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Development Trend of Chinese Hydroelectric Generation Technology of Hydro Power Plant (HPP)

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***Abstract*—**Water power is a renewable energy which is economically cheap, clean and reliable. Theoretical hydropower resources of China amounted to 680 million kW, the greatest in the world. For the water maintains circulating according to a certain hydrologic cycle continuously and uninterruptedly, the water resources are considered to be a renewable energy. Therefore Hydropower is low cost due to firstly, the energy carried by the water flow is the only energy required for the power generation in the hydropower station. Secondly, the applied equipment is simpler than that of thermal power plant, thus costing less in maintenance and overhaul. If taking the fuel consumption into consideration, the annual operation cost of thermal power plant is 10~15 times higher than that of hydropower plant. Beside hydropower is clean during the course of hydropower generation, neither harmful gas, smoke, dust, ash will nor nuclear pollution will be caused. Hydropower generation has a high efficiency and conventional hydropower plant can make use of 80% water resources, while the heat efficiency of thermal power plant only reaches 30%~50%. In this paper, the study is established in the necessary Engineering development of hydropower plants and hydroelectric generation technology in China. The Chinese model base of hydropower plants features, functions, flow analysis chart and ecologic Issues are also discussed in this paper.

***Keywords*—**Renewable energy, Hydropower, Hydroelectric, Generation, Function, analysis chart, ecologic issues

INTRODUCTION

The conventional energy sources falls into categories of coal, petroleum, natural gas, wind power, solar power and water power resources [1], [3]. The water power resource is a renewable energy that equivalent to 345 billion tons of standard coal (developable in technology) in gross reserves and 159 billion tons of standard coal (developable in economic) in the residual exploitable gross, sharing 2.6% and 11.5% respectively in the global gross reserves. Lump-sum investment for hydropower station is greater [2], [4]. Massive civil works and great flooding losses demand for more investment; and huge amount of resettlement cost need to be paid; the long project period impacts the capital turnover [14]. Even the beneficiary's department's share the cost, the investment per kilowatt is still much higher than that of thermal power station. The turbine-generator unit features a flexible start/ shutdown operation, quick output, increasing/ decreasing operation and large output variable amplitude, deemed as an ideal means for the regulation of peak load and frequency and the emergency auxiliary power supply. The ecological impact must be considered when construct a hydropower plant. If a larger reservoir is built, more area will be flooded and more people need to relocate, influencing people's production and living conditions and the living environment of the wildlife and meanwhile changing the original hydrological conditions as a result of regulated flow by the reservoir [15].

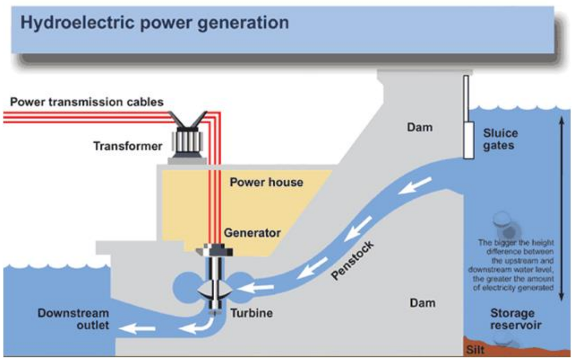

Figure 1. Large Hydroelectric power generation-scheme components [8]

I. FUNCTION OF HYDROPOWER IN POWER SYSTEM

The electric energy supplied by the hydropower plant is abundant, low-cost and pollution-free [5]. It shares 22% of the total electric energy, and costs much less [6].The main functions of hydropower in the power system are a function of load & frequency regulation and Function of Energy Storage. The hydropower plant functions as the frequency and load regulation [8]. For the heat stress, the thermal plant is difficult to start and connect to the power network within a short time while the operation of the hydropower is more convenient and fast. Therefore, the hydropower plant is capable and responsible for load and frequency regulation in the power system [5], [6]. The energy in the power system is unstable and the difference between peak and valley of some power networks are great. For this problem, we suggest construct pumped-storage power plants, utilizing the surplus power at valley to pump the water from downstream to the upstream

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reservoir [6]. The pumped and stored water will be utilized for the power generation in the peak load.

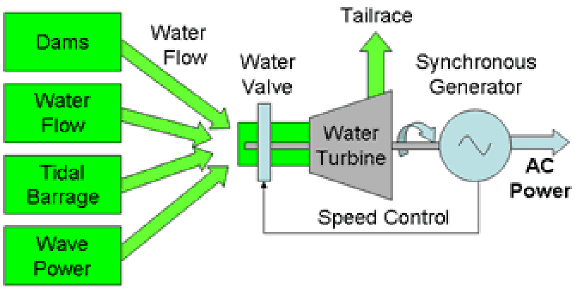

Figure 2. Typical Monitoring Parameters Configuration Diagram of Francis Type Hydroelectric Generating Unit

II. WORLD HYDROELECTRIC POWER GENERATION

The hydroelectric power generation growth has been raised gradually fast and steadily by an average 3% annually since last four decades. About 16% of global electricity generation has been accounted with 3,500 billion kW-Hours hydroelectricity in 2011. Almost all large hydro dams probably world's 45,000-plus were produced electricity only about 16% of the world's need in recent 2011 [7]. Therefore hydropower generation construction is going fast developing in over 160 countries. In fig.3 chart as shown below, we can analysis world hydroelectric generation's rate from 1965 to 2011 [7].

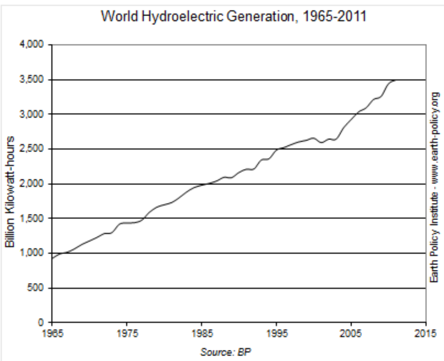

Figure 3. Configuration of monitoring system for a hydroelectric application

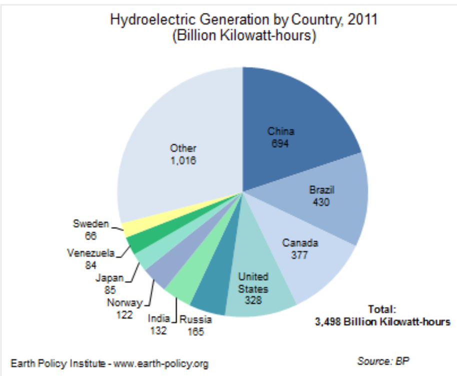

Figure 4. World Hydroelectric Generation by country, 2011

The Fig .4 is shown as 4 countries dominate the hydropower landscape: Brazil, China, Canada, and the USA. Among these countries, they are producing more than half of the world's hydroelectricity generation. The latest analysis chart is shown as per country's hydroelectric generation capacity in 2011 [7].

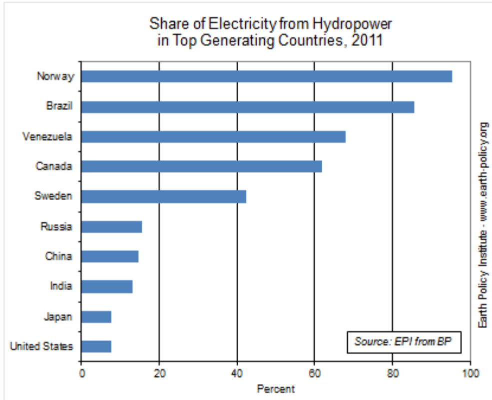

Figure 5. Share of electricity from hydropower in Top Generating Countries, 2011

Fig.5 shows sharing electricity capacity among the world's largest producers, Norway becomes the greatest share of its electricity from hydropower projects: a full 95%. Other countries get the bulk of their electricity from river power reported by world's energy resources [7].

III. HYDROPOWER DEVELOPMENT IN CHINA

Before 1949, only several hydropower plants operated in nationwide. The installed capacity, then only amounted to 360MW and the annual output was 1.2 billion kW•h, ranked the 20th and 21st place in the world respectively. Shilongba Hydropower Station, located in the Dianchi area of Yunan province, was the first hydropower plant of China built in 1912 with an installed capacity of 2920MW. Since the foundation of New China in 1949, Chinese hydropower construction has gained rapid and further development [11], [12]. From 1950s to early 1960s, Fengman Dam and Power Station were renovated, small projects like Longxi River and Gutian were continued and some small, medium and small hydropower projects (including power stations in Guanting, Huai River, Huangtankou, Liuxi River) were constructed. In the late 1950s, the cascade development for rivers like Shizitan, Yanguoxia,Tuoxi, Xinfeng River, Xijing and Maotiao River, Yili River, etc. were started.

From the middle 1960s to late 1970s, projects of Gongzui, Yinxiuwan, Wujiangdu, Bikou, Fengtan, Longyangxia, Baishan and Dahua were commenced. In the beginning of 1970s, Liujiaxia Hydropower Station, China's first station with installed capacity more than 1000MW, went into operation. In 1980s, the Gezhouba Hydropower Station with 2715MW installed capacity was completed, followed by a series of large-scale hydropower stations, including Three Gorges Hydropower Station, which was officially started in 1994 with 18200MW installed capacity.

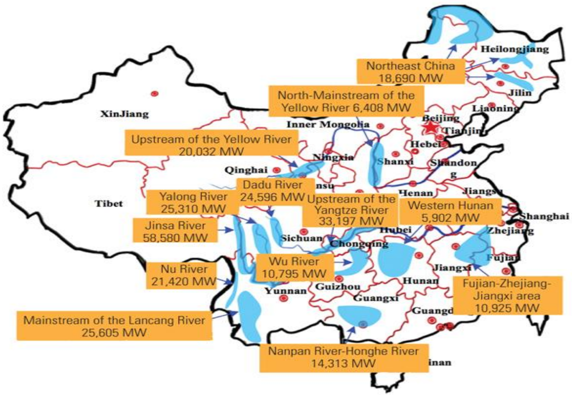

Figure 6. Hydropower generation river reservoirs in china [10]

By the end of 2000, there had 18 large-scale hydropower stations (storage station excluded), with 1000MW installed capacity or above, completed or under construction around China. The pumped storage power station has gained further development either. It was constructed in the water-deficient area and utilized to regulate the peak load on the power system. The Guangzhou Pumped Storage Station, completed with 2.4 million kW installed capacity, is the 1st station of this type in China and the largest pumped storage station in the world. In addition, we had built Yamdrok Yum Tso Lake Hydropower Station in Tibet, the pumped storage power station with the highest elevation in the world. Besides, other pumped storage power stations are built, including Henan Baoquan Pumped Storage Power Station, Anhui Langyeshan Pumped Storage Power Station, Shandong Taian p Pumped Storage Power Station, Zhejiang Tongbo Pumped Storage Power Station, Jiangsui Yixing Pumped Storage Power Station and Hebei Zhanghewan Pumped Storage Power Station.

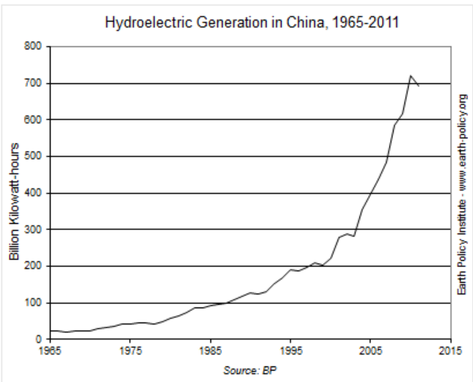

Figure 7. Hydropower generation in china from 1995-2011

China is one of the largest dam hydro generation making capacities in the world and much of the world's recent growth came from China. A Chinese hydropower generation more than tripled from 220 billion kilowatt-hours in 2000 to 720 billion in 2010. In 2011, despite a drop in generation due to drought, waterpower reported for 15 percent of China's total electricity generation [7].

IV. PROSPECT HYDROPOWER DEVELOPMENT IN CHINA

China's water resources are rich in western areas, occupying as much as 75% of China's [13]. However, only 8% have been developed by now. Yunan province has the most potential for the hydropower development in western areas with 23.8% developable installed capacity of China [12]. Its water resources are mainly distributed in 6 river systems: Jinsha River, Lancang River, Nu River, Zhujiang, Hong River and Irrawaddy River. With the implementation of develop-the-west strategy, the west-east electricity transmission project will take further advantage of the abundant water resources in the west and promote the hydropower development of China. Now, 2 giant hydropower stations, Xiluodu Power Station and Xiangjiaba Power Station, have been approved by the State Council, to be the largest hydropower base in China. Xiluodu Power Station, locating in the border of Sichuan and Yunan, is designed with 13.86 million kW installed capacity and 57.12 billion kwh annual output; Xiangjiaba Power Station, locating in the border of Sichun and Yunan, is designed with 6.4 million KW installed capacity and 30.7 billion kwh annual output; Compared with other large hydropower stations, they have the following advantages: great regulating capability, less flooded farmland and fewer resettlement, etc. The small hydropower resources are abundant. The theoretical reserve is approximately 150 million kW, the developable capacity is about 70 million kW and the annual output is about 200 billion ~250 billion kWh. With features of dispersed resources, small impact to the eco-environment, proven technology and small investment, the small hydropower is more applicable in the rural and mountainous area, especially for developing countries [11], [12], [13].

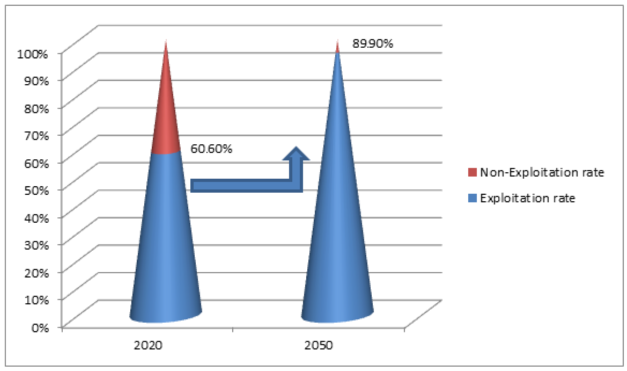

Figure 8. Chart of national hydropower installed capacity and exploitation rate

As a developing country, China's small hydropower construction has gained great achievement [11], [12], [13]. For now, 45,000 small hydropower stations have been completed. The gross installed capacity reaches 55.12 million kW and annual output amounts to more than 160 billion kWh, occupying about 30% of China's hydropower installed capacity and annual output. 2001—2010: large quantities of hydropower stations were built and put into operation, like Three Gorges, Longtan, Xiaowan, Gongbaxia, Shuibuya, etc. By 2020, the national hydropower installed capacity will reach 330 million kW and the exploitation rate will rise to 60.6%.

2011-2050: the exploitation rate of hydropower will go up to approximately 89%.

V. Deep Development of Water Resources

It is proven that when the development of water resources reaches a certain level, it will be more difficult to build a new hydropower station because the more social cost is required. Therefore, the developing mode will tend to deep development from the construction of a new station. There are 3 forms of deep development: expand capability and increase units; develop and utilize the surplus water resources; increase energy-stored units. According to incomplete statistics, there have 16 large-scale hydropower stations in China having expanded in capacity and increased in units, the added capacity amounting to 3068MW and occupying 38% of the original. In addition, a batch of hydropower stations has conducted small-scaled expansion by combining the irrigation with the existing hydraulic facilities, having promoted the utilization rate of water power and supplied the spare power for flood control and emergency as well. By 2020, the hydropower generating units having operated for more than 30 years in China will have a gross installed capacity of 52.184 million kW. If the expansion rate is assumed to be 10%, the expanded capacity will amount to 5.218 million kW; by 2050, the hydropower generating units having operated for more than 25 years in China will have a gross installed capacity of 328 million kW. If the expansion rate is assumed as 10%, the expanded capacity will amount to 32.8 million kW. It is clear that there has a great room for hydropower generating unit's expansion, which is considered as an important solution to cover the electricity shortage at present and in future.

VI. Ecological Issues In Hydro Power Development

At present, the greenhouse effect has caught the world's attention. Former Chinese Premier, Wen Jiabao, made a commitment to the world in the Leader's Meeting of Copenhagen Climate Change Summit held in Dec., 18th, 2009 that "We have set the new target of cutting carbon dioxide emissions per unit of GDP by 40-45 percent by 2020. On the basis of protecting the eco-environment, we have developed hydro power in an orderly way, actively developed nuclear power, and encouraged and supported the development of renewable energy, including biomass, solar and geothermal energy and wind power in the countryside, remote areas and other places with the proper conditions." China attaches importance to the eco-environment protection. Former Premier Wen proposed that developing hydropower was an important measure to cut carbon dioxide emissions. The river basin plan of HPP construction should connect the hydropower development closely with the economic and social development [5]. The comprehensive exploration in combination with flood control, water log control, irrigation, water supply, fishery, tourism, soil erosion and water resources and ecology protection should be taken into consideration. The environmental concerns in hydropower station construction and operation lie in as follows: vegetation deterioration and soil erosion; channel filling by dregs and spoils; influence on migrating aquatic animals and plants; noise in the course of construction and operation, etc. Therefore, assessing the environmental impact is necessary before the construction of a hydropower station [14].

Conclusion

Water resource is renewable. As long as the water-cycling system on the earth is workable, we can keep utilizing water resource. Hydropower is considered to be a typical clean energy, for it causes no water consumption, water and gas pollution, and greenhouse gases. Renewable energy has been playing an important role in China's overall energy plan in recent years. Its use has many favorable outcomes and reliable benefits of Chinese economic development. Therefore, accelerating the engineering development widely in hydropower generation technology and use of renewable energy is an essential means for China to simultaneously deal with the serious problems of energy production and supply as well as environmental protection.

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