



Research on China's rural household energy consumption – Household investigation of typical counties in 8 economic zones



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ABSTRACT

Rural household energy consumption is an important component of national energy consumption and plays an important role in rural social and ecological environment developments. In this paper, energy consumption of 1440 households in 8 typical counties of 8 China's economic zones was investigated. The investigation data analysis revealed significant difference of different economic zones in rural household energy consumption level and structure. For 8 studying counties, the annual average energy consumption per capita was 26.7 GJ, 10.4 GJ the lowest (Shanghang County) and 86.6 GJ the highest (Shulan County). In energy consumption, straw, biogas, fuel wood and electricity accounted for 44.33%, 23.13%, 12.79% and 9.61%, respectively. Rural families with high incomes preferred commercial energies (e.g. electricity and liquefied petroleum gas (LPG)) to biomass energy (e.g. straw and fuel wood). The traditional biomass energy is still the main energy source for China's rural household. Research results provide references to understand current situations and future development of China's rural household energy consumption, and formulate related energy and environmental policies.

1. Introduction

With the rapid growth of energy demand and consumption, problems concerning energy, environment and climate changes become increasingly prominent. Countries in the world are look for a way of harmonious development of society, economy, resources and environment [1–3]. Energy conservation, energy efficiency and renewable energy utilization could reduce fossil energy consumption effectively. This is good for ecological and environmental protection, mitigation of global warming and collaborative promotion of sustainable social development [4–7].

Energy supply-demand balance in rural areas of developing countries is closely related with local economic and social development as well as ecological environmental protection. This energy supply-demand balance in developing countries is an important content of sustainable development strategy of energy sources in the world [8–11]. Rural household energy consumption mainly refers to energies used for daily life of rural household, including illumination, cooking, heating, hot water and household appliances [12–14]. In rural areas of China, a developing countries, basic energy demands for daily life are satisfied by biomass energies (straw and fuel wood) [15–18]. Domestic researches on energy problems in rural areas began from the 20th

century and have achieved abundant fruits [19–21]. Zhou et al. thoroughly analyze household energy consumption in terms of energy sources and energy end-uses in villages of Huantai County [22]. Zhang and Guo identified the contributing role of different factors affecting the change of rural residential energy consumption in China [23]. The development potential of biomass and other renewable resources has also been studied by Li et al. [24]. However, most of existing researches on rural household energy consumption are macroscopic one and lack of the first-hand survey data as well as related information, resulting in the unsatisfying data reliability, comprehensiveness and accuracy. Most of them focus on some local areas, such as eastern China, western China and northern China. Existing researches are incomparable because they are carried out by different experts in different periods. Therefore, it is difficult to comprehend overall situation of the national rural household energy consumption [25–27]. Due to China's extensive territory, there's great difference among regions with respect to society, nature, economic-ecological environment and lifestyle. Since rural household energy consumption in China depends highly on non-commercial energy sources and available natural resources, there's outstanding regional difference in changes of rural household energy consumption.

This paper chose typical regions of different types for investigation

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of rural household energy consumption. Current situation of rural household energy consumption and regional difference were comprehended. It provides references to study level, substitution, variation, influencing factors and development law of household energy consumption.

2. Method and data

According to regional differences in nature, climate, economic development level and industrial status, China has been divided into 8 economic zones including south coastal regions, east coastal regions, north coastal regions, northeast China, midstream region of the Yangtze River, midstream region of the Yellow River, southwest China, northwest region. One typical county of 8 China's economic zones were chosen as the research objects. Typical county systems were determined by comprehensive analysis on district, environment, resources, economic level, industrial structure and rural household energy consumption. These 8 counties are Jing County (Hebei province), Jinhu (Jiangsu province), Shanghang (Fujian province), Shulan (Jilin province), Xinmi (Henan province), Yunmeng (Hubei province), Weiyuan (Gansu province) and Tongnan (Chongqing province). In each county, 180 rural families (2 towns, 3 villages of each town and 30 families of each village) were chosen randomly, getting 1440 effective samples. 54 college students and graduate students were invited as the investigator and trained together. The household investigation was implemented using uniform printed questionnaire. Questionnaire could be filled by others and main survey contents include basic family status, biomass harvest yield, energy consumption, attitude toward utilization of different energy sources, etc.

3. Results and analysis

3.1. Nature and basic conditions of investigated rural household in typical counties

These 8 counties are plains, mountainous regions and plateaus. Shulan and Weiyuan are in north China and have low annual average temperature, but rest regions show similar annual average temperature. According to survey data statistics, Shanghang County has the highest household permanent residences (5.08) and Tongnan has the lowest (2.75). There's prominent difference in annual household income per capita. Jinhu has the highest annual household income per capita (6372.6 RMB) and the Tongnan has the lowest (848.8 RMB). Jinhu shows the highest agricultural acreage per capita (2980 m²) and Xinmi shows the lowest (327 m²) (Table 1).

3.2. Household energy consumption level and structure

The survey data analysis reveals significant regional difference in rural household energy consumption (Table 2). The lowest (10,435.2 MJ) and the highest (86,568.8 MJ) annual household energy consumption per capita were in Shanghang and Shulan. The average

value of 8 studying counties was 26,725.2 MJ. Average proportions of straw, biogas, fuel wood and electricity in household energy consumption of a county were 44.33%, 23.13%, 12.79% and 9.61%, respectively. Northern China (Shulan, Weiyuan and Jing County) where has heating demands in winter show higher rural household energy consumption than rest economic zones. Electricity is universal in rural areas, but there's still regional difference of electricity consumption. Compared to poor counties, Jing County, Jinhu, Shanghang and Yunmeng in developed economic zones consume more electricity and commercial energy sources. This is related with higher household income per capita of these regions. Proportion of coal consumption in Jing County, Xinmi and Weiyuan where are rich of coal resources is higher than that of other regions. Rural families with high incomes prefer commercial energy sources (e.g. electricity and liquefied gas) to traditional fuels (biomass). This is one of basic features of well-off household energy consumption in China. Nevertheless, survey data reflects that commercial energy has not replaced the traditional energy sources completely in rural household energy consumption of China and traditional biomass energy is still an important part of household fuel structure.

To study basic features of rural household energy consumption, effective heat per capita, proportion of commercial energy in effective heat and electricity consumption per capita of 8 studying counties were calculated (Fig. 1). Household effective heat per capita is the total annual per-capita effective heats for cooking gained from various energies (thermal conversion efficiency of straw and fuel wood is 18%, and thermal conversion efficiencies of coal as well as liquefied gas and biogas are 22% and 60%) [16]. It is an index of effective household energy demand and reflects actual consumption level of effective heats, including household cooking, hot water, swine breeding, etc. To avoid influences of regional climatic variations, it excludes demands of winter heating and air condition effective heats (electricity consumed by air condition is counted in per capita electricity consumption index and electrical energy is calculated according to equivalent values: 1 kWh=11,840 J). According to the statistics, per capita effective heat mostly concentrates between 2.7 and 2.9 GJ, averaging at 2.86 GJ. This reflects household energy consumption situation under current rural social and economic development levels in China.

Proportion of commercial energy in effective heat is a qualitative index of energy consumption, which is 33.62% in average of 8 studying counties. Generally speaking, commercial energy only contributes 1/3 of effective heats, which is far lower than the commercialization level (commercial energy accounts for more than 50% of the effective heats) of rural household energy consumption. The big regional difference demonstrates diversity and complexity of household energy consumption for cooking. In Xinmi County, proportion of commercial energy in per capita effective heats reaches 65.40%, which is caused by low availability of straw and fuel wood given the small per capita agricultural acreage (327 m²). Residents in Xinmi County are used to consume coals for daily energy demands. Yunmeng County has high rural income per capita (about 5700 RMB). Local commercial energy sources mainly liquefied gas and coals, resulting in the high proportion of commercial energy in per capita effective heats. The proportion of

Table 1
Basic family situation on typical counties.

	Physiognomy	Annual average temperature/°C	Household permanent residences	Labor force per household	Annual household income per capita /RMB	Agricultural acreage per capita/m ²
Jingxian	Plain	12.5	3.79	2.23	4 168.7	2 560
Jinhu	Plain	14.6	3.12	1.87	6 372.6	2 980
Shanghang	Mountainous region	19.8	5.08	2.62	3 499.9	393
Shulan	Plain	3.9	3.91	2.37	3 941.1	2 400
Xinmi	Mountainous region	14.3	4.38	2.00	2 908.9	327
Yunmeng	Plain	16.0	3.90	2.69	5 714.8	1 013
Weiyuan	Plateau	6.0	3.89	1.94	908.8	1 673
Tongnan	Mountainous region	17.9	2.75	1.53	848.8	693

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