	64.80	30.49	142.90	1.02	1456.27

Source Authors' calculation

Table 2.7 Energy efficiency of space heating system: district versus distributed (kgce/h.m^2)

	Average	Median	S.D	Min	Max
District heating	0.00756	0.00664	0.00453	0.00266	0.06024
Distributed heating	0.00942	0.00640	0.01313	0.00000	0.08281

Source Authors' calculation

In addition, they had a much larger heating area since they could not control the thermostat settings. This implies that district heating systems use much more energy than distributed heating systems. As presented in Table 2.6, the average energy consumption per household with the district heating system was as much as 25 times higher than that of a household with a distributed heating system.

However, if we control for the heating time and effective heating area, the story is different. We estimated the energy efficiency indicated by energy consumption per hour and per square metre (kgce/h.m^2)[9] and the result for the two heating systems is presented in Table 2.7.

Presently the district heating system will consume less energy than the distributed heating system for the same area and same time. That implies that the distributed heating system will need higher energy consumption to obtain a similar level of comfort.

2.4.2 *Household Energy Conservation Activities*

Activities related to household energy conservation can be divided into two categories: efficiency and curtailment activities (Gardner/Stern 1996). Efficiency activities are one-shot activities and entail the purchase of energy-efficient equipment, such as insulation and adoption of appliances with higher efficiency labelling. Curtailment activities involve repetitive efforts to reduce energy use, such as lowering thermostat settings (Abrahamse et al. 2005). Our survey reveals information on both types of activities.

The survey results show that 24 % of the respondents had insulated their windows or doors, mainly paying for this by themselves, while 7 % of the respondents

[9]Due to space constraints, the estimation method is not included here. Readers can refer to Guo et al. (2014).

Table 2.8 Energy consumption for heating and cooling: with insulation versus without insulation

Type	With insulation		Without insulation		T-stat
	% of sample	Energy use for heating and cooling (kgce)	% of sample	Energy use for heating and cooling (kgce)	
Windows and doors	24	716	73	772	0.93
Walls	7	812	90	751	0.94
Loft and pipeline	2	577	93	770	−1.32

Source Authors' calculation
Note We did not include respondents who did not know if they had insulation

Table 2.9 Energy efficiency labelling for home appliances

Efficiency labelling	Refrigerator (%)	Freezer (%)	Washing machine (%)	TV set (%)	Computer (%)	Water heater (%)	Air conditioner (%)
No label	36	38	52	77	84	65	42
First class	38	17	20	11	8	16	16
Second class	15	29	14	6	3	11	15
Third class	8	13	11	4	3	7	13
Fourth class	2	1	3	1	1	1	4
Fifth class	1	3	1	1	1	1	10

Source Authors' calculation

had wall insulation, most of which was financed by the government (Table 2.8). The average energy use for heating and cooling of households with insulation was lower than that of households without insulation, although not statistically different.

Regarding home appliances, the penetration rate of refrigerators, washing machines, televisions, computers, air-conditioners and water heaters was 89, 91, 120, 89, 113, and 84 %, respectively. Among all water heaters, 43 % were fuelled by electricity, followed by natural gas or LNG. Solar was another major fuel source with a high percentage of 25 %. All of the home appliances were required to have energy efficiency labelling since 2004. Our survey results showed that for the above appliances, the percentage of those labelled higher than Class 3 was 61, 44, 21, 15, 45 and 34 %, respectively.[10] The distribution of energy efficiency labels for home appliances is presented in Table 2.9.

[10]In China's energy label system, grade 3 indicates the average level. The smaller the grade number, the more energy efficient a product is.

On curtailment activities, we asked respondents to select between two types of behaviours. The first was whether they turned off the power after using an appliance. Over half of the respondents reported that they would turn off the power when they were not using the computer. 64 % of the respondents would unplug their chargers after the charging was done. The second behaviour was concerned with thermostat settings. When asked, respondents revealed that if the heating system could be individually controlled through a thermostat, they would set the temperature at 23 °C when there were people indoors, and at 19 °C when there was nobody indoors.

2.4.3 Information and Perception Towards Policy

There are three subsidy systems to promote the use of energy-efficient products, such as for the trade-in of old appliances; the purchase of energy-efficient products; and for home appliances in rural areas. Our survey shows that around one-fifth of refrigerator users obtained some purchase subsidies. The percentage of users who obtained subsidies for washing machines, televisions, air-conditioner units, and water heaters were 14, 16, 10 and 8 %, respectively. Fewer users got subsidies for computers. Also, about 29–34 % of users believed that subsidy policies, had affected their purchase decisions.

According to our survey, whether people can, and how they, access information on energy consumption and energy bills may also influence their behaviour. In our surveyed samples, 96 % of respondents installed a separate meter. Most of these meters were visible to the user, of which 80 % were located in the corridor and 16 % in the community. Among all respondents, 78 % of households knew their monthly electricity consumption and expenditure, out of which 68 % were informed by electricity bills and 23 % were informed by meter readers. The meter's type varies greatly. The proportion of users of smart meters, mechanical meters and IC card meters were 41, 36 and 4 %, respectively. This variation of meters lead to significant differences in tariff payments. Around 32 % of respondents prepaid their electricity bills and the rest paid after use. As for the payment frequency, 85 % of users paid their bills or recharged their IC cards every 1–3 months. More than half of the respondents paid at the local grid company's counter, and around 35 % settled their payment via bank or internet transfers.

The time-pricing electricity policy and the block electricity tariffs policy were the most important instruments changing people's behaviour. Our statistics show that around 38 % of respondents knew the time-pricing policy and 27 % knew whether it had been applied locally, lower than that of the tier-tariff policy (57 and 47 %, respectively). Only 13 and 27 % of the respondents got notifications from the grid company for the time-pricing and tier-tariff policies, respectively. The time-pricing policy was not available until residents applied for it. Successful applicants could enjoy a lower tariff at a non-peak time. After the investigator explained the benefit of the time-pricing policy, 30 % of respondents still did not want to apply for it since they were worried about the difficulty of the application process. The block electricity tariff was applicable to most of the residents while the quantity for each block could be adjusted according to the family size and conditions on the application. Around one-quarter of the respondents would not make changes since they were concerned about the complexity of the application process.

2.5 Conclusion

Based on the detailed CRECS-2012 dataset with 1,450 surveyed households, this study aimed to provide a brief overview of residential energy consumption in the residential sector in 2012. Our results show that the average household energy consumption was 1,426 kgce in 2012, which was lower than that of several OECD or economically developed countries. For instance, the total household energy consumption was only approximately 44 % of that in the US in 2009, and 38 % of that in the EU 27 in 2008.

The overview of energy consumption gives us some idea of where the energy goes. We found that among various activities, space heating was the most energy-intensive, consuming about 54 % of residential energy. In China, most energy used for space heating is provided by district heating. The thermostat setting cannot be controlled, and all rooms are supplied with heating for the entire heating season (an average of 3.9 months). One flaw in using this method is that the cost of district heating is estimated using construction area; therefore, there is no incentive for households to take measures to prevent energy leakage or conserve energy. In our survey, we found only a few households that applied energy conservation activities for walls and windows. This number is expected to be lower without government subsidies. Thus, if the government can reform the current heating pricing scheme by making the charge according to actual usage, rather than total construction area, we believe it will create great incentives for energy saving. Technically it is possible to improve the infrastructure and install individually controlled thermostat settings. Another argument for this lies in the popularity of the distributed heating system in Southern China. We found that given the same level of comfort, the energy efficiency of the district heating system is higher than that of the distributed efficiency. Therefore, considering comfort and energy conservation incentives, the ideal solution is to have a centralised heating system, with a decentralised and incentivised payment scheme.

Our second objective relates to a better understanding of energy conservation behaviour at the household level. Our data shows that Chinese households have taken some steps to conserve energy use. These activities include insulation of walls, doors and windows, and the purchase of more energy-efficient home appliances. However, the insulation adoption rate is still low in China. As for home appliances, the percentage of households purchasing energy-efficient appliances, such as washing machines, freezers and refrigerators, was higher than that for computers and TVs. This is possibly because the former are more energy-intensive, thereby giving households more incentive to own such appliances so as to reduce energy use. One interesting future research area is how to understand the determinants of home insulation behaviour and efficient home appliance adoption.

This chapter provides a brief overview of Chinese energy consumption at the household level using basic statistical survey data, and we have presented an overall picture of Chinese residential energy consumption patterns. However, further in-depth statistical analyses are required to identify the reasons behind the urban-rural differences.

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