A Study on Renewable Energy Development Status in Rural China

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**Abstract.** Developing rural renewable energy has great meaning in improving the economics of rural area and the living quality of farmers. This paper introduces the energy resources and energy consumption structure in rural China and highlights the application situation of renewable energy in isolated and poor countryside. In addition, the challenges and suggestions of developing rural renewable energy have been discussed.

**Introduction**

The rural area in China is quite large. According to the data from National Bureau of Statistics of China, the rural population in 2014 is about 620 million, which makes up about 45\% of the whole population in China [1]. It requires a lot of energy to conduct production activities, support the farmers' daily life and develop the rural area. Energy consumption for living of the rural residents is being steadily increased [2]. Commodity energy can not satisfy the energy requirement in Chinese rural area. Moreover, the consumption of commodity energy will aggravate greenhouse effect. As shown in Fig.1, the CO\textsubscript{2} emissions is still a serious problem for China now. So, it is of great importance to develop rural renewable energy.

Renewable energy technologies can make better use of local available energy resources, such as solar, wind, geothermal and so on [4]. Moreover, the scale of renewable energy can be small so that they can be very suitable for isolated and poor rural communities [5]. Renewable energy have been considered as a favorable options for rural areas in developing countries in recent years.

The main purpose of this paper is to investigate the prospects of renewable energy in rural China. This article begins with an introduction of the energy resources and energy consumption structure in rural China. It highlights the application situation of renewable energy in isolated and poor countryside. At last, the challenges and suggestions of developing rural renewable energy have been discussed.
Energy Resources in Rural China

There are sufficient energy resources in rural China. The major energy resource base can be categorized into two broad types: commercial energy and non-commercial energy. Commercial energies include coal, oil and electricity. Non-commercial energies contain straw, firewood, biogas and other renewable energies, for example, solar power, wind power and mini-hydro power [6].

There are abundant biomass resources in rural China. Developing and utilizing modern biomass energy has great potentiality. In China, there are about 700Mt crop straws produced by agriculture activities per year, among which, nearly 35% straws are available for developing biogas [7]. Thus it can generate about $8.0 \cdot 10^{10}$ m$^3$ of biogas. Moreover, according to the statistics from Chinese Ministry of Agriculture [8], there are about 1120Mt of animal wastes produced by national large scale livestock breeding, which can produce biogas about $2.0 \cdot 10^{10}$ m$^3$. In addition, there is about 300Mt of forestry waste that is available for energy production, therefore the total installed capacity of biomass power can reach 24GW [9,10].

The small hydropower is extensively distributed in more than 1600 mountain counties, especially in the rural areas and remote mountain areas where are suitable for small hydropower development. The potential of small hydropower resources is about 160GW, which is equivalent to an annual generation of 1300TWh, and the actual exploitation amount of small hydropower resources is about 128GW [10,11].

The total amount of on-shore wind power reserves (based on the wind data above ground 10m height) is about 3.23TW, among which, the wind power reserves that can be utilized is around 0.25TW. The amount of off-shore wind resources is more than 1 TW, which also has great potential for developing [7,12].

China has abundant solar energy. The annual solar radiation quantity is more than 4190MJ/m$^2$. According to the solar energy radiation quantity, the solar energy zones can be divided into four types: extremely abundant area, very abundant area, abundant area and normal area, which account for 17.4%, 42.7%, 36.3% and 3.6%, respectively [13,14]. Especially in western part of Tibet, the solar radiation quantity is as high as 2333KWh/ m$^2$, which is ranking as top 2 in the world [7].
Energy Consumption Structure

The Science, Technology and Education Division of Ministry of Agriculture is the official government department which is responsible for rural energy statistics. However, the newest data we can get access is that in 2008, while the data afterwards have not been published in public so far [15-17]. On the basis of the energy consumption data of 2008, the energy consumption structure in rural China is analyzed in this paper.

The energy consumption of rural China shows a significantly increase trend in these years. The energy consumption in rural China is 672Mtce in 2000, and it increases to 922Mtce in 2008, among which the resident energy consumption and production energy consumption accounted for 63% and 37%, respectively.

As shown in Fig.2, the resident energy consumption is still traditional, which mainly consists of traditional energy such as coal, firewood, and straw burned directly with low efficiency. Currently most of the energy demand had been met by coal, firewood, and straw. Firewood and straw have made up 41% of the whole resident energy consumption. Followed is coal, which made up 27%. The renewable energy resources account for only a tiny share. However, according to the energy consumption data from 2000-2008 [7], the change of energy resident energy consumption during these years indicated that the consumption amount of coal, firewood, and straw decreased from 87% in 2000 to 68% in 2008; while the amount of commercial energy increased gradually. This indicates that the energy consumption structure is turning to a modern pattern which is more reasonable and scientific.

Due to rapid urbanization and the increased growth rate in industries, the proportion of production energy consumption shows a steady rise. Production energy consumption in rural China mainly consists of firewood, electricity, coal, coke, oil, etc. The consumption amount increased by 38.2% from 300Mtce in 2000 to 415 Mtce in 2006, while there was a slight decrease in 2007 and 2008 [7]. In general, the production energy consumption was largely dominated by non-renewable energy, among which, coal made up more that 50%, followed by electricity and oil. Coke and firewood accounted the least amount, which is less than 10%. However, this pattern brings about serious environmental pollution. Moreover, since the fossil energy is limited on earth, it is important and urgent to develop

![Figure 2. a) Resident energy consumption structure of rural China in 2008, Mtce. b) Production energy consumption structure of rural China in 2008, Mtce. [10]](image-url)
renewable energy. Renewable energy is helpful for the sustainable development of the society, so that it has been considered as a favorable option for rural areas in developing countries in recent years.

**Application Situation of Renewable Energy**

Renewable energy technology has been developed for many years and it has achieved great progress in recent years. According to China National Renewable Energy Centre, in 2014, about 4.75Mtce energy was provided by renewable energy, which made up 11.2% of the national energy consumption.

As we can see from Fig.3, biogas occupied a large proportion in rural energy. The households using biogas show a significant increase from 8.48 million in 2000 to 41.22 million in 2013. If a household built a biogas digester with 8m$^3$, the annual output of biogas would be about 350 m$^3$, which is normally enough for the energy consumption of cooking, heating and lighting for the whole household in 10 months [19].

![Figure 3. The usage of biogas in rural China from 2000-2013 [14,18].](image)

The main forms of solar energy usage in rural areas are solar heaters, solar house, solar school, solar cooker and photovoltaic power generation, among which, solar heater goes through the fastest growth during the past decades. As shown in Fig.4, the number of solar heater in 2013 in nearly 7 times of that in 2000. Solar heater is mainly used for heating water, while solar house is designed for using solar energy to provide heat or electricity for the house. However, due to the limitation of technology and the living conditions of rural residents, the number of solar house almost stay the same during these years. As for the number of solar cooker, even though it shows a steady increase for the past years, we can expect that the number will not increase too much in the future because of the more and more convenient access to electricity and electrical cooking equipments.
Both the small-scale wind turbine and micro-hydropower refer to the off-grid generation devices with output power less than 10 KW. As shown in Fig. 5, in 2013, the wind power capacity has reached 34.8MW, and the micro-hydropower capacity has reached 96.8MW. Considering the huge potential of wind energy and hydropower resources, there are definitely more possibilities for the development of wind energy and hydropower in the near future.

Based on the local geography and economic conditions, the development of suitable renewable energy would be a favorable option to realize the goal of rural electrification.

**Challenges and Suggestion**

Even though the development of renewable energy in rural China has obtained certain achievements [20-22], there still exist some challenges, such as technology shortcomings, policy impediments, financial constraint, managerial barrier. The average energy efficiency in China is about 33%, while the efficiency would be less in rural areas [23,24]. The usage of rural energy is not so reasonable that wasting energy is still a serious phenomena in countryside. The rural residents are
usually unaware of the benefits of the renewable energy and disadvantages of the existing patterns on health, economic and environment. Moreover, the current policy on renewable energy is guided by the ‘the bigger the better’ concept, which results in the lack of financial support and incomplete policies and regulations on distributed renewable energy systems and its application in rural areas. Chinese national energy administration has organized several actions from 2013 to make sure every person can get access to electricity by the end of 2015 [25]. Since delivering electricity directly to some remote regions are difficult and cost too much time and money, it is highly recommended to adapt off-grid solutions and promote distributed renewable energy systems in rural areas.

Since different places have different geographic and economic conditions, it is highly important to fully consider of the local situation when planning a rural energy project. In order to further promote the renewable energy in rural China, much more work need to be done. Followed are several suggestions. Firstly, distributed renewable energy systems with higher energy efficiency should be developed and promoted, while more training on maintaining and managing the energy systems should also be provided. Then, specific policy on rural renewable energy should be made, and corresponding laws and regulations should be added as well. Additionally, more investigations from companies and financial support from government should be encouraged.

**Conclusion**

This paper presents the status of energy scenario in rural China and gives suggestions for the future development of rural energy. Renewable energy has been proven to be an effective approach for affordability and facilitate energy access in rural communities. There is a rising awareness of developing renewable energy in rural China among Chinese government and public, however, more efforts should be made in this field from technology side and policy side at the same time.

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**References**


