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Overview of rural building energy efficiency in China

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HIGHLIGHTS

- Situation of rural energy consumption in China.
- Challenges in rural building energy-saving work.
- Design standard, special plan and some pilot projects are analyzed.
- Effects of existing energy policies for urban buildings.
- Some recommendations are given.

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ABSTRACT

Over the past three decades, people's living standard in China has been greatly improved, accompanied by the rapid increasing building energy consumption. Rural building energy consumption has become one of the most important parts of the total energy consumption in China, which deserves to be paid much attention. It is of vital importance to promote building energy efficiency for the New Socialist Countryside and energy conservation and emission reduction. This paper provides an overview of building energy consumption in the countryside, which figures out the situation and challenges in energy-saving work. The government has worked for years on rural building code system aimed at narrowing the energy gap between urban areas, but it is in the beginning phase. This paper has analyzed the only special issues about rural building energy efficiency and the mandatory standards for urban buildings, which can facilitate the development of rural building energy efficiency. Based on the above analysis, some recommendations regarding the improvement of rural building energy efficiency are given.

1. Introduction

Since the reform and opening up policy was initiated in 1978, the fast-growing economy in China has improved people's living standard and the enlarged building area (Long et al., 2007; Fan et al., 2011). Moreover, the rapid growth in economy has promoted the demand for energy and attracted the attention to environmental protection. According to the Ministry of Housing and Urban–Rural Development (MOHURD) of China, the building energy consumption has kept rising during the past few decades, and the proportion of building energy consumption section rose to 27.8 percent of the country's total energy consumption in 2008 from 10 percent in 1980 (CNBS, 2008; Kong et al., 2012). With this trend, the building energy will account for 30–40 percent of the total energy usage in 2030–2040, which will meet the current level of Europe and the United States (Perez-Lombard et al., 2008). At that time, the building energy will surpass other industries, such as industry, transportation and agriculture, to be the largest energy consumer in China (Jiang, 2007). If the fast-growing building energy consumption cannot be controlled, the present development model will bring negative effects to the sustainable development of China's national economy, which remains the top priority in developing countries (Zhang and Wen, 2008; Li and Yao, 2009; Zhou et al., 2010).

At present, according to the energy use in buildings, it can be divided into four categories as following: Heating energy

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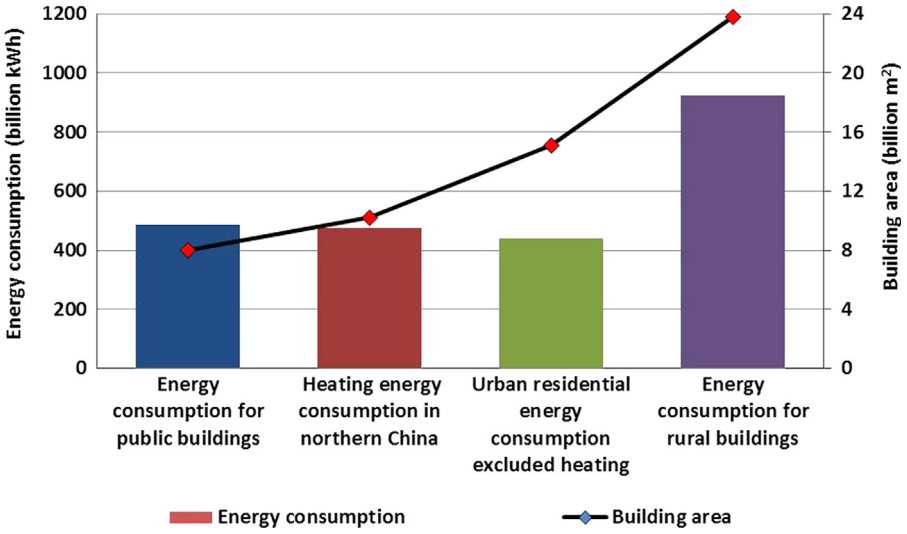

Fig. 1. Building energy consumption and buildings area in 2010.

consumption in northern China; Urban residential energy consumption excluded heating; Energy consumption for public buildings and; Energy consumption for rural buildings (Cai et al., 2009). Energy consumption and the building areas for each category in 2011 are provided in Fig. 1 (CNBS, and MOEP, 2011). Compared with other building types, rural building areas was much larger with an area of 23.8 billion m^2, which accounted for more than 50 percent of the total buildings area. At the same time, energy consumption of rural buildings was about 924.6 billion kWh, which is more than twice as much as urban residential energy use, and it represented approximately 40 percent of the total consumed energy. In terms of energy consumption per unit floor area, the value for rural building is 38.8 kWh/m^2 and it is also larger than the urban residential energy use 29.0 kWh/m^2. All the data has revealed that energy in rural areas has the potential to influence the economic growth and environmental protection in China.

As an important aspect of energy consumption is that the energy consumption of rural buildings deserves to be attached great importance (Zhu et al., 2011). This paper will make a brief analysis of the situation of rural building energy in the respects of general trend, energy structure and renewable energy development in the next section. At the same time, some factors such as regional differences and economic level that can cause great difficulties for energy efficiency work are highlighted. In Section 3, the design standard, special plan and some pilot projects launched by the central government and local governments to promote energy efficiency are analyzed. Next, the existing energy policies that can facilitate the energy efficiency such as national planning and the major national research project are analyzed. Based on the above analysis, Section 5 provides some suggestions on further improving the energy efficiency from multiple perspectives.

2. Rural building energy consumption: an overview

Over the past three decades, people's living conditions in China rural areas have been remarkably improved, which contributes to energy structure shift in quantity and quality. In rural areas, people have mainly relied on the traditional biomass energy resources such as firewood and straw for a long time (Xiaohua and Zhemin, 2001; Zeng et al., 2007), but these are gradually replaced by the commercial energy resources including coal, electricity, liquefied petroleum gas (LPG) and refined oil products, due to the low thermal efficiency and combustion-generated pollution of these biomass resources (Chang et al., 2003; Zhang et al., 2009). During the process of rapid urbanization, China has witnessed the rapid growth of energy consumption, so the Chinese government has encouraged using and developing renewable energies to alleviate both the pressure from energy shortage and environmental pollution. Due to these policies, renewable energies including biogas, solar energy, wind energy and geothermal energy have made considerable progress, and the exploitation scale and the level of technical development of solar system and methane system are in the leading positions all over the world (Jiang, 2008; Dincer, 2011). However, for the total energy consumption, the proportion of renewable energies is still very low, so it is necessary to increase the investments in the development of renewable energy technologies. At the same time, it is well known that the rapid development of economy had stimulated (Jiang, 2012; He et al., 2013; 2014a) the demand for household appliances and the growth of personal living space to a certain extent, which results to a rapid increasing energy consumption in countryside. China is a vast and big country with several climate zones from severe cold zone to mild zone, and the uneven distributions of renewable energies bring a huge challenge for both rural energy planning and building energy conservation policies.

2.1. Situation

2.1.1. The rapid increasing building energy consumption

In rural areas, people have not attached sufficient attention to the energy problems for a long time, so there are very few institutions specially established to tackle these issues at present. The data used in this paper are mainly obtained by the census of Chinese government. According to the statistics by Ministry of Agriculture (MOA) of China, the annual building energy consumption from 1999 to 2008 is provided in Fig. 2 (MOA, 1999, 2008; CNBS and MOEP, 2011). It is obvious that the rural energy consumption has significantly increased with a growth rate of 5.6 percent from 351.82 million tons of standard coal equivalent (Mtce) in 1999 to 569.75 Mtce in 2008. With this present trend, it is projected to exceed 1000 Mtce in 2018 and reach 2000 Mtce in 2030, leading to a huge pressure on energy supply and use in the countryside. Compared with the residential energy consumption in urban regions, the energy structure in village is far behind for the usage of traditional biomass. The biomass resources including