

# Scientifically Exploiting Hydropower Resource to Promote the Sustainable Utilization of Water Resources and the Sustainable Development of Economy and Society

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## 1. Brief introduction of China's water and hydropower resources

The total amount of China's water resources is  $2.8 \times 10^{12} \text{m}^3$ , in which the rivers runoff volume is  $2.7 \times 10^{12} \text{m}^3$  and the resources of underground water unduplicated with the rivers runoff volume is about  $0.1 \times 10^{12} \text{m}^3$ . The overall water resources reduce from south to north and from east to west. The water resources in the south, especially the southeast, are abundant, but the degree of development and exploitation is relatively lower. The water sources of the Yellow River and other rivers in the north are relatively small, but the degree of utilization is high. The water resources in China are featured by: (1) the total amount is far from abundance and the average amount per capita is even lower. China's total amount of water resources ranks 1<sup>th</sup> in the world, but the average amount per capita is only  $2200 \text{m}^3$ , about 1/4 of the world average. It is estimated that the population of China will reach the climax of 1.6 billion in 2030. At that time, the average water volume per capita will be only  $1750 \text{m}^3$ . The condition of the shortage of water resources will be more serious. (2) The distribution of water resources is not balanced and the resources of water and land are not matched. The land area of the Yangtze River basin and its south region accounts for about 37% of the total territory, but the water resources account for 81%. The land area of the Huaihe River basin and its northern region accounts for about 63% of the total territory, but the water resources account for only 19%. (3) The distribution of water resources is uneven between years and within a year. The damages of drought and waterlogging are frequently happened in the country. In most regions, the rainfall in the 4 months flood season accounts for more than 70% of the annual rainfall. In the history, there appeared a drought in consecutive 13 years. There are many rivers in China, of which more than 3000 rivers reserve over 10MW of hydropower energy respectively. According to the 4<sup>th</sup> national hydropower resources investigation in 1980, the theoretical hydropower reserves in the whole country were 67600MW, of which the exploitable was up to 37800 MW. The annual power generation is  $1920 \times 10^9 \text{kWh}$ , it accounts for 17% of the total worldwide exploitable hydropower resources, ranking the first in the world. The national hydropower resources includes the ample resources of small-size hydropower stations (which means the station with the installed capacity below 50 MW) with the exploitable amount of about  $0.128 \times 10^9 \text{kWh}$ . The hydropower resources of China are characterized by the following four aspects. (1) The total amount is abundant, but the average amount per capita is low. In term of electric quantity, the resource per capita is only about 70% of the worldwide average. (2) The distribution of hydroelectric power resources is not balanced and the resources are not matched with the economic development. 78% of the hydropower resources are concentrated in the west where the economy is underdeveloped, while 11 provinces and municipalities in the east and coastal areas with developed economy and concentrated

population have only 6% of the total, but the electric power consumption accounts for 51% of the total. (3) The water runoff of rivers varies greatly between years and within a year, which bring out difficulty for developing and using hydropower resources. The ratio of the maximum to the minimum annual runoff is 2~3 times for the Yangtze River, Pearl River and Songhuajiang River, up to 15 times for the Huaihe Rive and as many as 20 times for the Haihe River. (4) The development and utilization is not sufficient. At the end of 2003, the developed quantity of the national hydropower is only 24% of the exploitable amount, much lower than the average development degree of 60% of the developed countries.

## **2. Overview energy and hydropower development in China**

China is one of the few countries using coal as the main energy in the world. Statistics show that among the energy structure of China in 1997, the energy produced by coal accounted for 75% of the total energy; the petroleum, hydropower and natural gas accounted for 17%, 6% and 2%, respectively. Because 80% of coal, petroleum and other energy resources distribute in the central west where the economy is not so developed, but 60% of energy consumption concentrates in the east. The long distance transportation is a must. At the same time, the mining and processing of coal produces a large amount of pollutant and discharge large quantities of carbon dioxide, which result in serious pollution on air and environment. With the rapid development of economy in China and sharply demand for energy especially in recent years, oil, transportation, coal and electricity are tight in supply in the whole country. And the pressure on environment is prominent. In recent two years, the large extent power-cutoff in the country has brought great impacts on economic development and people's normal living.

To realize the sustainable development in economy and society, China has defined the energy development strategy of "taking coal as the main body, taking electric as key issue, and realizing the comprehensive development of petroleum, natural gas and new energies" in 2004~2020, and put forward the development principle for electric power of "accelerating the restructuring, strengthening the construction of power network, optimizing the structure of thermal power, actively developing hydropower, and appropriately developing nuclear power".

Electric power, as the key energy, is an important condition for national economic construction and social development and is of vital importance. In over 20 years' reform and opening to outside, the electric power industry in China has made great progress. Till the end of 2003, the national installed capacities was up to 391410MW and the yearly power generation is  $1905.2 \times 10^9$  kWh. The total installed capacities and annual power generation rank the second in the world, which make that China has entered into the countries of large producer and large consumer of electric power in the world. However, China's average installed capacity per capita is only 0.303 kW and the average power generation per capita is only 1474.3 kWh, less than half of the worldwide average and 1/6~1/10 of the developed countries. The average electricity consumption for people' living is even lower, only 173.2 kWh.

The hydropower construction is being well developed in China because the technology is relatively developed, the exploitation and operation costs are low and the pollution on environment is low. In 2003, the national installed capacity of hydropower was up to 94900MW and the total power generation was  $281.3 \times 10^9$  kWh. Of which, small-size

hydropower stations gained rapid development for the features of dispersed development, network construction and power supply on the spot and low cost of power supply. At the end of 2003, 42000 small-size hydropower stations were built with the total installed capacity of 30830MW and yearly electricity generation of  $97.9 \times 10^9$  kWh.

The potentials of nuclear power, wind power and other clean energies are limited by technology, economy and other factors. In the coming 20~30 years, hydropower will still be an important component of China's energy structure. It is estimated that till 2020, the national installed capacity of hydropower will be 230000MW (of which the installed capacity of small-size hydropower stations will be 93000MW). The newly annually installed capacity should be more than 8000MW. The construction of hydropower will shoulder heavy responsibilities.

### **3. Important role of hydropower development to promote sustainable development**

The hydropower construction possesses an irreplaceable, apparent overall effect in ensuring energy supply, ensuring the power supply, improving the power supply quality, reducing the discharge of pollutant, protecting ecologic environment, and also in flood control, water supply, irrigation and navigation. Its important function to improve the sustainable development of economy and society is widely accepted. As an important part of hydropower development, the successful practice of small-size hydropower stations in China has verified that it plays an important role in the integrated sustainable development of economy, society and environment.

The small-size hydropower station has been installed in about 1600 counties in China and the power supply from small-size hydropower dominates the main energy supply in about 800 counties, which ensures 500million people to use electricity. 653 preliminarily electrified counties have been established (with a population of 252 million) and 400 rural electrified counties are under construction, in which the power supply from small-size hydropower stations will replace the fossil fuels.

(1). Through developing small-size hydropower station, the ecologic environment can be improved and protected, and the works on returning farming lands to forestry, ecologic construction and sustainable development can be promoted. If it is calculated in according to  $97.9 \times 10^9$  kWh of the electricity generation of the national small-size hydropower stations in 2003 and is compared with burning coal,  $500 \times 10^6$  tons of carbon dioxide and a large amount of other harmful gases can be reduced. 20 million families are using the power from the dispersed small-size hydropower stations.  $1.3 \times 10^5$ ha forest woods are reduced from being cut down and about 90 million  $m^3$  lumbers are saved annually, so the forest is protected. The average forest cover rate of the 653 preliminarily electrified counties increased by 9.88% in 15 years, 5.4% higher than the national average. At present, the electricity generation of small-size hydropower stations in China accounts for more than 95% of the clean and renewable energy, so they play the basic function in promoting the development of clean and renewable energy.

(1) Small-size hydropower station has been an important way to realize the policy of supplying comprehensive service of electric power. In 2002, the installed capacity of small-size hydropower stations accounted for 55% of the total capacity of generating sets in county areas, which has been an important part of the rural energy in China. In 2003,

the installed capacity and annual power generation of small-size hydropower stations accounted for 32.5% and 34.8% of the total hydropower stations, respectively.

(2) The exploitation of small-size hydropower station accelerates the economic development in necessitous mountainous regions and minority nationality regions and the pace of poverty relief for the rural population. 82% of the preliminarily electrified counties are located in the central western region, of which over 200 counties are the residences of minority nationalities and over 100 counties are located in the boundary areas of the country. These counties are different in resource and economic and social conditions, but the objective of doubling in five years and 4 times in ten years of GDP , average net income of rural population and average electricity consumption was basically realized and the development speed was apparently higher than the national average .

(3) By driving the industrialization and urbanization through electrifying, the adjustment of economic structure was promoted. After the electrical construction in 15 years, the proportion of industrial production in the total production of industry and agriculture in the preliminarily electrified counties increases by 10% in every five years, and yet the national average increasing proportion was 10.9% from 1985 to 1999. More than 20 million rural surplus labor in the preliminarily electrified counties have transformed to the second and the third industries, which quickens the pace of urbanization.

(4) Integrated management and development of small- and medium-scale rivers are expedited to promote the rational utilization of water resources and to improve the production condition of agriculture and the living standard of rural population. Through combining water management and electricity development, a large number of integrated water conservancy projects are constructed and the reservoir capacity is increased by more than  $400 \times 10^9 \text{ m}^3$  in total. Through harnessing several thousands of small- and medium-scale rivers, the flood control capability is enhanced and the irrigation area is increased by more than 1.67 million ha and the grain production is increased by 30 million ton. The difficulties for getting drinkable water of 64 million person and 47 million livestock were solved. township and village road of 20 million km long was also newly constructed.

#### **4. Existing problems in hydropower development of China**

Although China has paid much attention on the development of hydropower, a large of manpower and materials have been invested, and great achievement has been made, there still have some problems mainly in the following five aspects:

(1) Water issues related to hydropower development are still serious. The standard of flood control is low and the flood and waterlogging disasters frequently happened. More than 70% national fixed assets, 44% population, 1/3 farmland and over 620 cities are located in the middle and lower reaches of the main rivers and threatened by serious flood disaster. The water conservancy projects are not capable of entirely defending the impact of flood and the standard of flood control of the main rivers is not high enough. With the development of economy, society and urbanization, the wealth and population in the regions threatened by flood is increasing consecutively, which makes much more difficulties for flood control. All these make more challenge in flood control and safety. The capacity of water supply is not enough, which result in serious draught and water shortage. According to the international standard, about 54% population, 50% provinces and 76% cities in China is in water shortage. Draught and water shortage are becoming a

severe factor to limit the economic and social development in China, especially in the northern region. Water pollution is serious and the ecologic environment is deteriorating. At present, the annual discharge of wastewater in China is  $63.1 \times 10^9$ t and the pollution of water body is becoming severe due to the inadequate treatment capacity. The water resources are exploited excessively in some areas and the underground water is over-extracted, which cause a series of ecologic environment problems such as the water interception of rivers, the falling of groundwater level, the invasion of seawater and the salinization of land.

(2) The exploitation degree of hydropower is low; the energy supply is not ample; the energy supply and demand is unbalanced. Till the end of 2003, the development quantity of hydropower resources only accounts for 24% of the exploitable. At the time when a large amount of water energy is wasted, the electric power and energy are scarce at the national extent and the power-cutoff happens in many regions and even large cities, which brings a tremendous loss, limits the development of economy and affects the normal living of people in some areas.

(3) The disadvantageous of hydropower development on ecologic environment emerge. The development of hydropower, especially the large-scale hydropower projects, brings inevitable negative effects on the environment, such as: changes of river course and flow regime, sedimentation; water quality deteriorates; changes of local climate; induced geological disasters, threatening to the original ecological environment, etc. However, it is our duty to shoulder the responsibility both on hydropower development and ecological environment protection.

(4) The administrative mechanism for hydropower development and utilization is not smooth. At present, the government is not completely conducting the necessary management of hydropower resources and the supervision and management of hydropower development should be strengthened more vigorously. The development of some hydropower projects failed in executing the overall planning of the river basin. Some hydropower stations unilaterally emphasize the efficiency of electricity generation and not operate in accordance with the comprehensive dispatching schedule. The transmission of electricity is monopolized in some regions, which causes the situations of tense electricity supply on the one hand and the dull sales of electricity of some small and medium sized hydropower stations on the other hand.

(5) The damage and waste of resource are serious and the utilization efficiency of energy is not high. Some water conservancy and hydropower projects have multi-functions in flood control, irrigation, water supply, power generation and ecologic protection according to the overall planning of the rivers, but they are developed only as a power generating project. Some developers fail to construct the power plant in accordance with the installed capacity specified in the hydropower development planning, but depend on the self-fund to reduce the installed scale. Some developers do not follow the cascade planning, but randomly select project site. All these cause a large amount of waste in resources and finance, and even endanger the safety of flood control, irrigation, drinking water of human and livestock and ecologic environment.

## **5 Scientific planning, strengthen hydropower construction, promote sustainable development**

The hydropower construction is an important part of the national sustainable development, and the hydropower development encounters an excellent opportunity. We shall pay much attention to overcoming the deficiencies in the past practices, persist in the idea of harmonious coordination of human and nature, plan scientifically, strengthen management and promote the sustainable development of economy and society.

### **5.1 Good opportunity for hydropower development**

The coming 15~20 years is a period of good opportunities for hydropower development in China.

(1) The strategy of large-scale development of the western region creates an important historical opportunity. The hydropower resource in the eastern region accounts for only 7% of the national amount, and the exploited ratio is more than 50%, while the hydropower resource in the western region accounts for more than 3/4 of the country, but the exploited ratio is only 8%. The exploitable hydropower resource is rather ample, thus the tasks of hydropower development primarily focus on the western region. Hydropower development in the west and the policy of “transmit the power in west to the east” can not only satisfy the need of economic development for electric power, but also can transfer the potential resource advantages into the actual economic benefits.

(2) The strategy of sustainable development creates a wide space for development of hydropower resources. The hydropower generation is free of consuming fossil energy. Hydropower to replace thermal power generation is not only favorable to reducing the discharge of greenhouse gas to protect ecologic environment, but also favorable to enhance the utilization ratio of resources and the overall efficiency of economy and society, which accord with the long-term benefit of the Chinese Nation and the requirements of the strategy of sustainable development.

(3) The excellent situation of current economic development in China offers the unprecedented favorable conditions for the hydropower development. The coming 20 years is a strategic period of opportunity in China and the economy will increase at a high speed. In order to meet the needs of economic development, the electric power, especially the hydropower shall be developed rapidly. In addition, with the overall economy is becoming better and better and the fund and financing situation is becoming looser and looser, which offer the unprecedented external condition for the development of hydropower resources.

### **5.2 Principles of strengthening hydropower development**

According to the practice of hydropower development in China and the overall requirements of coordinated and sustainable development of current economic and social environment, the following principles should be followed during the development of hydropower resources:

(1) Harmonious existence of human and nature. The harmonious existence of human and nature is the core of the strategy of sustainable development, the foregone conclusion of the continued development of economy and society and the natural requirement of the well-developed economy and society. During the hydropower development, the relations between social and economic development and natural ecological environment protection, the necessity of development and exploitation and the bearing capacity of ecologic environment, current benefit and long-term interests shall be well disposed.

During playing the specific functions of the project, we shall maintain the natural flow regime and the health of rivers as possible as we can. This is the core idea in resolving the water related problems including flood and waterlogging disaster, draught and water shortage, soil erosion and water pollution.

(2) Taking precedence of planning to ensure harmonious development of resources, environment, economy and society. The construction of hydropower project shall comply with the natural law and economic rule, and fully consider the bearing capacities of water resources and hydraulic environment. Within the range of the integrated planning and other strategic plans, we should comprehensively consider and coordinate the overall demands of all regions and all industries, rationally arrange the engineering layout and the development emphasis of the construction of hydropower, strengthen the optimized configuration, appropriate development and high efficiency utilization and effective protection, and ensure the harmonious development of population, environment, resource, economy and society.

(3) Making an overall plan in an integrated development, strengthen management and approving construction plan legally. The interests of the upstream and the downstream, the current benefit and long-term interests and the relation between development and protection shall be taken into the consideration in the development of hydropower resources. Under the conditions of fully considering the development condition of water resources and hydropower resource and the influence of investment and other factors, the hydropower development should be promoted from various aspects, levels and angles in the principle of promoting the beneficial and abolishing the harmful, and comprehensively developing water conservancy, hydropower, water supply and navigation. In the process of hydropower development, the government agencies should examine and approve the construction project according to the relevant laws and the overall factors in the river basin and intensify the supervision in the operation and construction.

(4) Taking people in the first place and resettling well the immigrant. The hydropower construction is always involves a large number of immigrants and the immigrant-related issues are the key for successfully implementing the hydropower project. Most population affected by the hydropower project is relatively needy, so we shall put people in the first place in the immigrant related works and should take the resettlement and supporting development as an excellent opportunity for the people in the mountainous region to get rid of poverty and expedite their development. Through strengthening the construction of infrastructure and supporting their production activities, we intend to enhance living standard and overall quality of the immigrants, gradually change the backwardness of the resettlement area in society, economy and culture to provide conditions for reaching the moderately prosperous society. The living and production conditions should be ensured and will be improved greatly to make the immigrants share the efficiency and benefit of the hydropower development. On the basis of improving the economic compensation, moving, resettlement, production supporting and other resettlement procedures mainly focus on economy, we should pay much attentions on the sociological issues of the immigrants. We should ensure that the immigrants are willing to move, live in peace and contentment and are capable of becoming rich. At the same time, we should gradually explore and put into practice the new resettlement mechanism in the condition of market economy and reform the management mechanism of “leading

by the government, competent department taking responsible, owner participating and level-to-level management” in national public welfare development project. For the development project by juridical person with independent right of operation, we should explore the system that the juridical person takes the responsibility of immigrant and the new method of investing for immigrants resettlement and overcome the past shortcoming of “judicial person acquiring benefit, the government being responsible of migration and the immigrants failing to share efficiency”.

In September 26, 2004, the installed capacity of hydropower in China broke the benchmark of 100000MW, which is the historical span of China’s hydropower development, and it is the data that should be memorized in the world history of the hydropower development. It is hoped that the worldwide colleagues work together and communicate the technique and experience on the development of water resources and hydropower for the purpose of scientifically and permanently using clean and renewable hydropower resource to serve the harmonious development of human and nature and to realize the sustainable development.