



Hydropower development situation and prospects in China



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ABSTRACT

China's economic development faces an energy challenge, and the appropriate solution to this energy bottleneck is the key to a robust, rapid, and sustainable development. Abundant hydropower resources provide unprecedented advantages and opportunities for China's rapid hydropower development over the last five decades. China's hydropower growth contributed greatly to the global output net growth, with the current installed hydropower capacity at 320 GW. This study uses the 13th Five-Year energy plan to summarize the development of China's hydropower sector for the past 50 years and its current progress, recommend the major hydropower bases and its scale, describe the main problems encountered in developing China's hydropower resources and the solutions to these difficulties, and predict China's hydropower development trends and prospects in the future. This study aims to give an overview of the present situation of hydropower in China and its future political, economic and environment perspectives and challenges.

1. Introduction

The accelerating pace of economic globalization has resulted in a new energy revolution that involves the gradual reduction in the use of conventional primary energy sources, such as coal, oil, and natural gas. A clean and renewable energy structure should be established to gradually replace the current energy structure that causes considerable pollution. Environmental problems caused by the use of fossil fuels, such as acid rain, greenhouse effect, and ozone depletion, are significant factors that restrict the development of the global economy and has attracted the attention of governments, the scientific community, and the people; thus, developing a new energy power generation scheme is imperative [1]. As the largest developing country, China plays a crucial role in the transformation of the global energy structure. Coal is the dominant source of China's energy needs; however, its supply is declining annually, with the current rate of 64% considered the lowest in the country's history. The use of non-fossil fuel and renewable energy has increased rapidly, in which the share of renewable energy in the global total in ten years from 2% to 7%. Table 1 shows China's primary energy consumption structure. Hydropower plays an important role in the development of China's electric power industry. To achieve the optimal allocation of resources, the state must save precious fossil energy resources, optimize the energy structure, reduce environmental pollution, and realize sustainable development. A comprehensive hydropower project comprises a variety of functions, such as irrigation and flood control, and its related projects can improve local

transportation and promote economic development. However, the establishment of a large hydropower station will affect the local climate, the resettlement and recovery of basic production is difficult, during the rainy season, and power generation the excess power transmission does not go out and cause wasted.

There are a large number of researches on hydropower both at home and abroad. In the Ref. [2], Sharma elaborated on the importance of hydropower development in Nepal and the issues that must be considered in hydropower development in Nepal. In the Ref. [3], Beatrie Wangner summed up the history of hydropower development in Austria, through the energy structure and consumption of Austria to highlight the importance of water and electricity in the country. It illustrates the challenges of hydropower in the future politics, economy and environment. Zimmy analyzed the level of use of hydropower resources on every continent in the Ref. [4]. China's hydropower development has also received many scholars attention, such as Ref. [5] and Ref. [6], Academician Youmei Lu pointed out compared with other renewable energy sources such as wind energy, solar energy, biomass and other renewable energy sources, energy conversion density and high efficiency, the technology is more mature, is used for power generation of high quality energy [7]. Qian Mou believes that China's coal-dominated energy structure of carbon emissions continue to grow in the situation is grim; we must vigorously develop low-carbon energy, including hydropower, to fulfill the world's emission reduction commitments [8]. Ref. [9], the author describes the development of hydropower in China for 40 years; it is including the famous Three Gorges

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Table 1
China's primary energy consumption structure from 2000 to 2015.

Year	Total energy consumption (Million tons of standard coal)	Share (%)			
		Coal	Petroleum	Natural gas	Nuclear, hydropower and others
2000	146,964	68.5	22.0	2.2	7.3
2005	261,369	72.4	17.8	2.4	7.4
2007	311,442	72.5	17.0	3.0	7.5
2008	320,611	71.5	16.7	3.4	8.4
2009	336,126	71.6	16.4	3.5	8.5
2010	360,648	69.2	17.4	4.0	9.4
2011	387,043	70.2	16.8	4.6	8.4
2012	402,138	68.5	17.0	4.8	9.7
2013	416,913	67.4	17.1	5.3	10.2
2014	426,000	66.0	17.1	5.7	11.2
2015	430,000	63.7	18.6	5.9	11.9

Project and the pumped storage power station and restrictive factors of hydropower development in China at present. The Refs. [10] and [11] have focused on the development of small hydropower in China, explained the development course, challenges and development prospects of small hydropower in China. In this paper, the overall situation of China's hydropower has done a detailed exposition including the reserves of hydropower resources, small hydropower, and major hydropower base and so on. We evaluated hydropower development of China will face challenges and future development direction during the 100-year history of China's hydropower development and the "Chinese electric power development planning in 13th Five-Year".

2. History of hydropower development in China

2.1. Initial stage

China's hydropower development started later than those in other countries. The world's first hydropower station was established in France in 1878. The United States also established the first hydropower station on the Fawkes River in Wisconsin in 1882. Tewoly hydropower station as the Europe's first commercial hydropower station was established in Italy 1885. It can be said that in the early 1890s, hydropower in North America, Europe, many countries have been paid attention to. Established in 1910 in Yunnan Province on the outskirts of Kunming Shilong dam hydropower station is China first hydropower station. After seven expansions in 1958, the installed capacity of this hydropower station is 6000 kW [12]. To date, Shilong Dam Hydropower Station is still in operation. This hydropower station introduced advanced foreign technology, equipment, and management, as well as introduced China's first hydropower team.

2.2. Development stage

China's hydropower sector experienced substantial development until the establishment of the "new China." The completion of the Xin'An River Hydropower Station on the upper stream of the Qian Tang River is a special historical symbol. This hydropower station is China's first large station that features local design, equipment, and construction process, and is considered a landmark in terms of the country's hydropower industry. Simultaneously, large hydroelectric projects were built in the Guangdong Xinfeng River. The Hunan Zhexi dam height was over 100 m. The small and medium-sized cascade reservoir development of the Fujian River was started in Gutian, Yunnan, Sichuan Yili River, Guizhou Longxi River, Beijing Maotiao River, and Yongding River. The Fujian Gutian Creek Station is the first cascade hydropower station and the first underground powerhouse of a hydropower station in new China [13]. This station is equipped with 2 sets of 6000 kW

turbine and 4 Taiwan 12000 and 500 W of turbine generator units. The first 6000 kW generating unit was operationalized in March 1956 [8]. The Sanmenxia Hydropower Station located in the Yellow River Started was started simultaneously with the Xin'An River Hydropower Station. The establishment of the Sanmenxia Hydropower Station provided experience for the development of China's hydropower training personnel. The collective experiences and lessons from the operation of this station resulted in the beginning of a gradual and scientific hydropower development in China. The further advancement of socialism enabled the construction of hydropower stations to be placed on the agenda in terms of policy making. During the "First Five-Year Plan" in China, the construction of the Liujiaxia Hydropower Station, a large hydroelectric power station and the first million kilowatt class facility in China, has been started. This station was eventually called the "Yellow River pearl." During the "Second Five-Year Plan," Bo Yibo, a former deputy prime minister of the State Council, explained that the development of the power industry in the future should involve the CPC Central Committee's resolute implementation of the use of hydropower and supplemented by the long-term construction policy stipulated in the 1958 national economic plan [14]. The proposed policy during the time of the development of hydropower played a role in promoting the use of this energy source. In May 1971, the construction of the Gezhouba Dam Hydropower Station was started. This project, which was the first large-scale hydropower project on the Yangtze River. Moreover, the Three Gorges project which started in 1994 has the world's largest five locks, highest concrete arch RCC dam, and highest CFRD. Moreover, are cord amount of concrete was used in this project. Fig. 1 shows the Three Gorges power Station.

Through "technology transfer, digestion and absorption, and independent innovation," the hydropower industry has achieved substantial advancements in manufacturing large hydropower equipment with enormous installed capacity. In addition, substantial independent research and development using the new technology has resulted in extensive use of new materials in hydropower engineering for the construction of hydropower plants.

2.3. Rapid development stage

The 21st century is a period of accelerated development for China's use of hydropower. Countries continue to promote the reform of the power system, local governments at all levels and various types of development of hydropower development of the enthusiasm is fully mobilized. In 2004, the installed capacity of China's hydropower to exceed 100,000 MW, thereby becomes the world's largest hydropower plant. Subsequently, numerous large hydropower stations have commenced construction, while the Three Gorges Hydropower Station will be completed. By 2010, China's hydropower capacity had exceeded



Fig. 1. Three Gorges power station.

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