



The development and application practice of wind–solar energy hybrid generation systems in China

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ABSTRACT

China is the largest developing country in the world. At present, more and more energy demand gives immense pressure to Chinese government. The inappropriate energy structure must be improved by Chinese government in order to achieve the sustainable development of economy and society. Development and application of renewable energy, such as wind energy, solar energy, biomass energy, etc., have been regarded by the government and the local people in the past 10 years, and more and more actual examples have been established, which are supported by government and plants in China. It is well known that there are abundant wind and solar resources in China. This paper presents the distribution zone and development and application practice status in China. However, a common drawback is existing in the stand-alone wind energy and solar energy generating power system, which is the unpredictable output electric power, and the output power depends on the unpredictable weather and climatic changes. Fortunately, the wind–solar hybrid generation system can partially overcome the problems. The conventional structure and key technology of stand-alone wind–solar hybrid generating system, the current status and outlook of wind–solar hybrid energy system are presented in the paper, for example, the city road lighting system, distributed generation, photovoltaic (PV) water pumping for irrigation, etc. At the end, the policies and laws of China central government and local governments are described, and the development barriers and recommendations are introduced.

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Contents

1. Introduction	1505
2. Current energy structures in China	1505
3. Chinese renewable energy situations	1506
3.1. Wind energy	1506
3.2. Solar energy	1507
3.3. Solar–wind hybrids energy	1508
4. Hybrid generating system applications in China	1509
4.1. The city road lighting system	1509
4.2. Distributed generation (DG)	1509
4.3. Water pumping for irrigation	1510
5. Renewable energy policy and barriers in China	1511
6. Conclusion and recommendations	1511
Acknowledgements	1511
References	1512

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1. Introduction

China lies in the northeastern part of East Asia between 4° and 53° North latitude and 73° to 135° East longitude with an area of 9.6 million km², and a population of about 1.3 billion. The Pacific lies in the east of China. The coastal zone of China consists of about 18,000 km. The southeastern coastal zone of China is the most developed economy zone, which inhabit more than 60% of Chinese people. The largest patch of serious desertification lies in the west of China, where is the homestead of millions of rural population, and the economy of west zone is poorer compared with coastal zone. But there is abundant natural resources deposit in the large west area.

The industrialization of Chinese society is on rapid development in every nook and corner, and the growing pressure of increasing population adds to the stress on natural resources, including land, water and air. The need for oil, natural gas and electric power are rapidly increasing with the development of Chinese society. According to the reports given by Chinese Development and Innovation Committee (CDIC), the total amount of oil dosage in 2007 was 0.35 billion ton, which ranks the second in the world and just behind America [1]. The rapid developing economy needs the import of fossil fuels, particularly oil, on a large scale. Based on the CIQ data, the amount of imported oil in 2007 was 0.16 billion ton [2]. The total amount of coal dosage in 2007 was 2.523 billion ton, which ranks the first in the world [3]. The total amount of SO₂ emission in 2005 was more than 20 million ton, which ranks the first in the world [4]. Many environmental problems, including air pollution, soil pollution, water pollution, acid precipitation, are all related to inappropriate energy structure of China to some extent. Moreover, too much reliance on imported oil is critical from energy security point of view. For a long time, the energy generated by using the coal plays a dominant role in China. The percentage of coal in primary energy production and consumption is more than 70% [5]. The renewable sources, i.e. solar, wind, tide, biomass, etc., occupy a very small percentage in the whole energy structure.

Because of fast-growing economy and population, the demand of energy is rapidly increasing, more and more cities in China face the energy lack and environmental pollution. Today, China has become the third economic system in the world, and is the largest developing country in the world at the same time. The energy and environmental questions in China have great effects on the world economic sustainable development. Based on the status, the Chinese government has realized the importance of energy and environmental questions. The Chinese government established the Renewable Energy Law in February 2005 to act as the guarantee and to lay a special emphasis on the subject of renewable energy development [6]. The adjusting energy structure and improving energy utilization efficiency are executed in the entire China. Currently, the renewable energy is applied to many domains in developed, and developing nations, the renewable sources are expected to play an important role in total electrical energy demand, and the renewable energy sources, such as solar, wind, biomass, etc., have gained a lot of attention because they are renewable, friendly to the environment, easy for distributing abroad, and flexible for installation. And more and more specialists of China realized the fundamentality of the renewable sources. The Chinese government has spent enormous money and energy in the renewable source domains in order to achieve the sustainable development in economy and society. But the renewable sources have some problems in that it is impossible to afford enough electric power alone, i.e. the density electric power of renewable sources are very low, and the stability is bad. The output electric power from renewable sources is always changing with weather

conditions. The combined powers of multifold renewable sources have been researched in some countries, and which is used in the remote villages and for city lighting system and water pumping for irrigation or desalination purposes, i.e. wind–diesel hybrid, solar–diesel hybrid, solar–wind hybrid, etc. The combined system of the solar energy and wind energy was called the photovoltaic and wind energy hybrid systems to supply enough electric power. The solar–wind hybrid system is possible to achieve much higher generating capacity factors and reliability by combining wind turbine with photovoltaic generators to overcome the fluctuations in plant output under various weather conditions. Chinese specialists consider the solar–wind hybrid system to act as an important role. More and more solar–wind hybrid projects are being established in hundreds of Chinese cities, and the projects are encouraged by the government policy.

This article will discuss the current status of energy structure in China. The following sections describe the distributing zone and applications of solar energy and wind energy in China. Then the application status and outlook of wind–solar hybrid energy system is discussed. Finally, the policy of central government and local governments and barriers and recommendations are introduced in this paper.

2. Current energy structures in China

Fig. 1 shows a graphical representation of Chinese primary energy supplies. Chinese energy admixture is highly dependent on fossil fuels, i.e. coal, oil, natural gas and other. Coal energy has a share of 69.4% in 2006, which is the most important fossil fuel in China. Renewable energy and nuclear energy has a share of 7.2%. Oil energy has a share of 20.4% and the remaining 3% is supplied by natural gas. The energy structure is very inappropriate to sustainable development. The high dependence on fossil fuels has a huge negative impact on economy and energy security and environment of the country. Fig. 2 shows a graphical representation of Chinese primary energy supplies in past 30 years. As shown in Fig. 2, the economy and the demand of energy are rapidly increasing in the past 30 years, but the inappropriate energy structure of China is hardly changed [5].

In China, there is a very big fossil fuel resource, and abundant natural resources deposit in the large area. The energy need of China is very big with the development of economy at the same time. According to the data of Chinese Development and Innovation Committee in 1999, Fig. 3 draws a comparison between the Chinese reserves of primary energy and the world reserves of primary energy. As it can be seen from Fig. 3, the reserves of Chinese coal energy is the most important fossil fuel in China, but the reserves can only be exploited for about 105 years, simultaneously with the world coal energy can be exploited for about 216 years. The oil energy of China can be exploited for about 15 years; the world oil energy can be exploited for about 45 years at the same time. Natural gas energy can be exploited for about 30

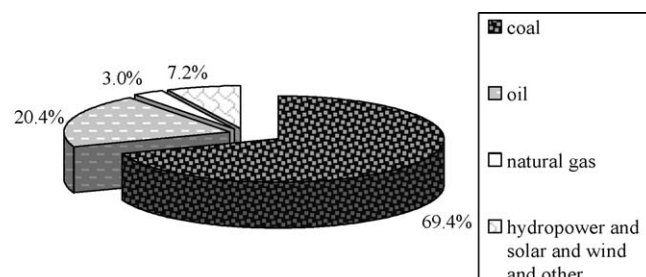


Fig. 1. Primary energy supplies by resource in 2006 (source: CDIC, 2006).

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