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Carbon emission reduction potential of rural energy in China

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ABSTRACT

With the largest population living in countryside, the carbon dioxide (CO₂) emission from rural energy consumption is a serious problem in China. The full development and utilization of renewable energy is the key and effective way for solving the CO₂ emissions problem. This paper reviews the rural energy consumption level and structure in China. Then, this paper discusses the potential for renewable energy development as well as its CO₂ emissions reductions in rural areas. Results show that if full development and utilization of renewable energy is achieved, on the basis of energy data in 2008, China's rural energy consumption and even 2.2 times of that can be supplied by 100% carbon-free energy resources (which do not contain the biomass energy) without considering economic and technical constraints, and 2.4 times of that can be provided by renewable energy. Moreover, to evaluate the application priority, cost-effectiveness of each renewable energy resource is analyzed. Based on the characteristics of renewable energy resources, new promotional strategies to ensure the full development and utilization of renewable energy in rural China are also presented.

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1. Introduction

Energy saving and emission reduction, the key to developing a circular economy and protecting the ecological environment, have become the focus in the world, along with which many low carbon energy scenarios such as Global Energy Assessment (GEA) [1] and Energy Technology Perspectives 2012 (ETP2012) [2] are continuously emerging. The GEA provides technical guidance for governments and intergovernmental organizations to develop pathways for sustainable development of energy and reductions of greenhouse gas (GHG). In the ETP2012, global scenarios and strategies to a sustainable energy system in 2050 are laid out. As a kingdom of Carbon Trade, China faces great challenges in providing pathway for emissions reductions. Since 2006, China's CO₂ emission has raced ahead of the United States and gone into the first place [3]. As the largest emitter of CO₂ in the world, China has established the target that by 2020, CO₂ emissions per unit of GDP would be decreased by 40–45% of 2005 levels [4,5]. The unprecedented pressure on reducing CO₂ emissions brings huge challenges to China [6]. As a large agricultural country, the rural areas play vital roles in reducing CO₂ emissions in China [7].

With China's rapid economic development, the demand for energy is increasing at a great rate. As shown in Table 1, from 2000 to 2008, China's total energy consumption rose from 967 to 2007 million tonnes of oil equivalent, which is equal to 1383 to 2867 million tonnes of standard coal equivalent (Mtce). In the meantime, China's rural energy consumption also showed a rapid growth, whose total amount had increased substantially from 672 Mtce to 925 Mtce [8]. Therefore, to achieve the CO₂ emission reduction target, energy saving and emission reduction in rural China is of vital importance. The analyses of rural energy issues in China have been booming [9]. Rural energy consumption, as a primary source of China's GHG emissions, is an important aspect in reducing China's CO₂ emissions. China, as an agricultural country with vast rural territory and huge rural population (more than half of the nation's population), has abundant renewable energy resources in rural areas. However, at present the rural energy consumption, for the most part, is still mainly composed

of the low-efficiency and higher carbon-content fuels such as coal, firewood, straw and coal. The high-quality modern renewable energy resources only occupy a low proportion. This kind of energy consumption structure intensifies the CO₂ emissions and brings negative influence to environment [10,11]. Thus, in order to solve the emissions issue, we should focus more on optimizing the rural energy consumption structure and developing renewable energy.

There are many related studies on China's rural energy consumption, such as its affecting factors, consumption pattern, relevant energy policy and sustainable development [12–14]. The previous rural energy studies presented a general idea of the rural energy consumption, however the specific way to promote emissions reductions still needs further studies. Thus, the low carbon development of China's rural energy certainly requires an in-depth, comprehensive study. Rural China has extremely rich renewable energy resources such as biomass, solar, wind, geothermal and small hydropower. Low carbon development for rural energy, the key is making full development and utilization of renewable energy resources. That is to say, it is necessary to construct a new rural energy consumption structure whose main components are renewable energy resources. To develop effective ways to guide sustainable energy system and solve CO₂ emissions problem, the analysis of development potential is essential. Hence, combining with the distribution and characteristics of China's rural renewable energy resources, the potentiality of exploitation and utilization of renewable energy, as well as its potential for reducing CO₂ emissions under ideal conditions is analyzed. In addition, the popularization and application priority of renewable energy resources are also analyzed and discussed in this study.

2. Rural energy consumption levels and structures in China

As shown in introduction, from 2000 to 2008, the total energy consumption of rural China has increased greatly, which is from 672 to 925 Mtce [8]. Correspondingly, per capita energy consumption has increased from 830 kg standard coal equivalent (kgce) in 2000 to 1310 kgce in 2008. However, from an overall perspective, the energy consumption structure in rural China is still traditional, which mainly consists of traditional energy such as coal, firewood, and straw burned directly with low efficiency, while the renewable energy resources account for only a tiny share. On the basis of the energy consumption data of 2008, the energy consumption structure and CO₂ emissions in rural China are analyzed first in this paper.

2.1. Energy consumption structure

The energy consumption in rural China of 2008 is 925 Mtce, among which the resident energy consumption and production energy consumption accounted for 63% and 37%, respectively [8]. The production consumption refers to the energy consumption which is used for agricultural production as well as its processing such as animal production, agricultural irrigation, crops cultivation, agricultural product processing and so on. As shown in Fig. 1, the energy consumption in rural China is still mainly consisted of

Table 1
The total energy consumption from 1990 to 2008 all over the world, in million tonnes of oil equivalent.

	1990	1995	2000	2005	2008	Rate of change
China	685	917	967	1572	2007	193%
India	181	236	295	362	441	144%
Japan	431	489	510	520	509	18%
Korea	90	147	189	222	236	162%
Taiwan	50	66	94	109	109	118%
Russia	862	658	614	649	681	–21%
South Africa	90	100	107	119	131	46%
Canada	251	277	300	323	335	33%
Brazil	124	150	183	198	228	84%
United States	1963	2117	2310	2342	2302	17%
Germany	349	332	329	324	310	–11%
France	218	235	254	260	255	17%
England	211	214	223	225	211	0%
The World	8097	8545	9260	10565	11315	40%

Data comes from BP statistical review of world energy.

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