SMALL HYORO POWER NEWS

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SHP IN CHINA

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HRC NEWS

Small Hydropower Development in China

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Small hydropower is internationally well known clean renewable energy, and quite rich in China. China already had a history of one hundred year in SHP development. Especially since the founding of new China, over 60 years of development, China has totally 45,000 small hydropower stations, with installed capacity of 59,000 MW, and annual output of 200 billion kilowatt hours, both accounting for about 30% of China's hydropower installed capacity and annual output. Small hydropower has played a very important role in electrifying areas without power, promoting rural social and economic development, protecting ecological environment, promoting energy-saving and emission reduction, guaranteeing the emergency power supply, known as the "luminous pearl" and "little sun" to rural area and won a good name among rural people. In new period, according to the requirements of people-oriented and sustainable development stated by the Central Party Committee and the State Council, and keeping in mind its role in vigorously promoting energy-saving emission reduction, developing low carbon economy, improving people's livelihood, we as rural hydropower workers shall reconsider the new historical mission and carefully study and solve the SHP development problems.

I REVIEW OF SHP DEVELOPMENT HISTORY

Electrification through small hydropower development is a unique way with Chinese characteristics and the people's great pioneering work, which is rooted in the rural areas and serves to agriculture, rural areas and peasants.

1. Small hydropower development conforms to the requirements of the times

At the beginning of reforming and opening, China's electric power construction mainly was concentrated in the big cities and its surrounding areas, unable to meet the development of rural production and farmer masses aspirations for a better life. Most rural areas were without electricity. With Deng Xiaoping's personal advocates, and corresponding policy support and financial aid, local governments and farmers were encouraged to develop small hydropower on their own efforts and with high enthusiasm, which makes a rural electrification development mode with unique Chinese characteristics. The development of small hydropower benefits 1/2 of country land, 1/3 counties and 300 million rural population without electricity, in one

word, small hydropower lighted up rural areas of China.

Entering the new century, along with the national electric power industry development, small hydropower transferred its function from mainly solving the electricity access problem of mountainous areas to improving rural electrification level, accelerating pace of impoverished areas to take off deficient to become rich, driving rural economic and social development in mountainous areas, promoting energy-saving emission reduction and ecological protection. The United Nations and the vast number of developing countries spoke highly of China's small hydropower in solving the problem of rural poverty, and small hydropower in China has become a worldwide recognized business card out of its mountains location!

2.Small hydropower development boosts policy reform

In small hydropower development process, each suits one's measures to local conditions, and a lot of experience and practice were created, and most of them gradually rose to national policies. Among them are the principles of small hydropower constructions such as “Three-self” (self construction, self operation and self consumption) policy, “Four-who”(who builds, who owns; who operates, who benefits) policy, the policy of “small hydropower to have its own power supply zone”, as well as the policy of “priority scheduling”, “full access and the same price to the same grid”, “to implement 6% value-added tax for small hydropower enterprises” and other supporting policies. In addition, the state launched the SHP development and rural electrification program in five continous Five Year Plan periods from the 7th Five Year Plan to the 11th Five Year Plan. Since the 11th Five Year Plan began full implementation of small hydropower replacing fuel ecological protection project, and special funds were arranged annually to guide scientific and orderly development of small hydropower. Small hydropower development promoted the introduction of the relevant policies, and these policies further greatly mobilized the development of small hydropower enthusiasm in local masses, which finally achieved a better development of small hydropower.

3.Small hydropower development promotes technical innovation

At the initial stage of Small hydropower development, electrical and mechanical equipment are non-standard production, so the technical key and applied research is to combine local actual situation, for example, to obtain raw material locally to build earth dam, rockfill dam, concrete pressure pipes; in 1970s, study focused on the standardization of equipment production and design in order to adapt to the needs of the development of small hydropower in scale; in 1980s, combined with the rural primary electrification county construction, the focus was on new technologies, new materials, new equipment application and technical management; in 1990s, research focused on small hydropower optimal dispatching, renewal and transformation, local power grid energy conservation; in the 21st century, combined with a series of project implementation including the hydropower rural electrification county construction and small hydropower replacing fuel project, study focused on computer application, automation, to meet the personalized needs of high efficient runner and mechanical and electrical equipment, and began

to pay attention to the impacts of small hydropower development on ecological environment. Through small hydropower technology innovation, China has become the world's small hydropower technology exporter and pilot, and effectively promotes international exchange and cooperation in small hydropower development.

4.Small hydropower development opens up a rural electrification road with Chinese characteristics

The development of small hydropower explored the rural electrification road with Chinese characteristics, which integrated the resources from the central governments and the local governments like a man walking on two feet, promoted the multilevel involvement in small hydropower investment and realized the benefits of local development for local supply. In 1983, with the development of small hydropower and the construction of corresponding local grids, China launched the campaign of rural hydropower and electrification. From the 7th Five Year Plan to the 9th Five Year Plan period, the campaign covered totally 653 rural primary electrification counties. During the 10th Five Year Plan and the 11th Five Year Plan period, there were a total of 815 hydropower rural electrification counties completed. The household electricity access rate of electrification counties rose from less than 40% in 1980 to 99.8% in 2010, the average annual power consumption increased from less than 200 kWh to 800 kWh, the power quality and reliability was greatly improved, which further promoted the development of local region economy. At present, with the start of the 12th Five Year Plan, the national new rural hydropower electrification county construction campaign has started in the round, which is to play its role in promoting the building of new socialist countryside.

Small hydropower development marched ahead in the twists and turns, and showed its strong vitality by innovation, responsive to the different periods of social economic development. Small hydropower development was part of the history, which not only showed up unremitting efforts and wisdom of several generations, but also witnessed how the local experience and practice transfered to national policy practice. Small hydropower installed capacity increased from about 100,000 kW at the founding of new China to today's 59,000,000 kW, with average annual growth of 29.6% (compared with China's power industry installed capacity annual growth of 11% on average). 60 years of small hydropower development in the brilliant success has constitutes a very important chapter of China's rural economic and social development!

II EXPLANATION OF SHP DEVELOPMENT VISION AND MISSION

60 years of small hydropower construction and development has made brilliant achievements in China, but we also realise soberly, along with the national finance system reform, electric power system reform, that the protection of the ecological environment and scientific development becomes the increasingly high demand, there are still problems to be solved in process of small hydropower development. One of key problems is that the development of diversion type hydropower stations is carried out without considering the ecological water flow, which leads to water reducing or dehydration of local rivers in the dry season; The second problem is that some station owners don't

consider the farmers' profits in the process of water resources utilization particularly in the resettlement and compensation issues; The third one is that development and construction process is against construction procedure, for example, some projects were built without permit and a large number of old power stations had low energy efficiency, and equipment were aged and full of hidden safety problems. These problems were not born problems of small hydropower, but problems occurred in the process of development. We should pay attention to the problems and try to find solutions in the historical perspective and with the objective attitude.

In recent years, the water administrative departments at all levels did a lot of work to address these problems. The Ministry of Water Resources organized some campaigns to carry out inspection on illegal hydropower stations, and over 5,200 hydropower stations were refurbished and upgraded according to requirements. Jointly with the State Administration for Industry and Commerce, the Administration of Work Safety, the Electricity Regulatory Commission, we issued the "Notice for Strengthening Small Hydropower Safety Production". Hunan, Jilin, Guizhou, Liaoning, Guangdong and other 10 provinces (autonomous regions, municipalities) introduced local regulations on water energy resources management. Shanxi provincial government stipulated a regulation on the water discharge of small hydropower station to ensure ecological flow through adding an unrestrained ecological discharging device; Zhejiang province implemented the program of "Thousands of Rural Hydropower Stations Benefiting Farmers". Guangdong Province encouraged and guided local villagers to take a variety of ways to invest in power plants and share the hydropower development profits.

At present, China has entered a new stage of social and economic development. The Central Party Committee and the State Council made an overall guideline as people-oriented, comprehensive coordination and sustainable development to build a socialist harmonious society. China is a big agricultural country, and rural population holds quite large proportion, therefore, it has always been care of the Chinese government to solve the problems that agriculture, countryside and farmers faced. Small hydropower is an important content in water and energy construction in mountainous area, a good way to enhance rural development and increase farmers' income, an important measure to improve the people's livelihood and ecological protection. This year, the No.1 file issued by the central government points out clearly that "accelerating the development of hydropower resources under the premise of ecological protection and farmers' interest," and "vigorously develop rural hydropower, actively carry out new rural hydropower electrification county construction and small hydropower replacing fuel ecological protection project construction, and rural hydropower grid reconstruction project". In 2007, the State Council put forward clearly in the "renewable energy and long-term development planning" that it's necessary to accelerate the development of small hydropower resources to realize a total small hydropower installed capacity of 75,000 MW by 2020 in China.

Standing at a new historical starting point, small hydropower must shoulder the new historical mission.

1. To secure and improve people's livelihood

China's small hydropower resources are distributed in more than 1,700 counties, and these places are basically consistent with the vast number of impoverished and mountainous areas, ethnic minority areas, old revolutionary base areas. At present, China's small hydropower development rate accounts for only 46%, compared to 70% ~ 80% in the developed countries, it indicates that China still has great potential. In the development of small hydropower, resources advantage is being tuned into economic advantage, but it is necessary to consider the promotion of local economic development, meanwhile to consider the local farmers' income increase and safeguard the legitimate rights and interests of immigrants, and continuously improve electricity consumption level for the mountainous people to enhance local people's production and living conditions.

2. To promote the adjustment of energy structure

At present, coal accounts for 70% of China's primary energy

consumption annually, coal consumption and carbon dioxide emissions are both the highest in the world. The Chinese government promised that by 2020 non-fossil fuels in primary energy consumption reached about 15%. The 12th Five Year Plan outline puts forward clearly that China's non-fossil energy consumption shall increase from 8.3% in 2010 to 11.4% by 2015. Hydropower has such advantages as mature technology, flexible operation, safe and reliable status with little water concentration, less migration, little submerging, little impacts on the ecological environment, with them SHP must play an important role in the adjustment of energy structure.

3. To ensure the engineering and power supply safety

With the extreme climate disasters increase, some hidden safety problems will easily happen to the old power stations with low efficient equipment, thus, we need to take measures to secure the people's life and property. With characteristics such as dispersed distribution, local development, near power supply, rapid opening and closing, small hydropower acts well as emergency power supply and plays an important role in improving power grid dispatching. In recent years there have been many cases of serious natural disasters, in which small hydropower in the first time protected the emergency power supply due to its distributed power supply advantage.

4. To improve resource utilization efficiency

Small hydropower, after 60 years of development, already has formed a considerable scale, but the early constructed old power stations have low comprehensive energy efficiency of less than 65%, far less than comprehensive energy efficiency level of 85% for the current domestic small turbine unit. That means waste of valuable water resources and loss of integrated benefit. We need to change the development mode and accelerate revamping the old power plant to improve resource utilization efficiency.

5. To protect and improve ecological environment

In recent years, the implementation of small hydropower replacing fuel program improves the recovery of land and forest, and has a prominent role in the protection of the ecological environment, but the current scale and limited range means limited benefits. For 7 consecutive years, the No. 1 central government file requested to expand implementation of small hydropower replacing fuel program. It is necessary to accelerating the implementation of small hydropower for fuel program as typical and demonstration project to realize an integrated development mode which coordinates small hydropower development, environmental protection and ecological construction

6. To go out to the international arena

China's rural electrification road through development of small hydropower was fully affirmed and highly appraised by the United Nations and the vast number of developing countries. We shall further develop small hydropower advantages and strengthen the capacity building for International Center on Small Hydropower and the Asia-Pacific Center for Small Hydro Power, manage well the international small hydropower base and promote internationalization of small hydropower technology standard, increase technical training for developing countries, to spread China's small hydropower

experiences in poverty alleviation in rural areas and mountain areas and achievements in the protection of ecological environment, to widen the comprehensive influence of small hydropower in the international stage.

III GUIDING THE SUSTAINABLE DEVELOPMENT OF SHP WITH SCIENTIFIC CONCEPT

We fully affirmed the achievements in the development of small hydropower, also found the problems that exist in development with an objective view. We shall make clear the mission at the present new period and take effective policy measures to guide and support the sustainable development of small hydropower with scientific concept.

1. To change the development philosophy

Small hydropower development must insist to the principle of serving for agriculture, rural area and farmers, adhere to the theme of scientific development. We must adhere to speed up the transformation of economic development as the main line and to pay more attention to the interests of farmers and ecological environment. Efforts shall be made to achieve four changes: the first is to change the past emphasis on water utilization into orderly development of hydropower resources; the second is to change the past emphasis on the function of power generation to ecological and environmental effects; the third is to change the past emphasis on economic benefits to local development and the interests of farmers; the fourth is to change the past emphasis on the new project development to old plant revamping and sustainable utilization.

2. To strengthen the policy guidance

With government investment increase, we shall vigorously implement the new hydropower rural electrification county construction and Small Hydropower for fuel program, and carry out rural hydropower efficiency revamping pilot projects. The small hydropower projects with central finance input shall be built as pilots projects to safeguard the ecological protection, farmers' benefits, benign operation as examples for guiding the healthy, orderly development of small hydropower. Applied policies in accordance with the Law of Renewable Energy shall be introduced to make small hydropower to enjoy support in grid access and electricity tariff and tax. Farmers are encouraged to involve in small hydropower development through share-holding system and other collaboration mode. Farmers shall be allowed to input with land compensation fees in efforts to broaden beneficiary channels. According to the principle of "who develops, who protects; who benefits, who compensates", we shall explore the establishment of ecological compensation mechanism and environmental recovery and management responsibility system.

3. To improve the government supervision

We shall strengthen management in river planning, and consider the corelations among flood control, water supply, irrigation, navigation, ecological environment to determine a scientific and reasonable development mode. It is necessary to specify small hydropower construction project approval procedures and the relevant

regulatory measures to strengthen safety supervision. It is necessary to implement chief responsibility system to ensure flood control security for people's life and property. It is necessary to accelerate rural hydropower legislative process to put rural hydropower into the legal track, giving a fundamental solution to the problems in the development of small hydropower.

4.To advance technical innovation

It is necessary to improve the technical standard system and accelerate the pace of internationalization of small hydropower standards. Technology innovation is encouraged to lead small hydropower technology into efficient, safe, reliable, and intelligent direction, to improve power quality and reliability, meanwhile reduce energy consumption. It is necessary to strengthen small hydropower basic theory and key technology research to improve planning, design, construction, operation and management of all aspects of applicable technology. It is suggested to carry out ecological design research by absorbing the international popular SHP and "environment integrated design" method. We shall vigorously promote the hydropower planning, construction, environmental protection technology and equipment manufacturing to reduce the cost and improve the energy efficiency. We shall promote small hydropower sustainability assessment and introduce the sustainable idea at each stage of the life cycle of small hydropower to promote the healthy and scientific development.

5.To strengthen social supervision

We shall have a correct understanding of the social supervision and take it seriously. The mass and public supervision shall really play an active role. With increase of small hydropower propaganda, we shall improve innovative forms of propaganda to broaden understanding and obtain support for small hydropower development and to form a good atmosphere of public opinion. A supervision system integrating advantages such as governmental dominance, industry self-discipline, social supervision shall be established to promote the healthy development of small hydropower.

Small hydropower is considered as a renewable energy with excellent advantages, and the history witnessed hydropower lighting up the vast Chinese villages. Time has given small hydropower new mission at this stage, we should take more confidence, more enthusiasm, more stringent attitude, more pragmatic style of work, and more hard work. Small hydropower will glow the new vitality and the vigor and face a new development period. I believe small hydropower will make new greater contribution for rural economic and social development! ■

Small Hydropower Development Modes and Technical Characteristics

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I Definition of SHP

The definition of small hydropower (SHP) differs from country to country, more consistent understanding is that small hydropower is divided into three categories: micro (< 100 kW), mini (100 ~ 1,000 kW), small (1,000 ~ 10,000 kW), see table 1.

In China, small hydropower refers to hydropower stations with the installed capacity of 50 MW and below, as well as small hydropower supplied local power grids. Small hydropower capacity classification is associated with the development of national economy in harmony, especially with the development of Chinese rural economics and rural electricity demand. In the

Table 1 Definition of Small Hydropower Capacity in Different Countries

Country/ International Organization	Classification(kW)		
	(Micro)	(Mini)	(Small)
International Conferences on small hydropower	<100	101-500	501-10,000
Latin American Energy Organization	<50	51-500	501-5,000
China	<100	101-500	501-50,000
Journal of Hydropower and Dam	50-100	300-5,000	10,000-50,000
Peru	5-50	51-500	
Thailand	<200	201-6,000	6,001-15,000
Turkey	<100	101-1,000	1,001-5,000
U.S.	<500	501-2,000	<15,000
India	<100	<2,000	<15,000
Malaysia	<25	25-500	<5,000
Nepal	<50	<500	<5,000
Panama	<100	101-1,000	1001-10,000
Ecuador	<50	51-500	501-5,000
Vietnam	<50	51-500	501-5,000
France	<500	501-2,000	2,001-8,000
Greece	<100	101-1,000	1,001-15,000
Poland	<100	101-1,000	1,001-15,000
Finland	<200	201-2,000	<20,000

▲ 4,700 m elevation in Tibet

▲ Automatic Shutter Dam

▲ Concrete Arch Dam

classification of small hydropower capacity, these factors such as load demand, local electricity construction capacity and equipment selection are mainly considered.

— In 1950s, hydropower stations below 500 kW are commonly known as rural hydropower stations.

— In 1960s, small hydropower capacity is limited up to 3 MW, and some power supply lines connected by several small hydropower stations appeared in a few areas, which is the rudiment of China's local power grids.

— In late 1960s, with electricity consumption increase in local agriculture and industry, social and economic growth, and national and local equipment manufacturing capacity improvement, capacity limits for small hydropower station went up to 12 MW, and power grids in a unified dispatching mode were formed at county level, mainly the grid voltage was below 35 kV.

— Entering 1980s, along with the implementation of small hydropower oriented rural electrification program, the construction of small hydropower experienced a rapid expansion, and small hydropower capacity also increased. People began building 110 kV local electric power, capacity limitation for small hydropower station was also extended to 25 MW.

— Entering 1990s, the State Planning Commission, the Ministry of Water Resources further clarified that hydropower stations under 50 MW could enjoy the preferential policy for small hydropower, meanwhile, some local power grids with capacity for ten thousands or hundred thousands of kVA appeared.

II SHP Development Schemes

Small hydropower development schemes can be classified according to different features, for example, as per the head, small hydropower can be divided into high water head, medium head and low head hydropower station; as per the concentration mode of water head, small hydropower can be divided into the dam hydropower station, diversion hydropower station and dam-diversion type hydropower station; as per regulating capacity, small hydropower can be divided into run-of-river hydropower station and reservoir power station.

1. Classification According to Head

There is no unified regulation for water head division. Some countries name hydropower stations with head lower than 15 m as low head hydropower station, head from 15 to 70 m as medium hydropower station, head from 71 to 250 m as high head hydropower station, head higher than 250 m as ultra high head hydropower station. In China, high head hydropower station often refers to head more than 70 m, low head hydropower station refers to head less than 30 m, medium hydropower station refers to head between 30 and 70 m, this classification standard is adapted to the grading for hydropower buildings and classification for turbine generating units in China.

The world's highest head power station is Lai Joseph Hill hydropower station in Austria, with a head of 1,767 m. The supreme head small hydropower station ever built in China is Tianhu hydropower station with a head of 1,074 m, located in Quanzhou County, Guilin, Guangxi Zhuang Autonomous Region, and its installed capacity is 4×15 MW.

2. Classification According to Concentration Mode of Head

(1) The Dam Type Hydropower Station

Dam type hydropower station adopts the dam to concentrate the water head, which can be further divided into riverbed, behind-dam, in-dam, top overflow hydropower stations, among them, the main small

hydropower station commonly seen are riverbed hydropower station (Fig.1) and dam-toe hydropower station (Fig.2).

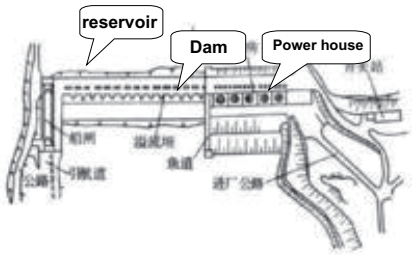


Fig 1 Riverbed Hydropower Station

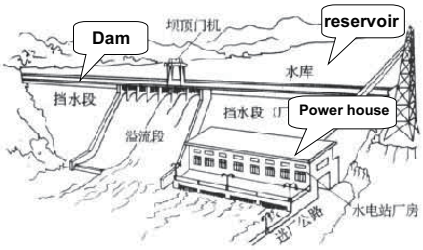


Fig 2 Behind-dam Hydropower Station

Dam type hydropower station has the main advantages in adjustable water flow with reservoir, big quotative discharge, large scale of installation capacity, high utilization of water. The main disadvantages are limit of water head by dam, large engineering quantity, reservoir submerging losses, high engineering investment and long construction time.

China has a small number of dam type power stations, but due to its regulating reservoir, dam type power stations often become backbone power stations in the cascade development or regional power supply. Dam type power station with single generation function generally has higher cost, but considering comprehensive utilization of dam type power station and investment allocation, the development is still quite economic.

(2) Diversion Type Hydropower Station

Diversion type hydropower station can be further divided into pressure diversion type and non-pressure diversion type hydropower station. This small hydropower development scheme was commonly seen in upstream area of rivers or cross river basins with steep slope and small flow.

Fig 3 shows a non-pressure diversion type hydropower station. Its characteristic is to use the open channel (some times non pressure tunnel). The forebay is arranged at the joint of non-pressure water diversion channel and the penstock, and this station is also provided with a daily regulation pond.

Fig 4 is sketch map of a pressure diversion type hydropower station. The station buildings include reservoir, dam, spillway, water inlet, pressure water diversion canal (pressure tunnel), surge chamber, penstock, powerhouse complex (including the substation, distribution buildings) and tail race channel.

Diversion type hydropower station often has the main advantages in gain high water head, no reservoir submerging losses, small engineering quantity, and low unit cost. The main disadvantages are low value of water and comprehensive utilization as well as small scale of installation capacity.

(3) Dam-diversion type hydropower station

Dam-diversion type hydropower station is a development portfolio, combining the merits of dam type and diversion type, part of head is concentrated by the river sluice, dam, and other part of head is concentrated by canal. This mixed hydropower station and the pressure diversion type hydropower station share the common characteristics in concentrating the head through a certain length of diversion channel, the difference is that the mixed hydropower station uses dam to form reservoir for runoff regulation, and pressure diversion type hydropower station uses dam to retain water.

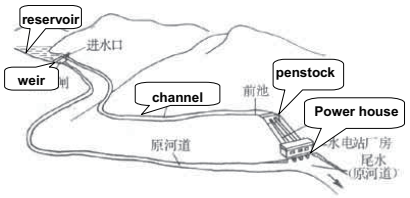


Fig 3 Sketch Map of a Non-Pressure Diversion Type Hydropower Station

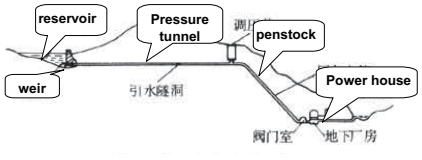


Fig 4 Sketch Map of a Pressure Diversion Type Hydropower Station

▲ Generator

▲ Low Head (3.5 m)

▲ Stone Masonry Arch Dam

▲ High Head

▲ Rubber Dam

3. Classification According to Regulating Capacity

According to utilization mode and regulation capacity in the natural water flow, hydropower station can be divided into run-of-river station and reservoir type hydropower station. Reservoir power station provided with a storage capacity through the reservoir, according to the regulation cycle, which can be divided into daily regulation, seasonal regulation, yearly regulation and multi-year regulation. Run-of-river hydropower station with no reservoir or a very small reservoir, has little ability to regulate natural water volume.

III China's SHP Technical Features

1. A Variety of Types

China has almost all types of small hydropower stations listed in a textbook.

— Design head: from 2 m up to 1,000 m.

— Dam type: China's small hydropower projects have various types of dams, including earth dam, stone masonry dam, concrete dam, rock fill dam, concrete facing rock fill dam, RCC dam, rubber dam, automatic shutter dam and so on. The largest dam is 5,842 meters long.

— Water intake and water diversion system: China has almost all types, including open channel, aqueduct (the largest is 2,000 meters long, 27 meters high, water discharge 1.7 m^3/s), all kinds of pressure, non-pressure piping, tunnel (the longest is more than 4 km, the diameter is greater than 10 m) etc.

— Various types of powerhouses: including ground, underground, circular shaft, elliptic shaft and so on.

— Overall layout: including the diversion type, dam type, dam-diversion mixed type etc.

— Power station elevation: some stations have elevation of 4,700 elevation built in Tibet.

2. Serialized SHP Equipment

China has more than 100 small hydropower equipment manufacturers. Small hydropower equipment manufacturing adopts unified design and drawings, as well as standardized spare parts. Small hydropower equipment standardization and serialization plays an important role in promoting high-speed and large-scale development of small hydropower in China.

Small scale turbines have a total of 26 models in series, 83 kinds of products, applicable in the head range of 2.5 ~ 400 m. The largest single capacity reaches up to 12 MW. Main turbine types are axial flow, propeller, shaft axial flow, bulb, Francis, Pelton, Turgo, cross flow, reversible pumped-storage unit and micro integrated units.

Hydro generators have 2 standard series, 16 kinds of models, and more than 280 products. In addition, governors, excitation equipment and other sets of equipment for small hydropower station all have standard series.

3. SHP Planning System

Small hydropower planning system consists of small hydropower oriented rural electrification planning and small hydropower development planning which combines small and

medium-sized river development and management.

(1) Rural Electrification Planning

Beginning in 1982, China carried out small hydropower-based rural electrification pilot counties, after 15 years, the completed task has covered the construction of three groups of a total of 653 electrification counties. Based on constant experience and practice, a set of suitable rural electrification planning method, model system and software have formed, and great sorts of rural electrification building system models have been established. Many valuable experiences have been summarized into national or industrial standards, such as "small hydropower supply area rural electrification planning regulations", "rural hydropower supply area power development planning guidelines", etc.

In 1982, China implemented a small hydropower-based rural electrification pilot counties, after 15 years, has built a total of three batches of 653 electrified counties.

(2) SHP River Basin Development Planning

The state has consistently emphasized that the development of medium and small hydropower is the important content in river management, and integral part of water resources course. Development of small hydropower can facilitate the preliminary administration for thousands of rivers, which is one of key reasons that small hydropower has a high speed and great development in China. In the development of small hydropower in combination with medium and small river development and management, China has accumulated a variety of effective small hydropower technology, including cascade development and cross basin water diversion, etc.

Small watershed cascade development planning: the advantage is that it can make full use of water in a river, build bibcock reservoir upstream, regulating flow for all power stations downstream. At the same time, interconnection of cascade hydropower stations can easily form local power grid, and connecting with the national power grid can further improve the economic benefits of the power station compared with originally isolated operation.

Small cross river basin development planning: cross basin water diversion is widely applied at present in China's small hydropower project development, especially the high head hydropower station, and this is a kind of effective pattern of small hydropower development technology. In a suitable terrain and geological condition, water diversion from projects built in feasible locations of other basin can increase the amount of power generation. But cross basin water diversion may cause the change of ecological environment, which must be considered, so it is not suggested to be spread in a blind way.

4. SHP Supplied Local Grids

Different from other developing countries, China attached great importance to building up its own power supply area in the development of small hydropower. The county level grids and local trans-area grids were formed in some places, with capacity generally ranging from about 30 to 80 MW. Out of more than 2,300 counties in China, over 1,500 have constructed small hydropower and built up different scales of local grids.

5. SHP Standard System

China has accumulated rich experience in small hydropower construction over past 60 years, so a relatively complete standard system of small hydropower has been formed. In water conservancy technical standard system table (SL) released by the Ministry of Water Resources in 2008, small hydropower was classified as a professional discipline, consisted of the generalization, planning, surveying, design,

▲ Tianhu Hydropower Station


Switchgear

construction, installation, operation and maintenance, quality inspection, safety assessment, monitoring and forecasting, material testing, equipment, total 11 parts, including 58 standards, among them 35 issued (appendix 1). Such a wide range of rules designed for small hydropower industry are seldom in the world. These documents not only formed the treasure-house of information during the development of small hydropower in China, but also an important contribution to China's small hydropower technology development. The Chinese government is planning to promote the international exchange on small hydropower by translating them into English.

Developing countries will encounter all sorts of obstacles in the development of small hydropower due to lack of funds and technology, of which, the lack of small hydropower standard is the main technology barrier. China is exploring to establish a complete set of international standards of small hydropower, to help and promote the development of small hydropower in the world.

6. Pay Attention to Ecological Protection of SHP

Small hydropower development on the whole has more benefits than disadvantages, but we can not ignore its impact on river ecological system, especially the diversion type small hydropower stations, if poorly planned, would cause environmental problems such as river flow dehydration. In recent years, China has begun research on the river base flow, explored the establishment of green hydropower mechanism to hold up the concept of "protection in the development, development in the protection".

IV Conclusion

1. Small hydropower is the rural renewable energy with the most mature technology, the longest development history, and the most rewording benefits.

2. China SHP technology has its unique characteristics. We would like to share our experience with other developing countries, therefore to promote the development of SHP worldwide. ■

Appendix 1 China's National and Industry Standards on Small Hydropower Issued and under Compilation

No.	Title	Standard No.	Status
	Generalization		
1	Rural hydropower technical terms	SL	under compilation
2	Rural hydropower electrification standard	SL 30-2003	Issued
3	Technical transformation code for small hydropower station	SL193-97	Issued
	Planning		
4	Hydropower and rural electrification planning regulations	SL 145-95	Issued
5	Small hydropower replacing fuel ecological protection program planning regulations	SL	under compilation
6	Medium/Small rivers water energy development planning guide	SL221-2009	Issued
7	Rural hydropower development planning site selection guide	SL294-2003	Issued
8	Small hydropower generation fuel ecological protection program standard	SL	under compilation
9	Rural hydropower supply area electric power development planning guide	SL 22-92	Issued
	Surveying		
10	Medium and small-sized water conservancy and hydropower engineering geology survey specification	SL 55-2005	Issued
	Design		
11	Small hydropower station construction project proposal document preparation procedures	SL 356-2006	Issued
12	Rural hydropower station feasibility report preparation procedures	SL 357-2006	Issued
13	Small hydropower station design report preparation procedures	SL/T 179-96	Issued
14	Small hydropower water energy design code	SL76-2009	Issued
15	Small scale water conservancy and hydropower engineering rolled earth dam design guidelines	SL 189-96	Issued
16	Small hydropower station design code	GB50071-2002	Issued
17	Small hydropower station automation design regulations	SL229-2000	Issued
18	Rural hydropower supply area power system design guide	SL222-1999	Issued

19	Small hydropower connection to power system technology standard	SL	under compilation
20	Small hydropower grid energy-saving design guidelines	SL	under compilation
Construction and Installation			
21	Small hydropower station construction technical specification	SL172-96	Issued
22	Rural hydropower station construction environmental protection guide	SL358-2006	Issued
Quality Inspection			
23	Hydropower and rural electrification acceptance specification	SL296-2004	Issued
24	Small hydropower replacing for fuel project acceptance specification	SL/Z304-2004	Issued
25	small hydropower station construction project acceptance code	SL168-96	Issued
26	Small hydropower station unit operation comprehensive performance evaluation standard	SL	under compilation
Operation and Maintenance			
27	Rural hydropower station optimal operation guide	SL293-2003	Issued
28	Rural hydropower electric power system dispatching automation specification	SL/T53-93	Issued
29	Technical specification for small hydro turbine governor	SL	under compilation
30	Small hydro turbine abrasion protection guide	GB	under compilation
31	Small hydropower supply area rural power grid dispatching rules	SL	under compilation
32	Specification for installation and operation of leakage current protector in rural areas	SL445-2009	Issued
33	Rural hydropower station technical management specification	SL	Issued
34	Rural hydropower station technical regulations	SL	Issued
35	Rural hydropower distribution lines and distribution network technical management rules	SL	Issued
36	Rural hydropower transmission line technical management rules	SL	Issued
Safety Assessment			
37	Small hydropower station construction Safety rules	SL	under compilation
38	Fire safety technical regulation for small hydropower station	SL	under compilation
39	Small hydropower station safety test procedure	SL	under compilation

40	Small hydropower station electrical and mechanical equipment scrapping conditions	GB	under compilation
41	Small hydropower planning environmental impact assessment procedures	SL	under compilation
42	Rural hydropower project environmental impact assessment procedures	SL 315-2005	Issued
43	Economic evaluation code for small hydropower projects	SL16-2010	Issued
44	Small hydropower replacing fuel project ecological benefit calculation methods	SL	under compilation
45	Small hydropower grid safety operation rules	SL	under compilation
Monitoring and Forecasting			
46	Hydrological calculation norms for small hydro power	SL 77-94	Issued
47	Small hydropower grid power loss calculation methods	SL 173-96	Issued
Material Testing			
48	Small hydropower station and pumping station efficiency test procedures	SL	under compilation
49	Small turbine site acceptance test procedures	GB/T 22140-2008	Issued
50	Hydro generator start test procedures	SL	under compilation
Equipment			
51	Electromechanical equipment guide for small hydropower station	GB/T 18110-2000	Issued
52	Rural hydropower 110 kV substation computer supervisory and control system basic technical condition	SL	under compilation
53	Fundamental technical requirements for small turbines	GB/T 21718-2008	Issued
54	Small turbine generators fundamental technical requirements	GB	under compilation
55	Box type hydropower station technical specification	GB	under compilation
56	Integrated micro hydraulic turbine generating units	SL 397-2007	Issued
57	Small hydropower control protection equipment application guide	SL	under compilation
58	Small turbine inlet valve basic technical condition	SL	under compilation

(***Note:*** *in the table GB stands for the national standards, SD refers to standards issued by the Ministry of Electricity and Water, SL refers to standards issued by the Ministry of Water Resources, DL refers to standards issued by the Ministry of Power*)

Small Hydropower Development Practice in Zhejiang Province

Mr. Xu Wenbin
Deputy Director of Zhejiang Provincial Department of Water Resources

I Overview

Zhejiang Province is located on the coastal area of East China Sea and to the south of Taihu Lake between north latitude 27°12′～31°30′ and east longitude 118°～123°, with a total land area of 101,800 km^2. Zhejiang's topography can be described to be "70% mountains, 10% water and 20 farmland".

Zhejiang Province is in the subtropical monsoon climate region with abundant rainfall. The annual average rainfall is between 1,100～2,200 mm. Most rivers in the province belong to mountainous rivers, with many canyons, high water head thus possessing abundant water resources.

The exploitable hydropower potential is about 8.625 million kW, of which small hydropower is 4.625 million kW. The SHP resource in this province ranks the 16th among all the provinces and cities in China, developed installed capacity ranks the 6th and developing rate ranks the 4th. By the end of 2010, Zhejiang province has set up 3,175 SHP stations with the total installed capacity of 3.7 million kW, the annual power generation of 10.93 billion kWh, and the rate of development being 80%.

In addition, Zhejiang Province is close to the load center of East China, thus enjoying outstanding geographical location. Taking advantage of favorable mountainous condition, existing reservoirs and numerous lakes, the development of pumped storage stations appears with bright prospect.

According to the preliminary investigation of pumped storage resources carried out by Department of Water Resources of Zhejiang Province in September 1997, the 92 sites blessed with favorable conditions for developing pumped storage stations, with total installed capacity of over 60 million kW, are the rare and precious natural resources for the power source structural adjustment in East China Grid.

Meanwhile, Zhejiang Province owns vast sea area and numerous islands, and its overall coastline extending 6,633 km, of which the continental coastal line is 1,840 km and island shoreline is 4,793 km. The tidal energy is abundant as the coast twists and turns (dramatically). The exploitable potential of tidal power in Zhejiang Province is 8.25 million kW, ranking the second in China.

II SHP Development Practice

In fact, the history of hydropower development in Zhejiang is a history of development and reform of hydraulic and electric power in Zhejiang, as well as the history of development and utilization of hydraulic resources, which can roughly be divided into the following phases

Phase one: 30 years before the 1980s

Before the founding of PRC, there were only three SHP stations in this province with the total installed capacity of 163 kW.

Since the founding of PRC, hydropower construction in Zhejiang Province has made great achievements. In 1950, China's first hydropower station since the founding of PRC Haitang Hydropower Station at Jinhua Lake with an installed capacity of 200 kW started its construction. Later, in order to solve the problem of power supply shortage in East China, the construction of big hydropower stations were flourishing.

In 1957, the construction of Xin'anjiang Hydropower Station began, and in April 1960, its first unit was put into operation. With a total installed capacity of 662.5 MW, this station was the first large-scale hydropower station designed, constructed and equipped by China's own expertise.

Fuchunjiang Hydropower Station, completed and put into operation in December 1968, had a total installed capacity of 297.2 MW. In December 1979, Wuxijiang Hydropower Station on the upper stream of Huangtankou Hydropower Station was put into normal operation, with a total installed capacity of 170 MW which was increased to 270 MW after renovation in 1996.

While constructing big hydropower stations, a large quantity of small and medium-sized hydropower stations scattered in Zhejiang Province has also been constructed, among which the major hydropower stations includes: Huangtankou Hydropower Station built in 1951 in Quzhou; and Baizhangji Cascade I Hydropower Station which had the highest water head at that time in China. It was built in Wencheng County in Feiyun river basin in May 1960, with a total installed capacity of 25 MW and a maximum water head of 359 m.

During this period, the exploitation of hydro resource in Zhejiang province mainly aimed at flood control and irrigation. SHP stations for exploitation of hydraulic energy were essentially developed along the flood control and irrigation engineering. Therefore, a batch of behind-dam hydropower stations with large storage and small installed capacity were put into operation.

Meanwhile, a number of SHP stations built in mountainous rural areas played a significant role in providing domestic electricity supply in urban and rural areas and later in the development of local small-scale industries. For example, the construction and interconnected operation of Hengjin, Nanjiang, Jinlan, Andi, Tongjiqiao SHP stations with reservoir, helped solve preliminarily the problem of power supply for production and living in urban and rural areas in several counties of Jinhua City.

Phase two: 15 years from the early 1980s to the mid-1990s

In October 1983, China had defined the guideline of rural electrification construction with Chinese characteristics, namely, the power source should be in accordance with local conditions focusing on small hydropower, so as to alleviate the conflict of power supply between urban and rural areas; the construction of rural electrification should be self-reliance, mainly relying on local self-financing; the power consumption was practical in conformity with the standard of a well-off life; and the management was conducted by the related local department so as to mobilize the initiative of local authorities.

Meanwhile, the State Council stated that rural electrification is a major issue for 800 million farmers, so in those areas with rich water resources, we should encourage the local authorities and people, through self-reliance, to actively develop small hydropower to realize rural electrification. Since then, a nationwide campaign of constructing and realizing hydropower-based rural electrification county was launched. SHP industry in Zhejiang Province, taking this opportunity, had enjoyed a prime period of 25 years of development.

26 counties in Zhejiang Province were enlisted in the first and second group of primary rural hydropower and electrification counties: the first group included 11 counties (cities) like Xinchang; the second group included 15 counties (cities) like Dongyang. The newly installed capacity of these 26 counties (cities) reached 256 MW during the construction period. Wuyi, Taishun, Yunhe, Jingning, Pan'an,

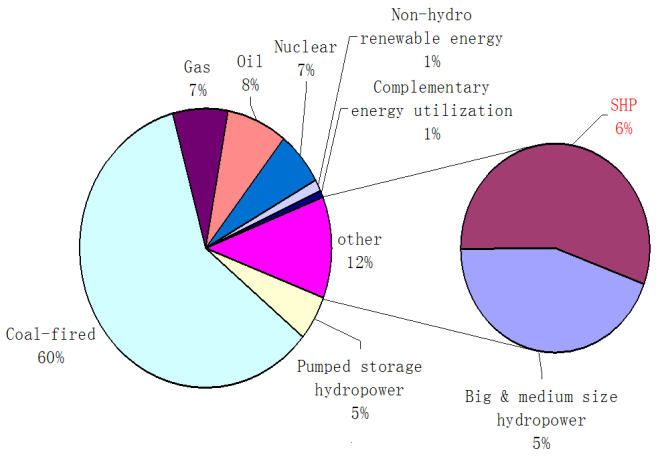
Qingtian, Yongjia and Wencheng also took this opportunity to promote the economy in mountain areas through the development of hydropower, and had successively been out of poverty.

This period witnessed the peak period for hydropower construction. There were 33 counties with the installed capacities of small hydropower stations of more than 10 MW, 7 of them exceeding 30 MW. This period was marked by comprehensive treatment of medium and small basins as the objective and hydraulic engineering projects mainly for power generation were set up, promoting the construction and renovation of rural power grid in the mountainous areas of Zhejiang Province. For the counties in mountainous areas, small hydropower stations had significantly mitigated the power supply shortage caused by the fast-growth of electricity demand.

Phase three: 10 years between mid-1990s and 2005

When entering into the 1990s, our economic reform had remarkably speeded up, and the goal of establishing socialist market economy with Chinese characteristics had gradually been clear. During this period, the Zhejiang People's Government had issued a lot of policies and regulations conducive to the development of small hydropower. Particularly, the enthusiasm of the whole society for the development of small hydropower was aroused by the policy on adjusting the off-take tariff of small hydropower and reforming the investment system of SHP stations to encourage private capital to participate in the development of small hydropower. Thus, with a lot of private capital, small hydropower had witnessed the rapid development on an unprecedented scale.

The SHP off-take tariff was adjusted by Zhejiang Prices Bureau respectively in 1994, 1996 and 1997, and the off-take tariff of small hydropower stations built before 1990 was raised in 1998. According to statistics, from 1994 to 1998, the installed capacity of small and medium-sized hydropower stations in Zhejiang Province reached 680 MW, which greatly promoted the economic development and social progress of mountainous rural areas.



▲ **Energy Structure of Zhejiang Province**

Five years from 2001 to 2005 were the fastest growing period for SHP development in Zhejiang Province. A new round of the hydropower station development rush appeared after the implementation of a unified off-take tariff. By seizing firmly this opportunity, Zhejiang Province created a new status of rural hydropower on the basis of scientifically analyzing the development trend of future exploitation and management of water resources, adhering to the scientific concept of development, combining the construction of rural hydropower with economic construction, river treatment, ecological protection, poverty alleviation, gradually carrying out the three compensation mechanisms "resource, economy, ecology", which scored remarkable achievements in the actual work.

The average completed installed capacity each year in Zhejiang Province is 250 MW, and the peak year was in 2005 with the completed installed capacity of 280 MW. During this period, the construction of 20 rural hydro-electrified counties was completed such as Taishun, Dongyang, Kaihua, Tonglu and so on, improving the rural electrification level. Jingning Shezu autonomous County, Taishun County, Wencheng County were successively awarded the title of "Home of Chinese Small Hydropower". Lishui city was conferred with the title of "the First City of Chinese Hydropower".

At the same time, Zhejiang Province was designated for the conduction of the SHP station pilot project of China Renewable Energy

Scale-up Program. 18 SHP station projects in 10 counties were included as World Bank Loan Program. The World Bank provided a loan of USD 20 million, together with a grant of USD 1.5 million that was received by Zhejiang Hydropower Development Center, the hydropower development in Zhejiang Province has been greatly promoted.

By the end of 2005, the total installed capacity of small hydropower stations in the province reached 2.8 million kW.

Phase four: the 5 years since 2006

After 2005, China's society has entered into a new period of development. Regarding the construction of new socialist countryside as a major historic task, the Central Committee of CPC and the State Council has attached great importance to the problems of agriculture, rural areas and farmers. Ecological environment protection, scientific outlook on development and construction of a harmonious society become the main themes of this phase. Achieving harmonious coexistence between human beings and nature, realizing sustainable development of resources, environment and social economy set higher requirement for water resources management.

Meanwhile, Renewable Energy Law accorded the legal status of water resources as an independent and renewable energy. The adoption and implementation of the law will exert a significant influence on promoting the development and utilization, conservation and protection of renewable energy, increasing energy supply, improving energy structure and realizing the sustainable development of our social economy. It has also paved the way in the legal domain for water resources management and exploitation in the near future.

During this period, the exploitation rate of small hydropower as a kind of energy increased. After long-term operation, the hydropower stations which were put into operation before the 1990s faced safety problems of different levels. The problems of rusty and aging electromechanical equipment and obsolete facilities were so evident that stations need rehabilitating urgently so as to resume safety and productivity. While endeavoring to construct new projects, we have transformed our approaches on water resources exploitation, and attached more importance to the refurbishment of old power stations and the enhancement of the sector's management.

Over the five years, Zhejiang Province has raised funds at different levels and through different channels, increased investments and vigorously carried out the construction of rural hydropower. The cumulative input for hydropower construction includes 48.5 million yuan of Central Electrification Construction Funds, 17.68 million yuan of loans from the World Bank, and 40.47 million yuan of fund from the provincial government. We have completed the construction of hydropower-based rural electrification county program in 11th Five Year Plan period and SHP pilot projects in Zhejiang funded by World Bank loan and initiated Refurbishment Project of A Thousand Hydropower Stations for Farmers' Benefit and for Safety.

In terms of the construction of hydropower-based rural electrification counties, during this five year period, 19 counties (cities, districts) in Zhejiang Province were designated as hydropower-based rural electrification counties which were built in accordance with RE county standards. 190 hydropower stations were newly built or completed, with the increased installed capacity of 600 MW and an increased annual power generation of

1.2 billion kWh.

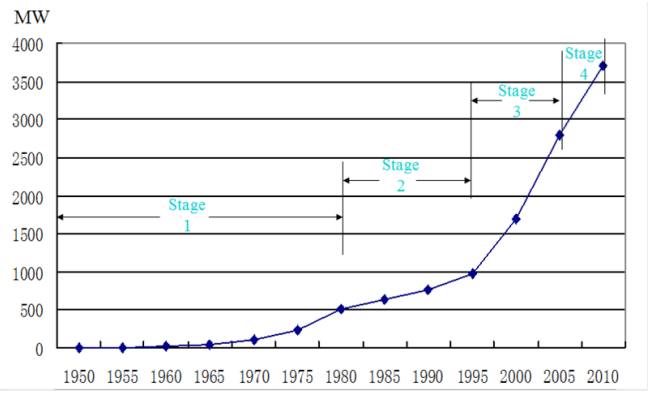
61 hydropower stations were renovated or expanded with an annual power generation of 160 million kWh, increasing by 27 million kWh and with a total installed capacity of 83 MW, increasing by 12 MW. After the construction, hydropower generation meets over 50% of the power consumption in all the counties, 100% of the rural villages have access to electricity; the rate of household access to electricity reached 99.8%.

In terms of the pilot projects construction of SHP loan from World Bank, World Bank Loan Project of Zhejiang Small Hydropower is the pilot project of Renewable Energy Scale-up Program which is carried out together by Chinese Government, World Bank and Global Environmental Facility.

During the 11th Five Year plan, 16 hydropower stations were put into operation under the World Bank Loan Project for Zhejiang Small Hydropower, with the total installed capacity of 49.9 MW, among which 6 hydropower stations were newly built with the total installed capacity of 13.6 MW, 10 hydropower stations were refurbished with the total installed capacity of 36.3 MW. The restored installed capacity from this program is 26.4 MW, newly increased installed capacity is 23.5 MW and increased power generation capacity is 78.57 million kWh.

The total investment of the project is 227.78 million yuan, with the participation of World Bank Loan of USD 17.68 million, a grant from GEF of USD 1.5 million. The pilot project construction of SHP World Bank Loan Program in Zhejiang Province was basically completed, and our province gained extensive experience in the utilization of World Bank Loan, resettlement, environment management, dam safety management. By and large, the pilot project has fulfilled the expected target.

In terms of promoting SHP stations refurbishment. Held in August 2006, the working Conference on Zhejiang Rural Hydropower listed the strengthening of the rehabilitation of old power stations as the main tasks of rural hydropower. In order to ensure the refurbishment of the old power stations, the province strived for the breakthrough in plan making, financial support, policy incentives, and management standardization and so on, firmed the foundation of renovation and stimulated the enthusiasm of the station owners for renovation.



▲ **Installed SHP Capacity in Zhejiang Province**

In terms of plan making, the compilation of Plans on the Refurbishment of Rural Hydropower Stations in Zhejiang during 11th Five Year Plan was completed in 2006, the compilation of Implementation Plan on the Refurbishment of A Thousand Hydropower Stations for Farmers' Benefit and for Safety was completed in 2008.

In terms of financial support, in order to exert the guiding role of financial funds, during the 11th Five Year Plan, more fund were put into and specialized fund were allocated for the refurbishment of old power stations in Zhejiang Province. In terms of policy incentives, Zhejiang Price Bureau stipulated that with regard to the approved technological renovation and operating units after refurbishment, the increased electricity to the grid should be calculated according to the equivalent on-grid guidance price at the time when the units were put into operation.

In terms of standardized management, Zhejiang Province had formulated Provisional Measures on the Management of the Refurbishment Projects of Zhejiang Rural Hydropower Stations so as to regulate projects construction. Over the past five years, 161 hydropower stations were discarded and rebuilt with the total installed capacity of 95 MW. 310 hydropower stations were renovated, with the total installed capacity of 187 MW.

Aging equipment and obsolete facilities were upgraded after the refurbishment and potential dangers of the power stations were eliminated. Efficiency of the power generating units increased by 10%～15% and the utilization rate of water resources was greatly improved. The new mode of power stations management

"unmanned/few manned on duty" reduced working staff as well as the operation cost.

By the end of 2010, the installed capacity of small hydropower in Zhejiang Province amounted to 3.7 million kW.

While constructing conventional hydropower stations, beneficial practice was carried out in the construction of pumped storage power stations and favorable effects scored. By the end of 2010, three pumped storage stations were put into operation: Anji Tianhuangpin (installed capacity is 1.8 million kW), Tiantai Tongbo (installed capacity is 1.2 million kW), Ningbo Xikou (installed capacity is 80 MW), which played an important role in the improvement of power supply quality, stability of system frequency and peak load undertaking and valley load absorbing of East China Power Grid.

Zhejiang Province also had some initial experience in developing tidal power. Now there are two tidal power stations with the total installed capacity of 3,350 kW. With the designed installed capacity of 3,200 kW, Jiangsha tidal power station in Wenling city that was built in 1980 ranks the first in China and the third in the world.

While paying adequate attention to the construction of small hydropower, Zhejiang Province also emphasized on the management of small hydropower, and improved it through perfecting system, setting standards, strengthening measures and cultivating talents, so as to gradually build a management system for small hydropower sector.

Zhejiang Province had issued Provisions of Safe Production of Zhejiang Rural Hydropower, Measures for Classification and Annual Inspection of Safe Management for Rural Hydropower Stations, Measures for Safe Management of Flood Control for Zhejiang Rural Hydropower and Measures for Management of Discarding Zhejiang Rural Hydropower Stations, which laid a institutional foundation for the management of production and public safety of small hydropower enterprises.

The province also organized to compile the Regulations for Management of Safe Operation of Rural Hydropower, which basically covers the technical conditions for the safe operation of all equipment and facilities of the rural hydropower stations. Zhejiang Province conducted the first annual inspection for the safety management of rural hydropower, covering all running hydropower stations, and strengthened the training for hydropower stations' operators and safety inspectors, realizing the rule of on-duty with license for operators and inspectors.

In the next five years, small hydropower in Zhejiang Province will continue to develop, focus on the theme of "constructing ecological hydropower, building picturesque mountains and rivers, and promoting rural development", and adhere to the shift of focus from project construction to sector supervision and from economic benefits to the integrated benefits of economy, society and environment.

We will focus on the resource development in combination with ecological construction, and plan to build 72 power stations, with the installed capacity of 296.64 MW and the newly added annual power generation of 753 million kWh. We will also complete to build 57 hydropower stations, with the total installed capacity of 226.91 MW; and 899 stations will be refurbished, with the total installed capacity of 670.84 MW.

Meanwhile, with the scientific outlook towards development as the guidance, we will continue to improve the management system of the hydropower industry, enforce the legislation of the industry, effectively strengthen the industrial supervision, actively enhance the capacity of the working staff in hydropower sector, and strive to achieve the goal of farmers' benefit, safety, standardized management, advanced technology, energy conservation and efficiency improvement. ■

Renewable Energy — the Best Remedy For Electrical Load Shedding in Pakistan

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Abstract

Average 33% time of daily electrical load shedding in Pakistan is most serious as it has affected all activities. Industries are crippled, commercial, official activities and daily life is being detoriated! Total loss to Export is $1.3 billion and oil import bill is $ 9 billion. If appropriate actions are not taken immediately, the situation is going to get worse when people will fight for every watt of electricity! The impounding crises are not foreseen and its gravity is not yet properly realized by the decision makers! Politics and several lobbies work against construction of major projects of hydel power and baseless controversies have been created. Pakistan is blessed with abundant renewable energy i.e. 2.9 million MW solar, tidal, wind 346,000 MW and 59,000 MW potentials of hydro electricity. Analysis of the reasons for the slow and no growth of these vital renewable potentials in Pakistan indicate that there are barriers which need to be mitigated to take immediate benefits to overcome menace of load shedding.

Local R&D, Design, manufacturing, installation and feasibility study capabilities are negligible. Institutional capabilities in most of the organizations can at best be ranked as average or weak. Other impediments and barriers that continue to hamper the load shedding are losses, attitude in the promotion of renewable and hydro power projects include: lack of serious attempts to mitigate the barriers, integrate the programs with profitability; inadequate evaluation of resources; non-availability of reliable baseline data; and lack of coordination among the relevant agencies; weak institutional arrangements for renewable energy promotion; absence of fiscal and financing mechanisms; lack of understanding, awareness, information and outreach; uneven allocation of resources; lack of appropriate quality management, monitoring and evaluation programs; and need of attractive policy framework and legislative support, building consensus among people and provinces, right person for right job, capacity building of relevant institutions, for promotion of hydro electric power and other renewable sources.

Public and private efforts in building a strong indigenous base for renewable energy technologies, designing, manufacturing, quality assurance, achieving cost effectiveness, reducing import dependence, promotion of self-reliance and minimizing environmental degradation is one of the objectives to be achieved. Electricity pilferage and technical losses, non payments of bills & corruption need to be seriously addressed.

The government's policy towards renewable especially hydro and other energy balances would not only help the country to meet growing demand for electricity, but would also provide additional benefits by increasing fuel diversity or our electricity generation portfolio, reducing our exposure to fossil fuel price spikes, security and supply interruptions, deforestation, development of rural areas, minimize migration to cities, increasing economic development activity from a growing renewable energy industry and improving our environment etc.

I Introduction & Background

It is very unfortunate that we are having load shedding varying from 4 ~ 12 hours daily for the last several years depending upon the supply and demand gap of electricity. These energy crises have crippled the economy, commercial daily activities and if appropriate actions are not taken immediately, the situation is going to get worse when people will fight for every watt of electricity.

Cost of Industrial Power Outages[1]

• *Cost of the Industrial Section*	*Rs 230 Billion*
• *Loss of Industrial Value Added*	*11percent*
• *Total Cost of industrial Load Shedding to the Economy*	*Rs 325 Billion*
• *Cost as % of GDP*	*2.5 percent*
• *Loss of Employment in the Economy*	*Rs 535,000*
• *Loss of Exports*	*$ 1.3 Billion*

(1.1) Installed Capacity of Power [2,3]

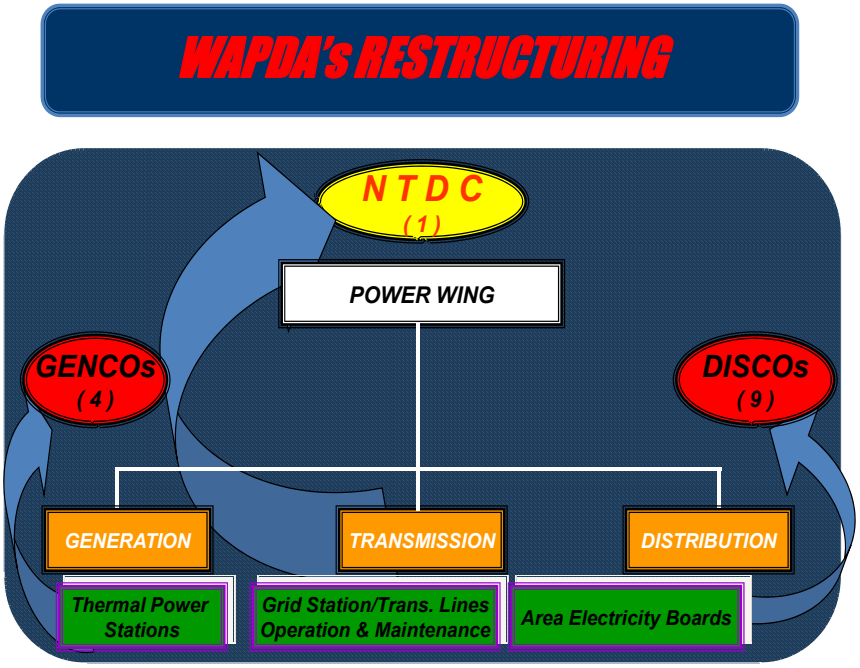
WAPDA Thermal	*6441 MW*
Hydel	*6464 MW*
Nuclear	*462 MW*
IPPS(Thermal)	*6154 MW*
Total	*19521 MW*

Utilization of various sources of power

Gas	*33%*
Oil	*34%*
Coal	*1%*
Nuclear	*2%*
Hydel	*33%*

The electricity is generated by various sources using oil, gas, hydel, coal, nuclear, and micro renewable energy by various generating companies e.g. WAPDA, GENCO, Independent Private Power Producers (IPPs), KESC etc.

Average demand during 2009-2010 was varying in the range of 14,000 ~ 20,000 MW depending upon weather conditions and holidays, while average generation was about 12,000 MW. Although total installed capacity is 19,521 MW but available was about 11,000 ~ 15,000 MW depending upon various factors. Therefore there was an average short fall of 3,000 ~ 5,000 MW. All the generation is picked up at High voltage by National Transmission and Dispatched Company (NDTC) and then transmitted and dispatch to Distribution Companies (DICOS) as shown in the above diagram.



After restructuring of power sector except Water and Power Development Authority (WAPDA) all are registered as private companies and are being co-ordinate by Pakistan Electric Power Company (PEPCO).

(1.2) Reasons of Load Shedding

- Circular Debt due to Non-Pavments of bills of oil and electricity

- Poor hydrological conditions

- Shortfall in gas supply to IPPs & GENCO & KESC

- Fuel Oil supply issues due to financial constraints

- Subsidies esp. cross subsidy to domestic sector

- Incompetence, nepotism and corruption

- Losses due to technical & pilferage

- Most of the thermal plants of GENCO and KESC are very old which need repair and rehabilitation. Their availability is low.

- System faults & over loading.

II Energy Generation Plan[4]

Pakistan Energy Resources [5]

III Renewable Energy Resources

Pakistan is blessed with vast resources of renewable energy i.e. hydro, solar, wind and ocean as discussed in tabulated form below.

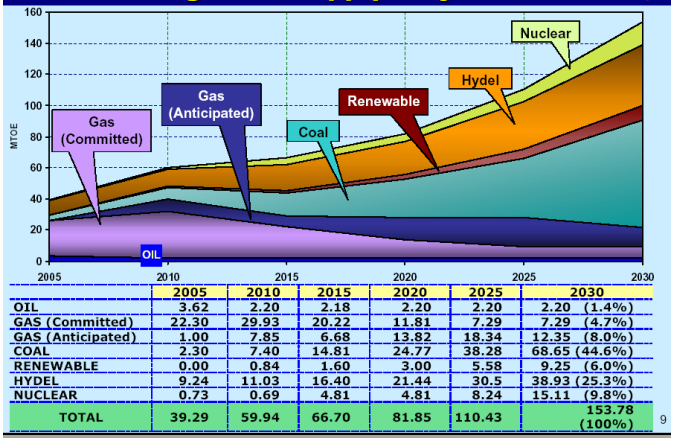
These Recourses are environment

Power Generation Plan

M.W

	Nuclear	Hydel	Coal	Renewable	Oil	Gas	Total	Cumulative
(2005)	400	6460	160	180	6400	5940	19540	
Addition	-	-	-	-				
2010	-	1260	900	700	160	4860	7880	27420
2015	900	7570	3000	800	300	7550	20120	47540
2020	1500	4700	4200	1470	300	12560	24730	72270
2025	2000	5600	5400	2700	300	22490	38490	110760
2030	4000	7070	6250	3850	300	30360	51830	162590
Total:	8800	32660	19910	9700	7760	83760	162590	

Indigenous Supply Projections



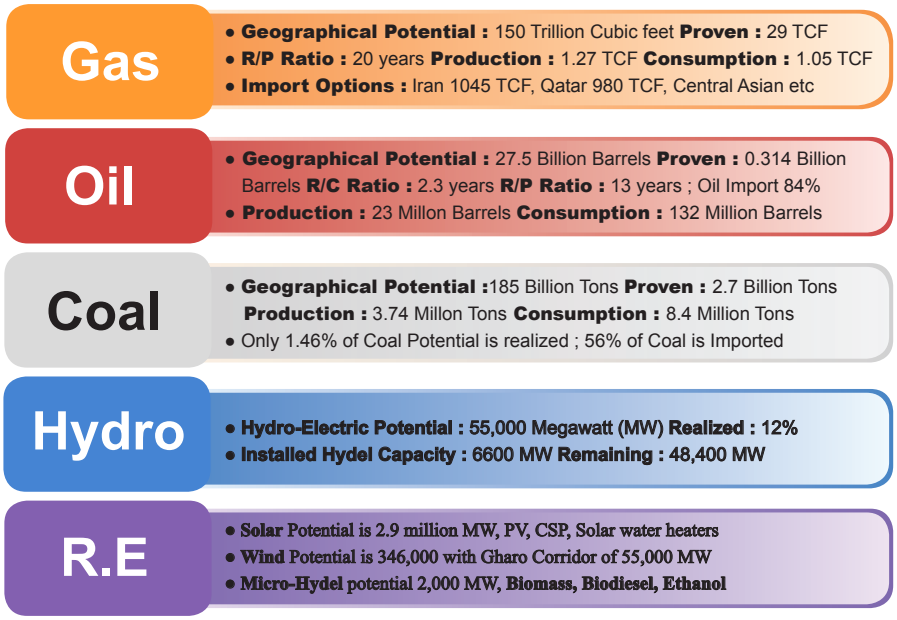
	2005	2010	2015	2020	2025	2030
OIL	3.62	2.20	2.18	2.20	2.20	2.20 (1.4%)
GAS (Committed)	22.30	29.93	20.22	11.81	7.29	7.29 (4.7%)
GAS (Anticipated)	1.00	7.85	6.68	13.82	18.34	12.35 (8.0%)
COAL	2.30	7.40	14.81	24.77	38.28	68.65 (44.6%)
RENEWABLE	0.00	0.84	1.60	3.00	5.58	9.25 (6.0%)
HYDEL	9.24	11.03	16.40	21.44	30.5	38.93 (25.3%)
NUCLEAR	0.73	0.69	4.81	4.81	8.24	15.11 (9.8%)
TOTAL	39.29	59.94	66.70	81.85	110.43	153.78 (100%)

9

Resources	Hydro	Solar	Wind	Ocean	Biomass	Geothermal
Magnitude	Large	Extremely large	Large	Very large	Very large	Very large
Distribution	Country wide	Country wide	Coastal mountains	Coastal, tropical	Country wide	Tectonic boundaries
Variation	Seasonal	Daily, Seasonal	High variable	Seasonal tidal	Seasonal	Constant
Intensity	Moderate to low, micro & small	Low 1 kW/sq m	Low average 0.8 MW/sq km	Low	Moderate to low	Low average up to 600 ^{0}C

Technology	Hydro	Solar	Wind	Ocean	Biomass	Geothermal
Options	Low to high turbines and dams, proven technology	Low to high temp thermal systems, photovoltaic	Horizontal and vertical-axis wind turbines, wind pumps	Low temp thermodynamic, mechanical wave	Combustion, fermentation, liquefaction, gasification	Steam and binary thermodynamic cycles
Status	Mostly commercial	Developmental, some commercial	Many commercial, more development	Developmental	Some commercial, more development	Many commercial, more development
Capacity Factor	Intermittent to base Load	25% w/o storage, intermediate	Variable most 15% ~ 30%	Intermittent to base load	As needed with short-term storage	High, base load
Key Improvements	Turbines, cost, design	Materials, cost efficiency	Materials, design sitting	Technology, materials, cost	Technology agriculture	Clean dissolved gases

Characteristics	Hydro	Solar	Wind	Ocean	Biomass	Geothermal
Environmental	Very clean impact on local aquatic environmental, land use	Very clean visual impact local climate, PV manufacturing	Very clean visual impact, noise, bird mortality	Very clean, impact on local aquatic environmental, visual impact	Clean impacts on fauna and other flora toxic residues	Clean dissolved gasses, brine disposal



friendly without using any fuel. Different Organization and Provincial Power Departments, Pakistan Council of Renewable Energy Technology (PCRET), Private Power and Infrastructure Board (PPIB) and Alternative Energy Development Board (AEDB) are working to harness these resources. Unfortunately no big break through is achieved so far, as their contribution has been negligible except of Sarhad Hydel Development Organization (SHYDO) who install 80MW in Malakand III and 1MW near Mardan.

(3.1) Pakistan Council of Renewable Energy Technology (PCRET)

Pakistan Council of Renewable Energy Technologies (PCRET) has been acquiring and updating know imperative for the promotion and mass propagation of Renewable Energy Technologies in the field of Solar, Microhydel, Wind etc. Various technological knowhow have already been adapted and indigenized by the Council, so far, in the field of Renewable Energy Technologies. The technologies being promoted developed and dissemination by the Council are not only technical time tested but are economical as well. In fact all the projects undertaken by the Council intend to promote and supplement Government efforts in solacing the vital energy deficit.

PCERT is basically a research organization with aim behind to evolve renewable energy technologies beneficial to the masses.

• Standard test procedures for testing of flat plate solar absorber and PV panel has been drafted and submitted to PSQCA for registration.

• On completion of project the testing services for solar products will be provided to parties/private sector for quality production of PV and solar thermal products.

One of the basic objectives of the Council is promotion of renewable energy technologies. In order to create awareness in the public for the use of the renewable energy technologies developed by the Council, a number of training programs were arranged, which were attended by various trainees (both in group and individually) from different walks of life. About 13,400 trainees were imparted training on economic cook stoves, income generating techniques, solar water heater, solar cooker, solar dehydrator, solar geyser, micro hydropower generation, solar system etc. through 140 training programs.

(3.2) The Private Power and Infrastructure Board (PPIB)

The Private Power and Infrastructure Board (PPIB) was created in 1994 to facilitate private sector in the participation of power generation in Pakistan. PPIB provides a One-Window facility to private sector investors in matters concerning establishing power projects and related infrastructure.

PPIB is working to attract and facilitate FDI in Pakistan power sector. A number of foreign investors have expressed interest in setting up power generation projects that would exploit our indigenous resources including hydel, wind, natural gas, and coal. Their proposals have been evaluated and the prospective investors facilitated and encouraged to come up with power projects focusing on maximum utilization of available local resources including renewable.

No renewable plant has been installed so far!

(3.3) Alternative Development Energy Board (AEDB)

Alternative Development Energy Board (AEDB) was established in 2003-2004. Its objective is to facilitate the private sector for installation of renewable energy plants on

commercial basis. It has claimed many achievements but mainly is able to establish parts of 2×50 MW wind power generation project at Gharo Sindh, 100 Solar homes program near Islamabad, 100 solar homes in Sindh and Baluchistan. AEDB also installed 2 micro hydro Kaplan turbines for demonstration on canal near UET Taxila and executed pilot project for installation of indigenously developed micro wind turbines.

IV Discussion & Analysis

Identified hydro power potential of 55,000 MW (3) yet to be exploited, including mega projects having dam's future planned Diamer Bhasha, Kalabagh, Dasu, and Munda etc. Other large, medium and small run of the river, mini as well as micro hydro power plants are renewable. Although some of the people consider major storage dams not to be under the category of renewable energy but even then we have hydel potential upto 45,000 MW available as renewable. While for the other resources proper identification and feasibility studies to estimate reliable potentials in MW are needed.

Pakistan current policies scenario leads to the conclusion that the new & renewable will continue to play a minor role in the energy supply picture until bold and drastic steps are undertaken by the government, otherwise this will result in greater dependence on oil & fossil fuels, with increased pressure on the global environment and import bill. Depletion of oil and natural gas along with political instability of supply security will bring major increases and justification in the use of renewable.

The accelerated introduction and expanded use of renewable energy could be one component of a more optimistic view of the future. Through sustained effort and dedication to preserving our energy options, a more flexible future can be achieved, but it will still take time to increase our dependence on renewable substantially. By 2020 the optimistic view concludes that as remedial measure we can achieve a higher penetration with the change in the current policies and approaches.

Renewable are well suited to distribute applications, providing the opportunity to enhance economic growth in the rural areas and reduce the pressure of migration of these people towards the already overcrowded major cities. Potential renewable supplies are very large, and their distribution allows for use of some types in our country. The environmental advantages of the renewable are real. Another important asset of the renewable is that the public opinion is very much in favour of expending our use of renewable where it makes sense.

(4.1) Barriers in the Development of Renewable

1. Technology and Information;
2. Regulatory;
3. Tariff;
4. Policy;
5. Institutional;
6. Financial;
7. Interconnection;
8. Procedural impediments;
9. To achieve consensus among people and provinces.

Technology and Information Barriers.

We lack knowledge & information about the technology of renewable. Need for proper on mass scale education of renewable technology is not only for the students & engineers but also for general public.

Strategy to achieve five Es:

E — Education
E — Energy
E — Employment
E — Equity
E — Enterprise

International Islamic University Islamabad has taken a lead in starting education for post graduate students about Energy Engineering to implement the most important "Es" of education in energy & for employment on equity basics for enterprises.

(4.2) Strategy Proposed to Develop Consensus about renewable energy in Pakistan

1. Inter Provincial Agreements for New Water Storages

2. National Comprehensive Law for Water as accord

3. Need of Reliable Telemetry System to win confidence of all

4. National provincial assemblies, senate to play leading role

5. Council of Common Interest (CCI) to play due role

6. Net Profit of Hydel Plants to be reviewed as per constitution

7. Wastage of 21 MAF of Water to Sea to be fully utilized

8. Feasibilities reports need priorities

9. Self reliance to be achieved

10. Departments & organizations to be made active

11. R&D institution & study groups to be established

12. Metrology office and forecasts need to be more reliable

13. Every drop of water must be used fruitfully

(4.3) Constraints for Pakistan Renewable Use

Extensive penetration of renewable into the Pakistan energy markets is not likely to happen quickly. There is a natural time lag between success of the prototypes and demonstrations, leading to a few initial commercial applications, and then incorporating learning into the next generation, and so on. There is a of R&D need to deploy significant manufacturing industries which require time for planning, financing, and training. The diversity constrains of the renewable resources are many a few common are discussed as below:

(1) Resource Definition

The magnitude of each renewable recourse is dependent on local conditions. To optimize the use of these recourses, better data is needed, especially on their variation. The comprehensive understanding of local conditions throughout the year will take extensive effort. Comprehensive national energy planning is emphasizing the maximum use or renewable needed.

(2) Technology Development

Many (but not all) of the technologies necessary to make efficient use of the renewable are quite immature, and /or relatively costly. Some renewable have a relatively low energy density in their raw form, and this either leads to high cost for concentration (if possible), or for structure to capture the energy in useful form. Therefore, material costs are often a high percentage of the capital cost, even for relatively simple designs. Further development, covering the range from basic R&D, will need to take place for users to invest the equivalent of future fuel costs with confidence. The areas for development include not only the design, but also manufacturing, installation, operation and maintenance of these systems. The success of renewable at higher market penetrations will also depend to a certain extent on the development and application of both improved energy storage and transportation system.

(3) Economic and Institutional Policies

Renewable energy systems typically have higher capital costs than fossil-fuelled systems, since all the fuel equivalent over the useful life time is purchased at the beginning of the system life. Emphasis on life –cycle costs and reduction of the risks of high capital investments will be necessary for the success of renewable.

(4) Environment

Much of the recent enthusiasm for developing renewable energy has been propelled by fears of climate change. However, one unfortunate consequence has been that the emphasis given to potential climate change has far outweighed the emphasis which should be given to the local adverse environmental impacts which in some forms and scales of new renewable energy can have.

(5) Public Education

The energy user takes for granted the supply of conventional energy unless this supply is disrupted as it is happening now! The average user does not understand the systems. This is one of the reasons that achievement of substantial gains in energy conservation or efficiency is very difficult. The widespread use of renewable will require even greater understanding of energy systems, and application of knowledge in making compromise in many aspects of daily life.

(6) International Co-operation and Sharing

The developed countries have most technology and the financial resources for utilizing renewable resources. There is need of time for international Co-operation with a different set of priorities and techniques for Pakistan.

V Recommendations

(1) Increase the priority for funding of renewable energy projects among financing institutions and for

bilateral aid programs, especially those programs that will lead to sustainable development based on indigenous resources. These programs will principally increase the flow of technology and financial resources

(2)Encourage private sector investment and involvement in the programmes for training and implementation of renewable. Promote the establishment of joint-venture manufacturing plants for local production of renewable energy systems.

(3) Establish or designate a single organization to give international focus and leadership to the increased use of renewable energy.

(4) Establish in universities and provinces centers of excellence for renewable energy, to provide training, technology support, and resources databases appropriate to the local needs.

(5) Increase R&D funds for renewable, eliminate subsidies on conventional energy, and reduce barriers that exist for the introduction of new different (especially small and distributed) energy systems.

(6) Review and update economic decision-making methodology to include the external impacts of the options under consideration.

(7) There is need for amendments in NEPRA Act, Rules, Regulations based upon the following issues to promote renewable energy.

a) Net Profit according to Article 161 of Constitution of Pakistan for hydro power projects needs to be worked out properly because AGN Qazi formula is defective.

b) Need to have legal coverage for all the energy policies.

c) Escalation and review formula of tariff for hydel power plants needs to be given legal protection.

d) Need to facilitate the micro/mini renewable electrical generating units (solar, hydel, wind) to get generation license without any fees and paper work. Accordingly to Clause 15 of NEPRA Act "No person shall, except under the Authority of a license issued by the NEPRA subject to the conditions specified in this Act and as may be imposed by the Authority construct, own or operate a generation facility" This was necessary because of safety and electricity Act 1910, but it is noted that there are thousand generating units without any such a license. We want the citizen to be law & safety abiding and to be able to install their own generating units should in addition to their own use inject electricity in the LT system. There should be effective & simple license free from any major paper work and fee for renewable.

e) Renewable need to be awarded reasonable up-front tariff.

f) NEPRA should have competent professionals and future vision of renewable to guide the nation. ■

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HRC's Annual Report on Foreign Affairs in 2011 and Work Plan for 2012

In 2011, HRC fully implemented instructions given by Ministry of Water Resources in enhancing international exchanges on water resources in close accordance with the spirit of No. 1 Document of the Central Committee of CPC concerning national water conservancy. Guided and supported by Ministry of Water Resources (MWR), Ministry of Commerce (MOFCOM) and Nanjing Hydraulic Research Institute (NHRI), all the staff members of HRC have made strenuous and concerted efforts for business expansion and innovation, actively undertaken foreign-aid training projects and conducted extensive international exchanges. By successfully completing a series of bilateral and multilateral international projects, HRC has further expanded the international markets, increased the export of electromechanical equipment of small hydropower, thus creating quite favorable social and economic benefits.

I Foreign-aid Training

1. General Situation

In order to strengthen foreign-aid human resources development, deepen south-south cooperation, popularize Chinese SHP technology and equipment, and promote exchange and cooperation among developing countries, HRC, under the guidance of MOFCOM and MWR, successfully organized 3 foreign-aid training workshops (seminar) in 2011, with totally 107 participants (officials) from 52 countries. Remarkable results have been achieved.

From 26 May to 6 July, the "***Training Workshop on Small Hydropower Technology for Developing Countries***" was successfully held in HRC, with 42 participants from 23 countries involved, and the working language was English. From 18 August to 28 September, HRC conducted the "***Training Workshop on Small Hydropower Technology for Francophonies in Africa***", with 40 participants from 17 French-speaking African countries involved. During the training workshops, the lectures and on-site visits were well combined. The presentations covered SHP specialized knowledge and professional skills, including Hydrology, Geology, Dam Design, Hydraulic Machinery, Hydro-energy, Head Works, Electrical Design, Automation, Powerhouse Design, etc. The case-study was focused on Site Selection of Hydropower Station, Water Conduit System, Development Modes, Technical Refurbishment, etc. In addition, special topics on Water Resources in China, Three

Gorge Project and South-North Water Diversion Project were introduced. Apart from listening to the lectures, the participants paid visits to the SHP stations designed by HRC or with equipment supplied by HRC, the hydropower equipment manufacturers in good cooperation with HRC for exporting, and the large-scale hydropower project — Three Gorge Hydropower Station as well.

With great support of MOFCOM and MWR, from 1 to 7 November, HRC organized the "***Ministerial Seminar on Water Resources and Small Hydropower for Developing Countries***", which was the 60th international training (seminar) project conducted by HRC since its establishment in 1981, and was the first ministerial seminar organized by HRC as well. The working language of the seminar was English. The leaders of MWR attached great importance to the seminar, and Minister Mr. Chen Lei gave a special instruction and entrusted Chief Engineer Mr. Wang Hong to attend the opening ceremony and delivered a keynote report titled "Development of Water Conservancy in China", laying a solid foundation for the success of the seminar.

The 7-day seminar was an attractive and rewarding event. Totally 25 high-level officials (including 12 ministerial officials) came all the way to be present at the seminar from 12 countries in Asia and Africa, including Cambodia, Egypt, Ghana, Kenya, Malawi, Pakistan, the Philippines, Sierra Leone, Syria, Tanzania, Uganda, Vietnam, etc. The Seminar aimed to strengthen the exchange and cooperation between China and other developing countries in the field of water resources and small hydropower, to share Chinese successful experience and advanced technology, to enhance the capacity of each country for utilizing water resources and developing SHP. The effect of seminar was well improved by the combination of presentations and on-site visits. The famous experts in the field of water resource and SHP were invited to respectively deliver presentations titled "General Management and System Construction of Chinese Water Resources", "Introduction on Eco-Hydraulic Engineering", "Development and Prospect of International Dam Construction Techniques", "Small

Hydropower Development in China", "Small Hydropower Development Practice in Zhejiang Province", and "SHP Development Modes and Technical Characteristics", etc. In addition to the National Water Museum of China, the visits to Three Gorge Project, Caoejiang Hydraulic Project, Suzhou River Gate Bridge, Jiufeng Power Station and Zhejiang Jinlun Electro-mechanic Co., Ltd were also well arranged, covering large hydropower project, SHP station and SHP equipment manufacturer with different characteristics and wonderful experiences.

The seminar has achieved a complete success, winning high appraisals from MOFCOM, MWR, the local government, the hydropower industry or beyond, and the participants as well. Mr. Gao Bo, Director-General of the Department of International Cooperation, Science and Technology of MWR, pointed out that "It is the first time for MWR and MOFCOM to jointly sponsor the Ministerial Seminar on Water Resource and Small Hydropower, which has won enthusiastic responses and significant effect." Vice Minister Mr. Hu Siyi was very supportive to HRC for organizing the seminar. He broadened the new approaches and pointed direction for the preparation of the seminar. Vice Minister Mr. Hu wrote comments in the "Report on the Seminar" submitted by HRC that "Based on thoughtful organization and implementation, the seminar has been completed successfully with fruitful results. It is expected that HRC would make persistent efforts to strengthen continuously international exchange and cooperation, and promote Chinese SHP further GOING GLOBAL."

Moreover, the officials at ministerial level from Ghana, Malawi, Uganda, Pakistan, Syria and Cambodia, etc. also delivered the passionate speeches respectively, expressing their sincere gratitude for the hospitality and good service from China, and making high evaluation on the enlightening presentations, wonderful visits and perfect arrangements, etc. The ministers from several countries presented souvenirs to HRC in acknowledge of its efforts.

2. Elaborate Arrangement and Thoughtful Preparation

With rich experience in conducting international training projects for 30 years, so far, HRC has successfully organized 60 international training workshops or seminars in total, with over 1,200 officials and technicians from more than 100 countries or regions involved. For each training project, the leadership of HRC attached great importance and made elaborate deployment. Several work meetings are held to ensure the smooth implementation. Especially for this ministerial seminar which is one of the few of its kind to be entrusted by MOFCOM and held beyond Beijing, HRC set up specially a competent working team led by HRC director, to make meticulous planning, efficient organization and thoughtful arrangement, to pay extreme attention to security and foreign affairs etiquette as well, ensuring the success of the seminar. The details are shown as follows.

(1) During the preparation of the first training workshop of 2011, the "HRC Training Manual" was revised and improved. The new version of the manual was characterized by beautiful print, nice illustration and rich information, containing the details of lecturers and highlights of the presentations. During the preparation of the second training workshop of 2011, a questionnaire titled "Situation and Demand of Hydropower Development in African Countries" was designed in advance, including the key items of "Theoretical Potential of Hydropower, Exploitable Potential of SHP, Total Installed Capacity of Power, Installed Capacity of Hydropower, Rate of Electrification, Demand of SHP, Main Problems and Difficulties, etc". Base on the kind assistance of the participants, the rich data of the 17 African countries was well collected,

▲ Mr. Wang Hong, Chief Engineer with MWR, P.R. China delivered keynote speech

providing a reliable information source for further bilateral cooperation with African countries.

(2) With respect to the course arrangement, the complete training schemes for the SHP training workshops were well designed by taking the suggestions of the old participants and based on actual situation as well, with the topics concerning renewable energy development added, such as the "Complementary of Wind Power, Hydropower and Solar Energy", etc. The lectures of the workshops over one month were arranged scientifically and orderly, covering all technical aspects of SHP. In addition, the on-site visits to hydropower stations and equipment manufacturers were also arranged, so as to improve training effect based on the combination of theories and practices.

With respect to the seminar, HRC designed the schedule elaborately under the guidance of MWR and MOFCOM, and the selection on presentations, experts and visiting sites were discussed for many times. Mr. Liu Heng, Director-General of International Center for Small Hydropower, Mr. Dong Zheren, Vice Chairman of Chinese Committee of Global Water Partnership, Mr. Jia Jinsheng, Chairman of International Commission on Large Dams and Vice President of China Institute of Water Resources and Hydropower Research, Mr. Tian Zhongxing, Director-General of Bureau of Rural Hydropower and Electrification Development, MWR, Mr. Xu Wenbin, Deputy Director of Zhejiang Provincial Department of Water Resources, Ms. Cheng Xialei, Director of National Research Institute for Rural Electrification (HRC), were specially invited to deliver presentations.

The Ministerial Seminar Held in Hangzhou in Nov.,2011

(3) Nice organization and management are the basic guarantees for the smooth implementation of a training program, and thoughtful logistics service is the solid support for the physical and mental comfort of participants. During conducting the training projects, the organization and management were proved to be efficient and meticulous, either from reception to farewell, from opening ceremony to closing ceremony, or from in-class presentations to on-site visits, from discussion on technology to discussion on cooperation, etc.

In addition to the informative lectures and on-site visits, the business talks on SHP international cooperation were held during the training workshops. All the participants took pleasure to have exchange and discussion with the experts and engineers from

Hangzhou Yatai Hydro Equipment Completing Co., Ltd of HRC. The participants introduced the details of their respective countries concerning the potential of water resources, the situation of hydropower development and the potential hydropower projects. HRC staff listened attentively, discussed actively, and offered many good suggestions. Based on the full communication, the mutual understanding was enhanced which laid a solid foundation for undertaking more international hydropower projects in future concerning technical consultation, engineering design and equipment export, etc.

3. Fruitful Results and Prosperous Prospect

HRC staff members and lecturers get along with the participants everyday during training workshops or seminar, and the mutual understanding and friendship were enhanced, which laid a favorable foundation for further cooperation in future. The participants of the training workshops kept in touch with HRC via E-mails, and some participants often informed HRC of local hydropower projects, inviting HRC to take part in technical service and equipment supply. During the ministerial seminar, the Director in Ministry of Irrigation of Syria specially paid a visit to HRC and its subsidiary company, Hangzhou Yatai Hydro Equipment Completing Co. Ltd. for the discussion on SHP cooperation, and he expressed that a proposal on potential cooperation with China would be submitted to the superiors after returning to Syria. The Minister of State for Environment, Ministry of Water and Environment of Uganda, Ms. Munaaba Flavia Nabugere who had been paying attention to the effect of SHP development on ecological environment hoped to learn more management experience from China, and it was expected that the potential cooperation with China, not only on technology, but also in the field of management, would be further discussed.

After the seminar, the Ministers of Cambodia, Malawi, Pakistan, the Philippines, Tanzania, etc. respectively sent letters to HRC, expressing their wishes on bilateral cooperation. In the letter of Mr. Heng Sokkung, Under Secretary of State, Ministry of Industry, Mines and Energy of Cambodia, he invited HRC to undertake an on-site survey for the two hydropower projects with the priority for development in Battambang Province of Cambodia, and he would make arrangement for HRC to call on Minister of Industry, Mines and Energy of Cambodia for the discussion on cooperation.

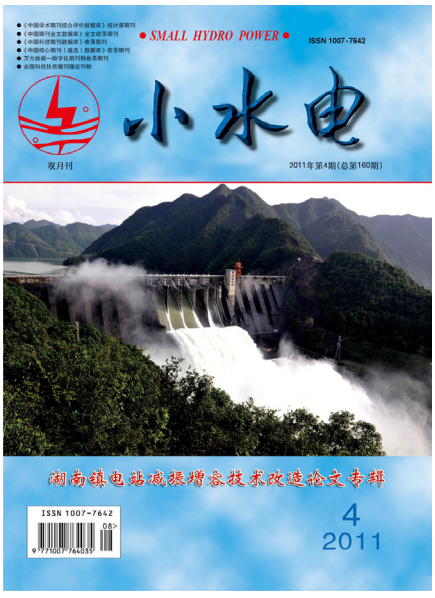
Based on conducting the foreign-aid multilateral training projects, the hydropower professionals were cultivated for developing countries, good relationship was enhanced and international exchange and cooperation were strengthened. It is expected that HRC will have a splendid and prosperous prospect to further promote economic and technical cooperation on small hydropower.

II Exchange with Foreign Countries

1. Information Exchange

(1) In 2011, HRC completed the translation of the "Electromechanical Equipment Guide for Small Hydroelectric Installations" and submitted it to the Department of International Cooperation, Science and Technology of MWR for examination. It is expected to be issued based on a further revision and a final examination according to the comments from the experts. Moreover, HRC will further translate and issue the "Technical Specification on Type, Parameter and Performance of Small Hydraulic Turbine" and some other technical norms. The task of formulating 5 and translating 3 national standards in 2012 has been assigned to HRC.

In recent years, the international market of hydropower has been expanded vigorously, and the international SHP projects of engineering design and equipment export have been greatly increased. Many countries are lack of national standards, and the SHP sector of some countries would like to draw on Chinese techniques and rich



experience in SHP development. Therefore, the formulation and issue of English Version of the standards are of great significance.

(2) HRC has edited and published the "SHP News" of 2011, collecting huge number of articles concerning SHP technology and development, as well as the news in the field of SHP of many countries. The website of HRC has played a more significant role and became an important window for publicity and information exchange. In 2011, it released 49 pieces of English news, widely introducing HRC and Chinese SHP to the colleagues all over the world. In 2011, totally 31 scientific papers and academic reports from the professionals of HRC were published (as shown in Appendix 3).

(3) In addition, HRC actively took part in the "South-South Cooperation on Science, Technology and Information Exchange", a project of Ministry of Science and Technology (MOST). The technical information on "Technology and Equipment of Small/Micro Hydropower" and "Technology of SHP Automatic Control" were compiled by HRC and collected into the "Applicable Technology Manual: South-South Cooperation on Science and Technology to Address Climate Change". The manual was issued successfully at the UN Climate Change Conference held in Cancun, Mexico in 2010, winning acclaim from the developing countries and the international organizations. According to the requirements from the Office of International Cooperation and Planning of MOST, the above-mentioned information was updated last year for the second edition.

2. Visits for Bilateral Cooperation

In 2011, HRC received totally 11 batches of 25 foreign guests, respectively from Turkey, Vietnam, Indonesia, India, Kosovo, etc (as shown in Appendix I). Meanwhile, HRC dispatched 8 delegations of 17 members to visit Turkey, Israel, Kenya, Angola, accomplishing the missions for the cooperative hydropower projects, such as equipment installation, technical consultation and discussion on contract of equipment export etc. Based on the visits and the communication with the old and new customers, several cooperative agreements were reached, and 5 contracts of technical consultation and equipment supply have been signed, providing favorable economic benefit.

Moreover, HRC has set up long-term cooperative relationship and reciprocally-visiting mechanism with Vietnam Academy for Water Resources (VAWR) and TEAM of Thailand, and signed the Memorandums of Understanding as well. Within the cooperative framework of China-Vietnam Joint Committee on Science and Technology Cooperation, HRC and VAWR jointly applied for several long-term and short-term research and development projects between Chinese Government and Vietnamese Government, enabling the MHP equipment, SHP automatic control system and the containerized turbine-generating units developed by HRC to be successfully exported to Vietnam for popularization. In 2011, HRC made cooperation with TEAM actively and greatly promote the export of SHP technology and electro-mechanical equipment to South Asia based on the mature markets of renewable energy established by TEAM in Thailand, Laos and Myanmar.

III International Cooperation

1. Engineering Consultation and Design

In 2011, the subsidiary design institute of HRC undertook technical consultation for 6 hydropower stations in Turkey, Vietnam and Indonesia.

2. Bilateral and Multilateral Cooperation

In addition to the cooperation with oversea companies, HRC carried on extensive cooperation with domestic companies, jointly developing hydropower markets abroad based on a strong alliance with complementary advantages. For instance, HRC cooperated to explore global market jointly with Sinosteel Tiancheng and Shanghai Electric Power Transmission and Distribution Engineering Co., Ltd in Turkey, Republic of Congo and Togo, etc. The cooperation with the general contractors can not only reduce risks, but also learn good experience in project management, enabling HRC to take root in the local hydropower markets, thus enhancing the market share and improving influence.

Within the Cooperative

Framework of China-ASEAN Joint Science and Technology Committee, HRC has set up long-term relationship with the Secretariat to jointly promote SHP development in ASEAN countries. The consensus was reached to hold a training workshop on hydropower and micro solar energy system in 2012 in Hangzhou, aiming at popularizing the containerized SHP technology and the micro solar system through project demonstration and cooperative research, thus promoting rural electrification in ASEAN countries. At present, the proposal has been approved by the ASEAN Sub-committee on Non-conventional Energy Research, and would be submitted formally to Chinese Ministry of Foreign Affairs after getting responses from the ASEAN countries.

3. Equipment Completing and Export

In 2011, HRC undertook the after-sale equipment maintenance for 12 hydropower stations which had been put into successful operation in Turkey, and supplied related spare parts at the request of the owners. The design of 3 Turkish hydropower stations, as well as the manufacturing and supplying of the embedded parts of equipment have been completed. HRC dispatched delegations to Turkey, carrying on the equipment installation. Meanwhile, based on the on-site survey, technical consultation and business negotiation fulfilled respectively, HRC actively made discussions with customers in Turkey, Angola, the Republic of Congo, Kenya, Indonesia and Thailand on SHP design, equipment completing and export, with great breakthrough achieved.

Since HRC set out to export hydropower equipment in 2005, so far, it has supplied electro-mechanical equipment and offered instruction or service of installation for 35 hydropower stations in the Philippines, Vietnam, Sri Lanka, Peru, Fiji, Turkey, Pakistan, Angola and Kenya, etc., with a total installed capacity over 400 MW, providing remarkable economic benefit. At present, HRC is taking root in Turkish hydropower market, and exploring the markets in the neighboring countries as well. In virtue of the high-quality electro-mechanical products, the perfect engineering management and the favorable after-sale service, HRC enjoyed good reputation and won high praises from the oversea customers.

IV Work Plan for 2012

Based on the fruitful achievements concerning foreign affairs in 2011, HRC will make unremitting efforts to continuously enhance international cooperation on SHP, actively undertake exchange and training, thoroughly implement the strategy of "Go Global", and promote SHP equipment export. The work plan in detail is shown as below.

To earnestly conduct at least three foreign-aid projects entrusted by MOFCOM, including Training workshop on Small Hydropower Technology for Developing Countries (23 May – 6 July), Seminar on Rural Electrification for Developing Countries (30 August – 26 Sept) and Formation sur la Technologie de Petite Centrale Hydroélectrique pour les Pays d'Afrique francophone (18 Oct – 28 Nov); to compile and publish the French version of the training materials "Small Hydropower", and revise the English version; make unremitting efforts to ensure the excellent fulfillment of the foreign-aid training projects sponsored by MOFCOM.

To fully take the advantages of HRC as the "Family of Small Hydropower in the World", playing a role as a bridge; to further strength extensive exchange between HRC and the SHP sector in other countries, enhance friendship and promote cooperation, enabling HRC to serve as an important "window" for international exchange and cooperation.

To thoroughly implement the strategy of "Bring In and Go Global", to introduce the advanced technology and management experience of water resource and SHP from the developed countries, which are to be turned into scientific and technical payoffs and popularized home and abroad. In particular, the micro containerized units introduced by HRC from overseas few years ago and the controlling technology developed by HRC should be applied well in the markets both home and abroad.

To fully play the role of an international platform; to strength the development of the two magazines and the website of HRC, ensuring extensive information exchange with the international organizations, the oversea SHP institutions and the colleagues home and abroad.

To deeply comprehend the important instructions given by leaders of Ministry of Water

Resources on enhancing international cooperation, to continuously implement the strategy of "Go Global", consolidate the achievements and actively develop bilateral cooperation with the countries in South America, Africa, Southeast Asia and East Europe. To promote the export of hydropower equipment, and at the meantime, to actively expand cooperation in the field of new energy such as wind power, solar energy and biomass energy, etc., and the fields of environmental protection and small-scale thermal power as well, thus realizing the "overall development based on main business" and achieving new business growth.

Appendix 1

Foreign Guests Hosted by HRC in 2011

No.	Time	Country/Organization/Delegate(s)	Objectives & Achievements
1	2/26	2 delegates from the Turkish company	The foreign guests visited the manufacturers, and the consensus was reached on the cooperative projects after discussions.
2	3/2-3/6	The General Manager and other 3 delegates from the Turkish company	The foreign guests visited HRC, undertaking technical discussions, making negotiation and signing contract.
3	3/15-3/18	The 3-person delegation led by Mr. Nguyen Vu Viet, Vice Director of Vietnam Academy for Water Resources (VAWR) and Director of Institute for Hydropower and Renewable Energy (IHR)	Discussion and deployment were made on the project "Emergency-supporting Technology for Rural Hydropower against Disasters Caused by Climate Change", a long-term cooperative project between the Chinese and Vietnamese Governments which was jointly applied by HRC and VAWR.
4	4/15	The 2-person delegation headed by MR. Nguyen Quang Dao , Chairman of the Board, Thai An Hydropowers., Jsc, Vietnam	Discussion was made on the design of 220kV transmission line and the relevant issues in construction. The technical scheme was determined.
5	5/10-5/13	2 delegates from the Turkish company	The foreign guests inspected the progress and quality of the turbine-generator units under production.
6	6/4-6/6	3 delegates from the power company in Indonesia	The delegates effectively communicated with the affiliated company of HRC over the project design and equipment procurement, and visited Shimentan Cascade Hydropower Station designed by HRC.
7	9/27	2 delegates from the international company in India	The foreign guests visited the equipment manufacturers. The supply scope and related technical problems were discussed in details, and the preliminary scheme for equipment supply was determined.
8	9/15	2 delegates from the Turkish company	The foreign guests inspected the progress of production and made technical discussion for the 3 projects under implementation.
9	10/6	The owner of hydropower project from Kosovo	Hangzhou Yatai Hydro Equipment Completing Co., Ltd of HRC made the preliminary design and offer for the containerized hydropower project which would soon be conducted, and the technical parameters and concrete requirements were clarified.
10	10/18	2 delegates from the Turkish company	A profound discussion was held on the projects in the fields of hydropower and others which were of common concern. The foreign guests visited some equipment manufacturers.
11	11/18	2 delegates from the Turkish company	The effective discussion was held on the three new projects, concerning the turbine-generating equipment manufacturers, the scope of supply, the offer of equipment and some technical issues, etc.

Appendix 2

HRC's Outbound Missions in 2011

NO.	Time	Delegate(s)	Country	Mission & Achievements
1	4/18-7/16	1	Turkey	To give installation instructions for the hydropower projects in Turkey.
2	6/10-9/7	2	Turkey	To give installation instructions for the hydropower projects in Turkey.
3	7/20-8/10	3	Turkey Israel	To hold discussion on the hydropower projects in Turkey and Israel.
4	7/14-10/5	1	Turkey	To give installation instructions for the hydropower projects in Turkey.
5	8/7-10/5	1	Turkey	To give installation instructions for the hydropower project in Turkey.
6	8/7-11/4	3	Turkey	To give installation instructions for the hydropower projects in Turkey.
7	11/4-11/11	2	Kenya	To carry on negotiation on the completing and export of equipment of hydropower projects in Kenya.
8	12/20-12/30	4	Turkey	To hold discussion on hydropower projects in Turkey, as well as the completing and export of electromechanical equipment.

Appendix 3

Papers Published in 2011

No.	Title	Magazine	Serial No.	Author(s)
1	Creative Design Work	Water Power & Dam Construction, Jan 2011, UK	ISSN 0306-400X	Lin Xuxin, Pan Daqing
2	Study on General Strategy of Water Power Resources Zones in China	China Water Resources June, 2011	CN11-1374/TV	Cheng Xialei, Chen Xing, Cao Lijun
3	Thinking and Suggestions on Establishing International Standards for Small Hydropower	China Water Resources Vol. 2, 2011	CN 11-1374/TV	Dong Dafu, Zhao Jianda, Cheng Xialei, Zhu Xiaozhang
4	The Effectiveness Analysis on the Improvement of Old Power Stations in Zhejiang Province	China Water Power & Electrification, Vol. 4, 2011	ISSN 1673-8241	Shu Jing, Jin Huapin, Lin Xuxin
5	Research and Design of Platform of Transportation in Taishir Hydropower Station in Mongolia	Small Hydro Power, Vol. 1, 2011	ISSN 1007-7642	Jiang Xinchun
6	Appraisal for Medium and Small Sized Hydropower Station Based on Investment Benefit	Small Hydro Power, Vol. 1, 2011	ISSN 1007-7642	Yan Jun
7	Analysis on Dam Safety Monitoring for Lower Reservoir in Huilong Pumped-storage Power Station	Small Hydro Power, Vol. 1, 2011	ISSN 1007-7642	Ren Suming, Chen Xiangming, etc.
8	Analysis on Temperature Stress of Tunnel Lining in Huilong Power Station	Small Hydro Power, Vol. 2, 2011	ISSN 1007-7642	Ren Suming, Chen Xiangming, etc.
9	Application of Pile Structure in Flood Protection Embankment in Residential area	Small Hydro Power, Vol. 3, 2011	ISSN 1007-7642	Zhang Hua, etc.

10	Discussion on Appropriate Technology for the Refurbishment of Small Sized Hydropower Station	Small Hydro Power, Vol. 5, 2011	ISSN 1007-7642	Shu Jing, Lin Xuxin, Fang Hua, Jin Huaping
11	Security Risks Assessment and Guarantee Technology of Rural Hydropower Station	Small Hydro Power, Vol. 6, 2011	ISSN 1007-7642	Xu Jincao, Dong Dafu, Jin Huapin, Shu Jing, etc.
12	Security Risks Assessment and Guarantee Technology of Rural Hydropower Station	2011 Annual Conference of China Society of Hydraulic Engineering, 2nd China Forum on Small Hydropower, Special Committee of Hydroelectricity Engineering Oct., 2011, Beijing	Presentation delivered	Xu Jincao, Dong Dafu, Jin Huapin, Shu Jing, etc.
13	Discussion on Appropriate Technology for the Refurbishment of Small Sized Hydropower Station	2011 Annual conference of China Society of Hydraulic Engineering, 2nd China Forum on Small Hydropower, Special Committee of Hydroelectricity Engineering Oct., 2011, Beijing	Presentation delivered	Shu Jing, Lin Xuxin, Fang Hua, Jin Huaping
14	An Example of the Straightening Treatment to Bending Shaft of Vertical Hydro Generator	Proceedings of 18th Colloquium on Chinese Hydropower Equipment Nov., 2011 Wuyi Mountain China Water Power Press First Edition, Oct., 2011	ISBN 978-7-5084-9088-5	Xu Wei, Du Jiang, Zeng Rong
15	Challenge of Chinese Small Hydropower Development and Its Policy Proposal	Seminar on Small Hydropower Development 25th July, 2011, Beijing	Invited Paper	Cheng Xialei
16	SHP Development Modes and Technical Characteristics in China	Ministerial Seminar on Water Resources and Small Hydropower for Developing Countries 3th Nov., 2011, Hangzhou	Invited Paper	Cheng Xialei
17	Extension Evaluation Mode of Water Resources Zones in China and Decision Supporting System	2011 Annual Conference of China Society of Hydraulic Engineering, 2nd China Forum on Small Hydropower, Special Committee of Hydroelectricity Engineering Oct., 2011, Beijing	Presentation delivered	Zhang Rengong, Cheng Xialei

18	Reference of the Development Experience of Japanese Pumped Storage Power Stations for East China Power Grid	Hydroelectric Engineering, Vol. 37, No. 12	ISSN 0559-9342	Wu Shidong, Jiang Xinfen
19	Research on the Decision-making Model of Renewal and Reconstruction of Small Hydropower Stations	China Rural Water and Hydropower, Vol. 6, 2011	ISSN 1007-2284	Qiu Jianghai, Lin Xuxin, Shu Jing, Jin Huapin, Xu Jincai
20	Grey Theoretical Mode for Health Diagnosis of SHP Hydraulic Structures	Journal of Hohai University (Natural Sciences), Vol. 5, 2011	ISSN 1000-1980	Li Yi, Cai Xin, Xu Jincai, Shu Jing, etc.
21	Seepage Analysis of Reinforcement Project for Danger Control of Earth and Rock-fill Dam	Water Resources Informatization, Vol. 1, 2011	ISSN 1674-9405	Wang Haibo, Chen Jisen
22	3-D Seepage Flow Field Analysis of Excavation for a Large Span Double-arch Tunnel	China Science and Technology Information, Vol. 16, 2011	ISSN 1001-8972	Zhang Bin, Chen Jisen
23	Discussion on the Application of Pore Pressure Coefficient in Soil Slope Stability Calculation	Henan Science & Technology, Vol. 11, 2011	ISSN 1003-5168	Zhang Bin, Chen Jisen
24	Improvement of Strain Hanging Plate Type in Corner Angle Steel Tower	Small Hydro Power, Vol. 1, 2011	ISSN 1007-7642	Zhang Bihui, Yin Xiaoqin, Fang Hua
25	Discussion on Stratified Water-taking in Reservoir	Small Hydro Power, Vol. 2, 2011	ISSN 1007-7642	Tang Sujuan, Tang Wen, Zhou Jianxiong
26	Application of Networking of Computer Monitoring System in Jiufeng Reservoir	Small Hydro Power, Vol. 3, 2011	ISSN 1007-7642	Xu Yanfang, Zhan Qingyun, Hu Changshuo
27	Construction Quality and Safety Management of Casing Well in Hongqiao Reservoir	Small Hydro Power, Vol. 3, 2011	ISSN 1007-7642	Shan Xianzhong, Chen Changjie
28	Practice on Underwater Repair for Expansion Joint of Impervious Facing Plate in Upstream Side of Dam in Yangxi Reservoir	Small Hydro Power, Vol. 3, 2011	ISSN 1007-7642	Jiang Xiaoyang, Shi Rongqing, etc.
29	New Type Operator with PID Controller	Small Hydro Power, Vol. 5, 2011	ISSN 1007-7642	Zhou Yufeng, Jin Huapin, Xu Guojun
30	Design and Construction of the Reinforcement and Rehabilitation for Yao Jiang Sluice	Small Hydro Power, Vol. 5, 2011	ISSN 1007-7642	Wu Yingyan, Shi Rongqing
31	Research on Economical Efficiency of Small Hydropower and Safety of Electrical Equipment	Small Hydro Power, Vol. 6, 2011	ISSN 1007-7642	Yuan Yue, Bai Xue, Fu Zhixin, Xu Jincai

(Source:HRC) ■

A Moment in Time

—— Closing Ceremony of Ministerial Seminar

"Smooth river flowing with languishing wind,
Mooned boat travelling on mysterious wonderland,
Shiny glass reflecting back merry laughter,
Our heart flooding with deeply friendship."

As the night approaches against skyscrapers along both sides of river lit by lingering lights, the serene and charming Huangpu River is just like a colorful ribbon spilling out from the sky, running forward in gentle ripples through the beautiful city of Shanghai. On 7th November, the closing ceremony of "Ministerial Seminar on Water Resources and Small Hydropower for Developing Countries", jointly sponsored by Ministry of Commerce and Ministry of Water Resources, undertaken by HRC, was grandly held on the pleasure-boat "SUN TECH" which had been elaborately decorated on Shanghai Huangpu River. The rostrum was decked with flowers, and the national flags of the 13 countries stood on one side of the conference hall on the boat, LCD Television on both sides played the slide show of the brilliant photos taken during the seminar. With the melodious Chinese folk music Jasmine Flower, well-dressed delegates entered into the conference hall.

At 18:30, Ms. Cheng Xialei, Director of National Research Institute for Rural Electrification / Hangzhou Regional Center (Asia-Pacific) for Small Hydropower, declared the beginning of the closing ceremony. Mr. Ye Jianchun, Director-General of Taihu Basin Authority, firstly delivered a speech. On behalf of Taihu Basin Authority, Mr. Ye warmly welcomed all the officials of this seminar to Shanghai for investigation and study, and congratulated on the successfully fulfillment of the seminar. He also expressed the willing to undertake technical exchange with foreign and domestic institutions on the management of water resources and the development of small hydropower, and to establish cooperative partnership with them in a wide range of areas. Finally, Mr. Ye Jianchun hoped that the trip to China will leave all the officials a wonderful memory.

On behalf of all the officials at the seminar, Ms. HANNA BISSIW, Deputy Minister of Water Resources, Works and Housing, Ghana, delivered a speech. She expressed that she was honored and pleased to be the representative of her country, Ghana to participate in this important international seminar. In the speech, she said that "the hospitality of our hosts for this week-long Ministerial Seminar on Water Resources and Small Hydro Power (HRC) is really welcoming and refreshing." "The key objective of this Seminar was to avail delegates the unique opportunity of being better acquainted

with the Water Resources Utilization and Small Hydro-power development in China with the view to jointly promoting the development and utilization of the Technology in our respective countries." "My participation in this Ministerial Seminar today is considered a significant milestone in furtherance of the long political, economic and diplomatic relations between Ghana and China in particular and participating Sister countries, in general." "This Seminar has been designed with modern pedagogical methodologies including presentations, discussions, on-site-visits and simulation modules considered suitable for a platform of this caliber. I believe that my colleague delegates would agree with me that, this Seminar is an eye opener, thus providing us with a better understanding of Water Resource Utilization and Small Hydro-power development in China." "Our visit to various sites including the National Water Museum, the Caoejiang Hydraulic Project, the Small Hydropower Station in Jinhua and the Hydropower Manufacturer, Three George Hydro Power Project, and the Suzhouhe Tide Gate others are very impressive engineering master pieces that can easily overwhelm first time visitors. As Chinese you have indeed demonstrated your commitment to your country and the welfare of your people. It clearly demonstrates

also the ability of the Chinese to apply modern technology by developing small hydropower systems to ensure socio-economic growth and development." "It is worth mentioning that, we have noted with admiration during our field trips that, China has advanced in the utilization of water resources and its management which I believe could be traced to the policies and institutional regulation of their use. It was indeed very mesmerizing to behold how rivers have been dredged, well crafted and linked up to create canals which serve as means of transportation and also to ensure the sustainable use of small hydropower as a vehicle for national development." "I wish to thank you once again especially the wonderful Seminar Working Team, you made us feel at home we will surely miss you." "Long Live the Friendship between The People's Republic of China and the Developing Countries." The sincere and passionate speech echoed in the hearts of all other officials and received enthusiastic applause.

In the following step for free speeches, Ms. VERA CATHERINE CHILEWANI, Deputy Minister of Malawi Ministry of Natural Resources, Energy and Environment, said: "While enjoying the beautiful night view along Huangpu River, on behalf of the Malawian government and all the participating officials, I would like to express my sincere thanks to the organizing committee, the whole team of HRC. I was a little bit hesitated when

▲ Ms. Cheng Xialei, Director of NRIRE (HRC) presided over the closing ceremony and the farewell banquet

▲ Visit the National Water Museum of China

▲ Visit the key project of Cao'e River Floodgate

▲ Visit Zhejiang Jinlun Electro-mechanic Co., Ltd

I first accepted the invitation. I was in Addis Ababa and was quite busy when they asked me to come to China for this seminar. But at last, I thought it is a rare opportunity for me to know more about China. When I came here, I realized it's a serious seminar with love and care. When I informed my colleagues about the courteous reception and thoughtful care I received here, they wondered with admiration that whether I am attending a seminar or enjoying a vacation, The seminar is full of enthusiasm, love and care, which I don't take for granted. I hope our country could carry out further cooperation with China in the field of the utilization of Water Resources. I firmly believe that the support from Chinese Government to all the developing countries will never end; the aid for developing countries will benefit us more and go even further. Thank you, China!"

Ms. MUNAABA FLAVIA NABUGERE, Minister of State for Environment, Ministry of Water and Environment of Uganda, said: "I am very pleased and honored to attend the Ministerial Seminar on Water Resources and Small Hydropower for Developing Countries. On behalf of the government of Uganda and all the officials present here, I would like to express my gratitude to Chinese government on the occasion of this well prepared and romantic closing ceremony. I have been to Asia for several times, Thailand for an example. And I just have attended the Ministerial Seminar on Strengthening Cooperation of Forestry (Bamboo) among China and Other Developing Countries which was also sponsored by Chinese government. I have a good stay here and I have had an unforgettable birthday party organized by the working team of HRC, which was really a very big surprise to me. Chinese government is a pioneer among developing countries in the field of environment treatment and water resources management, which is almost 100 years ahead than that of Uganda. The government of Uganda has the great confidence in and strongly supports the China's technology. I noted down the advanced experience of China during this seminar and I will share it with my colleagues after I come back to my country with the hope to put China's experience and technology into practice development. At the same time I hope that the Chinese government will give us more support and invite more colleagues of mine to come to China for various seminars and training courses of this similar type so that we can bring back more successful experience. My country won't always hope the Chinese government to give us financial support, but we urge more technological support."

Mr. HAMID ALI KHAN, Additional Secretary with vice ministerial level, Ministry of Water and Power of Pakistan, said: "Everyone asks me that if I feel lonely here because Pakistan only sends me to attend this seminar but at least two officials for other countries. I can proudly tell you that the answer is "No". China is my second hometown and Chinese people are my brothers and sisters. The relationship between China and Pakistan is historic and based on cooperation and trust. China is a country of unique relationship with Pakistan, and our relationship goes well beyond government level to a people-to-people

▲ Visit Jinhua Jiufeng Reservoir powerhouse

▲ Visit the central control room of Suzhouhe Tide Gate

level. As a well-known saying goes in our country, our relationship is higher than the Himalaya, deeper than the sea and sweeter than honey. Long live the Chinese government, long live Chinese people."

Two officials of Ministry of Irrigation of Syria, Mr. ABDULLAH MTANES SAADA ALDAOUD, Director, and Mr. HEKMAT HUSEIN ZARIFA HASSO, Vice Manager, said: "We want to give my thanks to the organizer for their thoughtful arrangement. Those presentations and study visits are very valuable to us. Please allow us to extend our gratitude to the sponsor, the Chinese government and the organizer, HRC and all the participants in the same field. On behalf of the Ministry of Water Resources of Syria here, we would like to give HRC a gift to express our thanks to HRC for their contribution in the field of water resources for our developing countries."

▲ Old trainee with HRC's staff

Mr. HENG SOKKUNG, Under Secretary of State, Ministry of Industry, Mines and Energy of Cambodia, said: "There are no words to express my gratitude for HRC and the sponsors. I arrived here 9 days ago and I feel very good. I would like to extend my gratitude to the Chinese government, the sponsor of the seminar, as well as to Director Cheng of HRC, the organizer. I benefit a lot because I have learned a lot of new knowledge. I also believe that China will be the most powerful country in the world. I hope to establish a far-reaching cooperative relationship with China and welcome Madam Cheng and her team to come to Cambodia for more projects cooperation." Applauses aroused when Mr. HENG SOKKUNG said that “I hope I am the last speaker."

Several Ministers gave gifts and souvenirs to HRC.

Finally, on behalf of the organizer, Director Cheng Xialei extended the congratulation to the complete success of the seminar. She expressed her sincere gratitude to all the officials for their kind understanding and support to our work, and thanks also went to the Taihu Basin Authority, MWR, for their good arrangement for our stay in Shanghai. She hopeed to promote the communication, deepen mutual understanding and strengthen the friendship through this seminar. She also expected to make further contribution to the effective utilization of water resources and sustainable development of small hydropower in the world based on joint efforts and more cooperation.

Site visiting to Three Gorge Project

The farewell banquet began, and the hosts and guests gave a toast to the complete success of the seminar. A video "A Moment in Time" prepared by HRC was played during the scene of the farewell banquet. The ministers and officials, who had been serious and worked intensively, felt at home and relaxed with those wonderful and warm moments and melodious Chinese folk music in the video. Here found their good memories in China. They were very excited by the beautiful and magic night view of the two sides of Huangpujiang River. This was not only a seminar, an

▲ Visit to Jinhua Hydropower Manufacturer

academic and technological exchange platform, but also a witness to the mutual help between China and other developing countries and the strengthening friendship. Officials hug each other, drank toast after toast and took pictures during the closing ceremony.

The friendship is so rare and so precious. This is a moment to remember for the Huangpu River, for China and the world. Our friendship is everlasting and unchanging.

The leaders from Taihu Basin Authority, including Mr. Lin Zexin, Deputy Director, Mr. Wu Zhiping, Deputy Chief Engineer, Mr. Jia Genghua, Chief of Division of Foreign Affairs, Science & Technology, also attended the closing ceremony and the farewell banquet. The chiefs of Division of Foreign Affairs & Training, Division of International Cooperation, Science & Technology, New-Tech R & D Center for M/S hydro of HRC, Mr. Pan Daqing, Mr. Li Zhiwu, Mr. Zhao Jianda and Mr. Lin Ning, as well as other HRC staff members were present at the closing ceremony and the farewell banquet as well.

During the study visit in Shanghai, all the participants of the seminar visited the Suzhouhe Tide Gate, Shanghai Municipal History Museum, the Oriental Pearl TV Tower and the Bund.

(Source:HRC) ■

▲ Sight-seeing on West Lake in Hangzhou

SHP Training Opportunity by HRC for 2012

No.	Name of the Training	Date	Working language	Fee
1	Training Workshop on Small Hydropower Technology for Developing Countries	23 May - 6 July	English	Fellowships could be provided, including international airfares, boarding, lodging, local transportation and etc. Those interested may contact & apply from Commercial Office of the Chinese embassy in your country
2	Seminar on Rural Electrification for Developing Countries	30 August – 26 Sept	English	
3	Formation sur la Technologie de Petite Centrale Hydroélectriques pour les Pays d'Afrique francophone	Du 18 Oct au 28 Nov,	French	

30th Anniversary Celebration and New Year Ceremony of HRC

Snow flakes bid farewell to the old year, reminding people of the harmonious past of HRC; the golden dragon ushers in the Chinese new year, while celebrating the 30th anniversary of the founding of HRC.

On 14th January, 30th Anniversary Celebration and 2012 New Year Ceremony of HRC were held in Hangzhou. Over 190 people happily gathered together to have a review on HRC's development during the past 30 years, as well as to celebrate the coming New Year.

Mr. Zhang Jianyun, president of Nanjing Hydraulic Research Institute (NHRI) gave a passionate speech. On behalf of NHRI, he conveyed his sincere greeting and heartfelt thanks to HRC staff and wished all the retired staff, HRC leaders and staff members a happy new year. In Mr. Zhang's speech, he pointed out that HRC has done a lot for the international cooperation of small hydropower and provided effective technical service and support for development of domestic rural hydropower and electrification program after its creation. HRC made remarkable achievements in various aspect of work in the past 2011. Firstly, the total output of scientific research and development reached RMB 150 million Yuan, hitting a new record. Secondly, HRC gained a growing influence both at home and abroad, especially after the successful implementation of Ministerial Seminar on Water Resources and Small Hydropower for Developing Countries which was highly praised by Ministry of Water Resources. Thirdly, it is not easy for HRC to keep stable development in world market during the period of economic recession. Fourthly, HRC staff members put on a brand new image with full energy and vitality. At last, President Mr. Zhang Jianyun wished everyone be healthy and lucky in the new year, and hoped that HRC could make more outstanding achievement in 2012.

At the ceremony, HRC Director Ms.

▲ A publication of HRC's 30-year chronicle

Cheng Xialei, HRC's honorary director Mr. Zhu Xiaozhang delivered speeches respectively and expressed their best wishes for the New Year.

All the divisions, league branch, retired staff and HRC leaders prepared wonderful performances such as dancing, chorus, solo, playing saxophone, Kunqu opera, playing Chinese violin, etc, as well as playing games and lottery.

Stars twinkled that night and the new year was stepping in soon. With expectation and passion, we are anticipating a bright future. The ceremony ended with the dance named "Getting Better and Better".

(Source:HRC) ■

▲ President of NHRI Mr. Zhang Jianyun gave a passionate speech

▲ Director Ms. Cheng Xialei delivered a speech

▲ HRC's honorary director Mr. Zhu Xiaozhang delivered a speech

The Second "China Forum on SHP" Held in Beijing

On October 12, 2011, sponsored by the Hydro Power Committee of Chinese Hydraulic Engineering Society, the Small Hydro Power Committee of China Society of Hydropower Engineering and the National Institute of Rural Electrification, the International Center of Small Hydro Power co-organized the second "China Forum on Small Hydro Power" with "small hydropower and improving people's livelihood" as the theme in Beijing. Mr. Tian Zhongxing, Director of Bureau of Rural Hydropower and Electrification Development (BRHED), Ministry of Water Resources, attended the forum and delivered keynote speech "Bearing New Mission to Realize New Development". Members of China Society of Hydropower Engineering attended the meeting.

As an affiliated organization of SHP Committee of China Society of Hydropower Engineering, HRC organized and implemented the forum.

After the meeting, the Xinhua net of Xinhua News Agency, Guangming Daily, China Economic Herald, China Energy News, China Water Resources News and other mainstream media and websites competed to report the forum, which affects widely.

(Source:HRC) ■

World Bank Project Undertaken by HRC Passed the Acceptance

World Bank Project Undertaken by HRC Passed the Acceptance

On May 18, 2011, China Renewable Energy Scale-up Program (CRESP) "Researches on the Refurbishment Technology of Zhejiang Small Hydropower Stations" undertaken by HRC passed the acceptance organized by Zhejiang Hydropower Management Center, and the representatives from CRESP office attended the acceptance meeting.

The project team completed three reports, including the Analysis Report on Operation Status of Hydropower Stations over 20 Years, the General Decision-making Model for the Refurbishment of Zhejiang Hydropower Stations, and the Technical Research Report on Hydropower Stations Refurbishment, the research achievements of which will efficiently promote and guide the refurbishment of Zhejiang hydropower stations in the next stage.

(Source:HRC) ■

Seize the Opportunity to Carry out Cooperation *in Africa*

Following the further development of the Sino-Africa new-type strategic partnership, with the purpose of strengthening the cooperation and exchange between African countries and HRC, at the invitation of the minister of Republic of Congo Ministry of Energy and Hydraulics, HRC Division Chief of International Cooperation, Science &Technology, Mr.Li Zhiwu, staff member of Division of Foreign Affairs & Training, Ms Shi Jin, together with their partners—leaders and experts of Shanghai Electric Group Co., Ltd. conducted an investigation on water conservancy and hydropower projects in Congo(Brazzaville) from April 30th to May 16th .

Congo (Brazzaville), i.e. Republic of Congo is located in the Midwest of the African continent, with the equator traversing its midland. It covers an area of 342 thousand square kilometers with a population of 4.2 million. In Feb. 22, 1964, Congo (Brazzaville) established diplomatic relations with China. Congo (Brazzaville) is rich in water resources and has more than 100 rivers, most of which belong to the Congo River system. Numerous tributaries and branches of Congo River form a dense water network system, which can be well developed and utilized. At present, the political situation in Congo (Brazzaville) is relatively stable, and the electricity supply for industry and household is insufficient with the antiquated power supply system. There is a great demand in electricity.

On May 3rd, the minister of Energy and Hydraulics of Republic of Congo met our delegation cordially and discussed on the cooperation in the field of power energy. The minister expressed his gratitude to HRC for having cultivated small hydropower professionals for Republic of Congo and welcomed HRC representatives to conduct inspection in Congo (Brazzaville), hoping Chinese SHP technology can be contributory to Congo (Brazzaville) in the construction of power projects and the bilateral cooperation between China and Republic of Congo can be sustained. A memorandum of cooperation concerning reconstruction of urban power grid and SHP projects was signed.

Taking this opportunity, HRC representatives paid a visit to the former participants of international training workshop. The participants said that what they had learned in HRC was very useful in their daily work. They would be very supportive of HRC's follow-up work in Congo (Brazzaville) and actively promote and facilitate the relevant cooperation.

This visit to Africa is very conductive for HRC to further develop African market, and it is significant in improving HRC's influence on African market, and seizing the opportunities to carry out cooperation with the peers in Africa.

(Source:HRC) ■

Three Hydropower Projects Commissioned *in Vietnam*

Thai An 220 kV Substation in Vietnam designed by HRC's affiliated company, Zhejiang Zhongzhou Planning & Design Co., Ltd. for Water Conservancy and Hydropower, was connected to Vietnam National Grid for operation on September 29, 2011.

Thai An 220 kV Substation is equipped with an OSFSZ10-160 MVA/220 three-phase auto-coupling transformer, with rated capacity of 160/160/50 MVA and transformation ratio of 225±8×1.25%/115/10.5 kV.

The major function of this substation is to step up the power generated by Thai An Hydropower Station and THUAN HOA Hydropower Station to 220 kV and make it connect to Ha Giang 220 kV Substation of Vietnam and further to Vietnam National Grid.

Thai An Hydropower Station designed by Zhejiang Zhongzhou Planning & Design Co., Ltd. for Water Conservancy and Hydropower, was officially put into grid-connected operation on September 29, 2011.

The main objective of the project is power generation. The design water head of the power station is 186 m, equipped with two vertical Francis turbines with the installed capacity of 2×50 MW. The normal capacity of the reservoir is 3,540,000 m^3, and the total capacity is 6,300,000 m^3.

Thai An Hydropower Station is a key project of Ha Giang Province, Vietnam. Its successful connection to the grid for power generation effectively relieved the shortage of power supply in northeast part of Vietnam.

Muong Hum Hydropower Station in Vietnam, designed by Zhejiang Zhongzhou Planning & Design Co., Ltd. for Water Conservancy and Hydropower, was connected for power generation officially on 18th April 2011.

With designed head of 110 m, two vertical Francis units and installed capacity of 2×16 MW, the project has the main objective for generation. The reservoir is constructed with the normal capacity of 1.91 million m^3,and a total volume of 2.14 million m^3.

Muong Hum Hydropower Station is a key project in Lao Cai Province, Vietnam. The successful grid-connected electricity generation of this project had effectively mitigated the power supply shortage situation in the north-western area of Vietnam.

(Source:HRC) ■

A LETTER FROM CAMBODIA

Monday, November 7, 2011

H.E.Professor CHENG Xialei
Director General
National Research Institute for Rural Electrification
Hangzhou Regional Center (Asia-Pacific) of Small Hydropower

Dear Madame Professor:

On behalf of my colleague Mr. Pan Narith, Chief of Hydroelectricity Project, and on my own self, I wish to express my deepest thanks and gratitude to Madame Professor and all your colleagues, Mr. PAN Daqing, Mr. LI Zhiwu, Mr. LIN Ning, Mr. ZHAO Jianda, Ms. SHEN Xuequn, Ms. SHI Jin, Ms. TANG Yanqiu, Ms. ZHOU Qunfeng, who provided us a very warmed welcome and great arrangement during our stay in the beautiful cities, Hangzhou, Yichang and Shanghai of China.

The Ministerial Seminar on Water Resources and Small Hydropower for Developing Countries, which was organized by National Research Institute for Rural Electrification (HRC) and sponsored by Ministry of Commerce and Ministry of Water Resource of the People Republic of China has just successfully and fruitfully finished, and were very meaningful and crucial to grant a great chance for the developing countries, to get more understanding of China new technologies and know-how which protect environment and harmonize to nature and with these always updated technologies, I do hope that China will become the most powerful country in the world in a very near future.

Last but not least, I would like to take this opportunity to wish you and your colleagues all the best and success in all your noble mission and I also wish our bond of historical friendship, solidarity and cooperation between our two countries and peoples are constantly strengthening and expanding. I really hope to welcome you and your team in Phnom Penh for small hydropower and other projects in the upcoming future.
Please accept, Madame Professor, the assurances of my high considerations and esteems.

HENG SOKKUNG
Undersecretary of State
Ministry of Industry, Mines and Energy
Kingdom of Cambodia
Nation Religion King