# Strategic Measures and Incentive Policies of SHP in China

Hangzhou Regional Center(Asia-Pacific) for Small Hydro Power

**1. Corresponding development of equipment manufacture**

At the primary stage of SHP development (1960s～1970s), wooden or iron-wooden turbines manufactured by agricultural machinery works were mainly adopted in China. Before 1949, SHP equipment was generally imported due to lack of domestic manufacturing capability. In 1952, the first turbine-generator unit of 800 kW capacity was successfully made in China, followed by further production of 10,000 kW units in 1954. However, the supply of electromechanical equipment was still insufficient then. In some places, water pumps and motors were retrofitted to replace turbines and generators, while bamboo and wooden pipes were used to substitute for steel pipes.

**In the 1960s,** more than ten professional factories for small-sized turbines were set up across the country, with a total production capacity of 100,000 kW. For turbines, a metal structure was mainly adopted.

Since the Chinese type-series of small-sized turbines was first issued in 1965, production of medium and small sized units has become standardized. Revised and supplemented in 1978 and 1992 respectively, it includes two types of runners, i.e. axial-flow (propeller ZD & Kaplan ZZ) and Francis (HL). The type-series, as the foundation of serialization, generalization and standardization, specifies the series of turbine, runner types and the main parameters of the turbines. It is not only an important basis for type selection, variety development and new product research, but also a significant technical standard. With the turbine type-series, more demand can be met with a few, rational number of products, thereby simplifying design and manufacture, facilitating large-scale production, ensuring product quality, reducing costs, and shortening production cycle as well as simplifying things for end-users.

Up to the 1970s, the number of the factories specialized in production of turbines and auxiliaries increased to over 60 nationwide, with a total annual production capacity of 1,000 MW. The unit capacity of serialized turbines ranged from 250 kW to 12,000 kW.

**In 1978,** China began to unify the design for small-sized turbines, which led to the unification of diagrams, standardization and universalization of the components. Taking advantage of the existing products, and adopting newly developed runners, the unified design improved the design efficiency of the products. In addition, it increased the proportion of standardized and universal fittings, and thus facilitated production, operation and maintenance.

Stepping into the 1980s, China owned more than 100 SHP equipment manufacturers, with a total annual production capacity over 1,500 MW. Meanwhile, a great number of local township enterprises also had the capability of producing SHP equipment. With respect to standardized turbines, there were 26 modes and 83 types, with water head ranging from 2.5 m to 400 m, and unit capacity from several kW to 12,000 kW, which could be adapted very well to various site conditions. Up to 1993, some more advanced runners were included in the type-series, indicating that the parameters and performance of Chinese SHP equipment has reached a relatively high level. The performance and parameters of two kinds of runners, axial-flow (propeller ZD & Kaplan ZZ) and Francis (HL) included in the Chinese turbine type series are shown in Table 1.

Owing to the implementation of serialization and standardization, the production cost of small-scale hydro turbines is reduced, and the ordering and production cycle time can be shortened. Meanwhile, it can also promote the standardization of some cascade or neighbouring hydropower stations, so as to adopt the same type of turbine-generator set and significantly lower the cost. Though the efficiency of small hydro turbines in China is 1%~3% lower than that of Western countries, for small rivers and small stations, it is totally worthwhile to obtain more benefit from a great price reduction even with slight loss in efficiency. That is also the reason why more and more SHP stations in American or European countries would like to adopt Chinese-made turbine-generator units.

In order to coordinate and cooperate among the design department, the construction unit and the manufacturing organisation, and to unify their understanding about the equipment manufacturing and opera-

**Table 1 Performance and Parameters of Chinese Small-Sized Turbines (Axial-flow & Francis)**

| Water head (m) | Runner type | Optimized working condition | | | Operating limits | | | |
|---|---|---|---|---|---|---|---|---|
| | | Unit speed ($n'_1$ r/min) | Unit discharge ($Q'_1$ $m^3/s$) | Efficiency (η %) | Specific speed ($n_1$ m. kW) | Unit discharge ($Q_l$ $m^3/s$) | Efficiency (η %) | Cavitation coefficient ($\sigma_M$) |
| 3~8 | ZD760 | — | — | — | — | — | — | — |
| | ZZ600 | 142 | 1.03 | 85.5 | 552 | 2.0 | 77 | 0.7 |
| 6~15 | ZZ560a | 140 | 1.06 | 89.0 | 569 | 2.0 | 84.2 | 0.83 |
| 12~22 | ZZ560 | 140 | 1.08 | 88.3 | 554 | 1.9 | 84.0 | 0.71 |
| 18~30 | ZZ500 | 128 | 0.98 | 89.5 | 479 | 1.65 | 86.7 | 0.585 |
| 26~40 | ZZ450/D32a | 120 | 0.92 | 90.5 | 430 | 1.5 | 87.3 | 0.54 |
| 20~45 | HL240 | 72 | 1.10 | 91.0 | 240 | 1.24 | 90.4 | 0.2 |
| 35~60 | HL260/A244 | 80 | 1.08 | 91.7 | 263 | 1.275 | 86.5 | 0.15 |
| 50~80 | HL260/D74 | 79 | 1.08 | 92.7 | 261 | 1.247 | 89.4 | 0.143 |
| 70~105 | HL240/D41 | 77 | 0.95 | 92.0 | 239 | 1.123 | 87.6 | 0.106 |
| 90~125 | HL220/A153 | 71 | 0.955 | 91.5 | 218 | 1.08 | 89 | 0.08 |
| 110~150 | HL180/A194 | 70 | 0.65 | 92.6 | 180 | 0.745 | 90.5 | 0.078 |
| | HL180/D06A | 69 | 0.69 | 91.5 | 185 | 0.830 | 87.9 | 0.053 |
| 135~200 | HL160/D46 | 67.5 | 0.548 | 91.6 | 160 | 0.639 | 89.4 | 0.045 |
| 180~250 | HL120 | 62.5 | 0.32 | 90.4 | 113 | 0.38 | 88.4 | 0.063 |
| | HL110 | 61.5 | 0.313 | 90.4 | 110 | 0.38 | 86.8 | 0.055 |
| 230~320 | HL90/D54 | 62 | 0.203 | 91.7 | 94 | 0.266 | 87.8 | 0.033 |
| 300~400 | HL90/D54 | 62 | 0.203 | 91.7 | 94 | 0.266 | 87.8 | 0.033 |

tion of SHP equipment, China is organizing the compilation of "The Parameters of Small-scale Hydro Turbine Types and General Technical Conditions", "The Basic Technical Conditions of Small-scale Hydro Turbines" and "The Norms of Acceptance Test for Small-scale Hydro Turbines" for issuing as national standards. These technical documents summarizing decades of experience will bring equipment selection for China's SHP to a new stage of development.

In recent years, thanks to the development of computers and simulation technology, as well as stimulation from the market-oriented economy, more updated runners with better performance and parameters have been successfully designed and adopted, with application of the binary and quasi-ternary CAD system for Francis, as well as the CAD system with singular point distribution method for axial-flow turbines. Usually, these newly developed runners are numbered according to the serial code of the research institutions and then successively applied for production. Optimization calculations have been undertaken for the main turbine components, including their structure, shape and dimensions; stainless steel runners with high anti-cavitation and abrasion-resistance have been adopted; the panel for the hydro-generator pole made of high strength material 20Mn5 has been developed to increase its low temperature and rupture tenacity; the elastic metal-plastic pad for thrust bearings with high anti-abrasion and low friction factor has been adopted, making possible operation at extra low speeds, and meeting the demand for cold or hot starts, thus ensuring safe and reliable operation, resistance to pad damage during repair and maintenance and high load-bearing capacity; and the fan-less ventilation system with the feature of low ventilation-loss is used to seek higher efficiency. In addition, more new technology, new material and new processes have been developed and applied, including the parallel box stay ring and circular diversion ring box stay ring; thermopress shaping of runner blades; welding technologies for special type steels used for runners; new assembly processes for the main shaft; and a new process for on-site stacking and assembly of a full circular stator core.

The production of governors has been standardized. With 8 grades of regulating capacity, i.e., 3000, 1800, 1000, 600, 300,150, 75, and 35 kg-m, the governors can be classified into micro or small by capacity. For micro governors, there are 4 types, i.e. TT35, TT75, TT150 and TT300, all of which are electro-hydraulic, with pressure produced directly by an oil pump. For small governors, there are 3 types, i.e. YT300, YT 600 and YT1000, all of which are electro-hydraulic with a pressure oil tank. Besides the small-scale mechanical or electrical ones, microprocessor-based governors have been applied in SHP stations in recent years, of which, a kind of advanced computerized governor with high oil pressure proportional control valve has been newly developed. With respect to this device, the guide-vane servomotor is operated directly through control of a proportional valve, which improves reliability and stability, and avoids possible dead zones or failed action of the mechanical lever because there is no mechanical drive structure inside; and the air vessel energy storage system has been adopted, which reduces investment and facilitates maintenance since there is no high pressure gas system in the station. Inlet valve types include gate valve, gravity butterfly valve, and ball valve and back valve.

With respect to the small generator, there are two series (SF and SFW) serving the present market in China which match the small turbines, with 16 frame dimension numbers and 280 varieties in total, and capacities ranging from 5 kW to 10, 000 kW. SF and SFW indicate units with vertical main shaft or horizontal main shaft respectively. For vertical units, the capacities range from 5 to 10,000 kW, while the horizontal ones are generally below 5,000 kW. There are two voltage grades for small generators, i.e. low voltage of 400 V and high voltage of 6.3 kV. Generators with capacity below 500 kW are usually of low voltage. So far, unified design has been undertaken in China for units of SF and SFW series.

The governor, exciter, control and protection panel, switchboard, automation components as well as valves, are included in the auxiliaries of the SHP units. The series standards and quality stipulations have been formulated in China to facilitate product selection or purchase by power station designers or users. To reduce costs for low voltage units with capacity below 500 kW, electrical/manual or simple hydraulic operators are sometimes adopted to substitute for automatic governors which have a complex structure. Integrated utilization of electrical/manual operator or simple hydraulic actuator with micro computerized controllers enables the units to be automatically controlled, leading to reduction of attendants or unmanned operation for the SHP station.

Micro packaged units refer to those with unit capacity below 100 kW and whose turbine, generator and intake valve are assembled together as an integrated unit. The feature of the packaged unit is its simple structure, generally with removal of the complex guide structure. Sometimes, asynchronous generators are used instead of synchronous ones. Thanks to its reliable performance, convenient operation and low price, packaged units are considerably applied in South China, and contribute to the development of local water resources, and meet the electricity demands of dispersed farmers. There are several dozen kinds of conventional packaged units, including Francis, propeller, tubular and Turgo, with water head ranging from 1.3 m to 100 m.

**2. Training of professionals**

A great deal of effort has gone into the training of professionals. In many colleges and universities nationwide, special enrolment is offered in order to nurture technicians for development of rural hydropower and construction of the power grids. In particular, a large number of qualified people so far have been trained in the College of Rural Electrification, Hohai University and others, to meet the demands of rural electrification. Meanwhile, specialized training schools in each county have made great contributions to the training of skilled workers by combining theory and practice.

**3. Basic stimulating and protection policies**

During decades of SHP development in China, especially since constructing the hydropower-based primary rural electrification counties, a variety of preferential policies and measures have been carried out to promote SHP development. The policies and measures are varied at different stages.

*(1) In the 1950s*

After the founding of the People's Republic of China in 1949, the national economy began to recover and the government focused much attention on power supply in rural areas. A special authority on SHP was set up in 1953. "To emphasize water conservancy and bring along SHP development" was the main policy concern then.

The principles of "three focuses" and "dual-purpose SHP for motive power and for lighting" have been carried out, i.e. "focusing on small scale and commune-run hydropower, utilizing SHP as a source for both motive power and lighting, and emphasizing construction and management simultaneously. It calls for overall planning, integrated utilization, hard work and high efficiency."

*(2) In the 1960s*

In 1963, the Rural Electrification Bureau, with approval of the Central Government, was set up under the original Ministry of Water Resources and Electrical Power. A series of policies and measures on SHP development was put forward, embodied as: To develop rural power grids and rural SHP simultaneously, focusing on the base of commercial foodstuff and cotton, to put emphasis on electricity for irrigation and drainage and to use power from the grid as the main supply.

To enforce the principle of "adjustment, reinforcement, enrichment and improvement". In order to strengthen the role of SHP and arouse people's enthusiasm to develop SHP, relevant measures were adjusted and implemented from 1961 to 1963. The investing structure was "Investment to be shared by three parties, i.e. country, local authority and commune", and with the approval of the Ministry of Finance, the policy of "further developing SHP with benefits from existing stations" began to be undertaken then.

*(3) In the 1970s*

During this period, the development of SHP was based on the principle of "focusing on small scale, commune-run and local manufacture of equipment", and provided power supply for irrigation and drainage, production and repair of agricultural machinery, processing of agricultural by-products, meeting the electricity demand from county/ commune-owned industries and farmers' daily living and lighting needs. In order to deal with new problems arising in the development process of the power industry and SHP, corresponding policies and measures were further formulated.

Firstly, the definition of SHP was put forward, with the proposed planning principles. Those hydropower stations or transmission/transformer projects with unit capacity no more than 6,000 kW or installed capacity no more than 12,000 kW were called SHP. With respect to planning, the principle of "overall plan, comprehensive conservancy and combined water control and power supply" was undertaken.

The construction and management system was clarified. It required attention and investment on SHP from administrations at all levels, i.e. county, commune and brigade with the preferential policy known as "3-selfs", i.e. "self-construction, self-management and self-consumption".

The policy on investment was characterized by depending mainly on local financing, with appropriate financial support from the central government. Stations with unit capacity below 500 kW were usually built by the communes and brigades, with special subsidies earmarked by the central government from the public allocation for small-scale farmland water conservancy, which came to about 150-200 Yuan per kW on average, i.e. equal to 20% of the total investment; other stations above 500 kW were mainly constructed by municipalities and counties. With checking and approval of the provinces, these would be listed in the local development plan for water resources and electric power infrastructure, with funding coming mainly from local mobilization, and with 40%-60% of the total investment aided by the central government. The equipment needed was listed under planned supply.

The policy encouraged SHP to be integrated into the power grid. The relation between the large and small power grids was detailed as: the large power grid should make a contribution to agriculture and give support to SHP's integration; the property rights of SHP stations should not be changed after the integration and making a profit should not be the aim when setting the purchasing price for the SHP absorbed by the large grid.

*(4) From the 1980s*

In order to speed up the development of primary rural electrification, a series of related government policies have created a favorable environment for SHP.

*a. Policies on development*

The policy of "focusing on local capability with assistance from the central government" was carried out, to encourage enterprises or individuals to be involved in SHP development. It was characterized by "self-construction, self-management and self-consumption", which means that those who invested in SHP stations would get the benefits from the station.

— Self-construction

That is to allow and encourage the local governments and the local people, who were full of enterprising spirit, determination and self-independence, to plan and construct local SHP stations by themselves with local capability, local resources, local technology and local material. The funds were also mainly raised by local mobilization, and in some places, even the SHP equipment concerned was produced locally.

— Self-management

That means that those who invested in SHP would have the ownership of these stations. It avoided administrative interference in re-allocation of assets, and protected the enthusiasm of local governments for developing SHP. Therefore, the SHP managerial system that operated was quite advanced, as it could be regarded as an embryonic form of today's market economy.

— Self-consumption

That means that the electricity generated by the SHP station was usually mainly supplied to meet local demand. It required that SHP should have its own supply area, and a unified SHP market of electricity generation, supply and consumption should be established. In order to carry out the principle of "self-consumption", the government stipulated that large power grids should support SHP financially and ensure supply areas for SHP. After integration into the large power grid, the original SHP property rights, affiliation and financial system should not be changed, with the approval authority for construction of SHP within the local grid and transmission or transformer facilities remaining with the local hydropower authority. After integration, electricity exchange between grids operated as mutual supply or bulk sale, i.e. supply was balanced by using the self-supply capability of the small grid. If the small grid capacity was greater than the load for more than half a year in any one year and was able to supply to the large grid, then it was to be regarded as mutual supply, and the small grid could enjoy the same sales and purchasing prices as the large grid. Otherwise, a price based on bulk sale would be implemented on a quarterly or monthly mutual balance basis; the large grid should not directly develop load for direct supply within the area of the small grid, i.e., whoever supplies electricity should also be responsible to the users.

The principle of "3-selfs" was regarded as the core of SHP policies in China. During many years' practice, the government stuck to the principle of "3-selfs" and formulated a corresponding series of preferential policies for local exploitation of SHP, thereby creating a SHP development system with Chinese characteristics.

*b. Policies on investment*

The central government granted subsidies and special loans for developing SHP and rural electrification. With the policy of "Electricity supports electricity", all the profit from SHP stations and local power grids could be exempted from tax and used for reinvestment in SHP. In the year 1996 alone, profits from the stations used for further developing SHP nationwide reached 480 million Yuan. Nearly 20 years' implementation bears witness to the fact that this policy has played a significant role in SHP development. With financial support from local governments, Rural Hydropower Development Funds were established, and in rural areas with power supply from SHP, 0.02 Yuan per kWh used was levied for these Funds.

*c. Policies on tax*

Before implementation of the new tax system in 1994, only 5% of the profits from a SHP station were levied as a product sales tax. Since 1994, the policy of 6% value-added tax was levied for SHP, versus that of 17% for large hydropower and large grids. With respect to income tax, 33% of the company profits were stipulated to be levied, however in some provinces, half of this, and in some cases, even the full amount, would be refunded to the stations. These policies were more preferential than those for large hydropower stations.

*d. Policies on mobilization*

The farmers took great interest in SHP construction, and it was common to convert the labour contributed by the farmers into funds. Some counties set the regulation that every farmer had the duty to make a contribution in developing hydropower and communal facilities, say, no less than 8-10 working days each year. During the construction of hydropower stations and power grids in some counties, the work contributed by the farmers could be converted into investment in kind in the form of shares.

*e. Policies on loans*

Central government and local governments at all levels granted low-interest loans amounting to several hundred million Yuan for SHP construction, for which the repayment period was around ten years.

**4.Other preferential policies**

In recent years, following in-depth institutional reform, reforms in the power system and the "unified price after reconstruction of rural power grids and refurbishment of high-loss transformers", a series of preferential policies have been issued.

*(1) Making full use of the policy of "converting debt into equity" and the policy of "granting subsidised loans for technical rehabilitation of enterprises"*

Since the government stressed the development of the central and west regions and support the minority autonomous regions with preferential policies, more new policies are expected to come out, including "subsidised loans", "extending the loan repayment period", "collateral electricity fee ", "adjustment funds for loans and interest repayment for rural power grid construction or rehabilitation", "fund for development of hydropower and rural electrification", "partial allocation of the local portion of value-added tax", "two-year exemption and three-year reduction of income tax", and "separation of old and new accounts with zero interest for the old ones".

*(2) Attracting more investment and financing*

*a*. According to the financial forecast for the construction of hydropower-based rural electrification counties or regions (including the Green Development Plans, such as "replacing firewood by electricity", for the promotion and protection of the ecological environment), a special financing of 1,000 million Yuan for construction, and a special policy loan of 4,000 - 6,000 million Yuan are expected to be issued annually by the central government. The Bureau of Rural Hydropower and Electrification Development, Ministry of Water Resources, its affiliated economic entities, and the related provincial (regional, municipal) hydropower groups or companies are authorized, in coordination with the State Development and Reform Commission, Ministry of Finance and banks, to be in charge of the supervision, management and operation of the loans, and their rolling utilization.

*b*.With respect to the construction of state-owned hydropower stations, financial institutions at all levels should contribute to a reasonable proportion of the required capital investment. For projects which combine flood control, irrigation and water conservation, a reasonable allocation from the water resources budget should be used as investment capital.

*c*.The principle of "basin development, cascade development, rolling development and integrated development" should be observed, and a mechanism to promote the growth and development of basin power corporations and basin hydropower groups should be set up. Relevant investment policies have been formulated for compensating headwater reservoirs, and improving the regulating capacities of cascade stations during dry or wet seasons. Usually the first station of the cascade hydropower development is invested directly or mainly by the central and local governments, and then the benefits from it would be used for further cascade development, i.e. being the parent entity of the cascade stations, the first station would be in charge of further rolling development.

*d*.Shareholding or joint-stock hydropower stations should be developed enthusiastically. Actively broaden the ways to go to the stock markets for issuing bonds and seeking financing, meanwhile, pay attention to attracting foreign investment in hydropower.

*(3) Carry out the principle of "focusing on the large", and seek multi-forms of realizing public ownership*

*a*.Promote the rational flow and restructuring of state-owned assets, magnify its function, and improve its capability to control, influence and act as a role model. Guided by the market and interlinked by their assets, numerous hydropower groups of various forms and various scales have been formed. The emphasis is on the establishment of provincial hydropower industrial groups, the implementation of proper asset restructuring, and structural adjustment and system reform. The enterprises are expected to enhance their capabilities in capital management, science and technology development, and market competition and risk management.

*b*.A variety of flexible measures have been taken to invigorate the local state-owned hydropower enterprises, such as restructuring, recombination, merging, lease, contracted marketing, joint-stock system or sale. "Sale" is restricted to the non-key power stations, and should be carried out only in accordance with the relevant national regulations.

*(4) Strengthen the building up of a legal system, and normalize the trading in power and the related supervision mechanism*

*a*.Fully carry out the "Law on Electric Power". Guided by the related economic sectors, the Ministry of Water Resources actively carries out its duties according to the law, focusing on the checking, ratifying and demarcation of the power supply areas for the local grids, and the supervision and checking of issues related to power supply or consumption, with the aim of preventing vicious competition and providing better services for the users. Great efforts are made to promoting entities with multi-legal persons, and the growth of the power market with orderly competition

*b*. With respect to those power supply businesses which have been awarded a business license after being checked, ratified, and allocated a supply area, the related rights and benefits should be ensured with no infringement according to law.

*c*. Strengthen the building up of the legal system and the rule of law to fight against monopoly and unjust competition; set up and normalize the trading in power and the supervision mechanism to ensure the sound development of medium and small hydropower in the poverty-stricken rural areas. The medium and small hydropower enterprises integrated into the large power grid in the central, west and autonomous regions should have guarantees they can mainly operate based on the principle of "self generation and self consumption", however, any surplus should be integrated into the grid and any deficiency should be supplemented by the grid. "Self-consumption" must not be restricted. The station should not sell to the grid at a low price, nor should it be forced the buy high price power from the large grid.

*d*. Establish a rational scientific mechanism for electricity pricing, which enables the price to really reflect the value, the relationship between demand and supply as well as fair treatment. It is expected to lead to lower electricity prices in rural areas, peak and off-peak period pricing, implementation of the system of pre-purchase of electricity, guaranteed electricity payment and to promote commercially-minded management.

*e*. Closely study the proposal of the World Bank to implement the policies for poverty-alleviation and development and offer electricity subsidies to low-income households in the central and west regions and other poverty-stricken rural areas.

*(5) Deepen the reforms and reinforce management*

*a*. During the process of the institutional reform of local governments, based on the main functions and responsibilities assumed by the Bureau of Rural Hydropower and Electrification Development, MWR, and according to the principles of "To seek high efficiency and perfection, to unify responsibility and power, to unify construction and management", attention has been focused on the adjustment and reform of the hydropower administrative institutions in the field of water resources, the implementation of hydropower-based rural electrification, the institutional reform of the rural electrical system, the rehabilitation of the rural power grid, and unifying the power grid and power prices so that they are the same for both urban and rural areas.

*b*. With authorization from the government, the water resources sector has been confirmed as the representative of the investor for state-owned water resources and hydropower assets. A system for the investors has been established, and they are exercising their responsibilities to ensure the safety, integrity and increase in value of the state-owned water resources and hydropower assets. Efforts are being made to set up and improve the system of supervision and management of the state-owned water resources and hydropower assets, and supervision and management of property rights are carried out by the relevant authorities of the water resources sector and its related entities (Groups or Holding Corporations).

*c*. Management of the industry is to be strengthened through the following concrete means: (a) reinforce the formulation of planning programming, principles and policies as well as emphasising overall arrangements, coordination, supervision and checking; (b) actively nurture the interconnecting relationship of property rights within the industry and gradually strengthen the significant role of property rights linkages; (c) intensify the building up of industry associations so they can fulfil their roles of networking, advising, research, consultancy and providing other services.

*d*. Establish a modern enterprise system, with rational integration of the reform, reorganization, restructuring and strengthening of the management; set up and improve administrative institutions for legal person governance, define responsibilities and the related 'checks and balances' mechanism; improve the various bylaws, reinforce work at the grassroots and improve the quality and talent of the employees; stick to the principle of " safety first and quality first", put emphasis on professional management, cost management and quality management, realize the safe and civilized production and management of electricity supply.

*e*. Strengthen the auditing and supervision of the economic activities of the enterprise, reinforce awareness of the law and the concept of creditability, and run the business in compliance with the law; establish and improve the mechanisms for giving incentives and restraining business managers, set up a system for tracing responsibility when mistakes are made in decision-making; establish a compensation system integrating "pay according to work" and "pay based on production element", based on the principle of efficiency first and also taking into account fairness. ■

## "Report on the Development and Major Issues of the Small Hydro Power in the Asia-Pacific" Completed

The report (around 80,000 Chinese characters) on the development and major issues of small hydropower in the Asia-Pacific has been completed by HRC recently.

While focusing on Asia-Pacific developing countries, it also refers to some developed and developing countries worldwide. The report mainly covers: 1) Small hydropower resources, development conditions and prospect in various countries; 2) Significance of incentive policies; 3) Analysis on the macro & micro benefit from the small hydro power both in theory and practice; 4) Public-private participation in the development of small hydropower in China and internationally.

The aim of the report is to provide comprehensive, detailed, objective reference material with deep insight and independent viewpoint for SHP decision makers in China and elsewhere in the world. ■

## "Rural Hydropower and Electrification in China" published

In order to provide a comprehensive and detailed introduction to the experience and technology in the rural hydro and electrification drive with unique Chinese features, Hangzhou Regional Center for Small Hydro Power (HRC) has compiled the book titled <Rural Hydropower and Electrification in China> in English for the reference of the hydropower personnel especially SHP colleagues throughout the world. The 170-page book covers a survey of SHP development in China, its main features, SHP resources in China,SHP-based rural electrification, strategic measures and incentive policies, SHP technical level, current barriers to further development, measures to overcome them, outlook for SHP development, SHP international cooperation and etc. ■


# China's International Cooperation on SHP Strengthened

The 2004 TCDC (Technical Cooperation among Developing Countries) Training Workshop on SHP Equipment was held from 12 Oct to 22 Nov 2004 by Hangzhou Regional Centre for Small Hydro Power (HRC). Attended altogether 25 participants from 13 countries, covering Africa, Asia, Eastern Europe and Oceania.

This training workshop which is the 38th international SHP training workshop conducted by HRC was sponsored by Chinese Ministry of Commerce, as one of the technical collaborative projects among the developing countries. All the lodging, boarding, training, pocket money and the domestic transportation fees were borne by the Chinese government. That is part of the Chinese contribution to the South-South cooperation.

Most of the teachers were from HRC, with some from abroad. The subjects included procedures of SHP development, feasibility study, hydrological analysis, low-cost and simplified civil structures, turbo-generator units and auxiliary, electric equipment design, technical refurbishment, computer application in SHP stations, SHP economic evaluation, etc. Such special topics as hydro power resources in China, quality control, marketing and management, renewable energy, hydraulic ram and micro power units were also introduced and evaluated by the participants as beneficial.

Study tours were arranged to Shaoxing, Shengzhou, Xinchang, Linhai, Wenzhou, Haiyan, Ningbo, Nanjing and Shanghai, where the participants felt to have benefited much. In Shaoxing, Shengzhou, Xinchang and Linhai, they visited some SHP stations of various development types including the rubber dam, siphon intake and equipment manufacturers. Visits were paid to Linhai Machinery Plant and Linhai Electric Machine Plant where participants were able to see the whole process of the hydropower equipment manufacturing. On-site discussions and inquired were made concerning the ordering and the service of the hydropower equipment. In Wenzhou, participants were excited to visit the big private company Chint Corporation Ltd which has been fast growing in the recent years. The company is listed No 1 so far in China in the production of low voltage electric equipment. Its production line is highly automatic. The participants were so deeply impressed that they would associate the technical level of the company to that of such global big companies as GE or Siemens. The products were observed as reliable, appropriate and moderate in price. In Haiyan, participants were delighted to be able to visit one of China's nuclear power plants — Qinshan Nuclear Power Company which is the first nuclear power station designed, constructed, tested and operated by the Chinese. Some African participants expressed that never in their life have they ever seen a nuclear power plant and such experience was very important.

Participants went to Ningbo, visiting a pumped storage station with installed capacity of 80 MW. This station designed by HRC in the past few years was put into operation at the end of 1997. It has a big role to play for the station to provide energy to the grids at the peak hour and its financial record all these years after the commissioning is also encouraging.

Also, three days were spent in Nanjing and Shanghai —the largest city and port of China. In Nanjing, participants paid visit to Tiexinqiao Hydraulic Experimental Base which is China's largest hydraulic experimental base. With the opening and reforming policy set forth by the Chinese government some 20 years ago, tremendous changes have taken place in Shanghai. A great number of skyscrapers pop up, with its modern and convenient transportation network.

During the training workshop, HRC provided a forum for the exchange of SHP experience and technology. The participants were earnest to offer their presentations. Altogether 13 presentations were made by the participants, introducing the experience and lessons learnt in the practice of developing SHP in their own countries. Some of their presentations are being considered to be issued at the quarterly *SHP News* that HRC edits and publishes.

Apart from training and study tours, sightseeing programs were arranged. Visit was paid to Xitang, one of China's ancient towns, where participants were deeply impressed by its old houses, quiet life, local flavours and kind people. In Hangzhou, such famous sites as Su Causeway, Flower Harbour Park, Hefang Street, Flower Nursery, Silk Museum, Dragon-Well Village and etc were visited. Table tennis competition, singing and dancing parties were conducted. How exciting!

The CD-ROM presented to participants at the closing ceremony contains a briefing to HRC and Nanjing Hydraulic Research Institute, the details of 2004 TCDC SHP participants, presentations by HRC's lecturers, presentations by the participants at SHP forum, photos reflecting activities of 2004 TCDC training workshop on SHP equipment, one-hour-long selected Chinese traditional master music pieces and the photos of scenery around Hangzhou — a paradise on earth.

2004 TCDC Training Workshop on SHP Equipment that HRC implemented was a success. At the closing ceremony, the monitor who was from Nigeria put it: "The methodology of teaching and instruction was excellent and the lectures gave their best in terms of knowledge and experience in their field of study."

Previously, a series of SHP training workshops have been conducted for African participants by HRC. For instance, HRC implemented two SHP training workshops in 2001 and 2002, as sponsored by MOFCOM, China. The SHP potential in Africa is huge and SHP resource exploited represents less than 20% of the exploitable SHP resource so far. However, in Democratic Republic of Congo, the national electrification rate is only around 7%, the population with no access to electricity over 47million. In Kenya, the national electrification rate is only around 8%, the population with no access to electricity over 30 million. In Nigeria, the population with no access to electricity accounts for 47million. Therefore, China's cooperation with African countries in the future is great in the field of SHP.

In 2005 HRC is planning to conduct two international training workshops on SHP including one for participants from African countries. With its technical service and experience for decades, HRC is committed to participating in the SHP development process for African countries and elsewhere in the world. Those interested in our upcoming SHP training workshops are welcome to contact with us. ■

*(By D.Pan, HRC training coordinator Email: dqpan@hrcshp.org)*

# Speech at the closing ceremony of 2004 TCDC Training Workshop on SHP Equipment

*Prof.Cheng Xialei Deputy Director of HRC*

Good afternoon,
Ladies & Gentlemen:
As our director, Dr. Chen, has a business visit to Taiwan, I will deliver a closing speech on behalf of him.
The 2004 Training Workshop on SHP Equipment will end today. We have 25 participants of 13 countries from Asia, Africa, South Pacific and Eastern Europe attending the Workshop. It has got a great success.
Firstly, through your study in class, you have learnt some essential technology and experience related to the development of SHP. The subjects included procedures of SHP development, feasibility study, low-cost civil structure, turbo-generator units and auxiliary, electric equipment design, automation technology, equipment manufactureing quality management and so on. And also some special topics as the status of hydro power resources in China, the rubber dam, the pumped storage plants, foreign trade practices etc were introduced. The engineers or specialists from HRC and elsewhere shared their rich experience with you. Secondly, the study tour was arranged to Shengzhou, Xinchang, Linhai, Wenzhou, and Xiaoshan where you visited some SHP stations of various kinds, hydropower equipment manufacturers and big private enterprises. These will help you to understanding the technology of SHP. Thirdly, we successfully hold the forum for the exchange of SHP experience and technology. All the presentations your delivered were well prepared and really wonderful. Some of your presentations will be issued at the quarterly SHP News that HRC edits and publishes.
In addition to training and study tours, sightseeing at weekends in Hangzhou, table tanniss competition, dancing party etc were arranged. Also we visited Shanghai—the largest city of China and Nanjing. In Nanjing, we paid visit to Tiexinqiao Hydraulic Experimental Base which is China's largest hydraulic experimental base. Through these actives, you were able to see more about China, to know its people and to make Chinese friends. That is to promote the traditional friendship between China and foreign countries. Obviously, the Chinese language lesson arranged before the presentation helps such exchange and communication.
With all your earnestness, you were active and responsive in class, and very cooperative during the whole training period. For that, we were very impressed. And here I'd like to express our sincerely thanks to all of you. It is expected that you will play a more active role in the exploitation of SHP resources in your own country and for the benefit of your people when you are back home.
The mission of HRC is to promote the SHP development worldwide by means of training, consultation, R&D, information dissemination etc. We plan to conduct another TCDC SHP training course in 2005 and your colleagues or friends working the hydropower sector are warmly welcome to participate.
You are leaving HRC soon. I hope you keep close contact with HRC and concrete SHP cooperative projects could be set up between us with your assistance. I believe all of you will serve the important bridge in the cooperation of all fields between China and foreign countries in future. When there is chance, you are welcome to visit HRC again in future.
Finally, I wish you all good health and smooth trip to your own country!
■

# Speech at the closing ceremony of 2004 TCDC Training Workshop on SHP Equipment

*Prof. Zhu Xiaozhang Honorary Director of HRC*

Congratulations to the completion the TCDC Training Workshop. During the past 40 days, a lot of meaningful and interesting activities has been held in addition to the formally scheduled lectures in the classroom. I assume yon enjoyed your staying here for not only obtaining the knowledge of SHP development from Chinese lecturers but also acquiring broad information through valuable exchange and discussion on SHP development of relevant countries among all participants. You have also offered your contributions by presenting your county reports to the workshop. In this respect, I' d also express my thanks, on behalf of HRC, for your valuable contribution to the international cooperation for SHP development worldwidely. As you have been staying and studying here for 40 days, you have surely become old friend of Chinese and of HRC. I' d request that you will act as the bridge of cooperation between China, HRC and your respective country after you go back. If there is any potentiality of set up cooperative items or projects with us, or if there is any new information that you feel to be interesting to the SHP sector in world, please feel free to contact us or send the info to us. We will be glad to keep contact with you in the future and hearing any follow-up response from our colleague graduated from this Workshop.

Finally I' d express warm congratulations for your graduation and being awarded of the certificates. Also hope your back journey to your home smooth and pleasant.

Thank you.

■

# A Chinese Magazine "Small Hydropower" by HRC

The Chinese "Small Hydropower", a magazine that National Research Institute for Rural Electrification (NRIRE) and Hangzhou Regional Centre (Asia-Pacific) for Small Hydro Power has edited and published for 120 issues (bimonthly), was allocated with the International Standard Serial Number ISSN 1007-7642, and China Standard Serial Number CN33-1204/TV. It was published in Chinese attached with title of articles in English. Its special features are technical experience of SHP development in China. Information of international SHP activities and important events in the field of SHP have also been widely included.

This magazine carries news, views and articles on all aspects of small hydro power. It is useful to those who are intersted in technical experience of SHP development in China.

"Small Hydropower" is the only professional publication on small hydropower in China, which is issued domestically and abroad. It is widely circled in all corners of China concerning SHP, and getting more and more popular in over 600 rural counties which is primarily hydro-electrified, more than 2,300 counties with hydropower resources, more than 50,000 small-sized hydropower stations, thousands of colleges or universities, research institutes and other administrative authorities on SHP. Advertising is welcome for any equipment manufacturer to target Chinese market on SHP construction, equipment purchasing or other businesses. ■

# Country presentation
## —Republic of the Philippines

*(2004 TCDC Training Workshop on SHP Equipment Hangzhou, China)*

**By Dante Operario**
*(Lisa_operario@yahoo.com)*
***Department of Environment & Natural Resources – DENRMines & Geosciences Bureau, the Philippines***

**By Bienvenido Donila**
*(Bien_donila@yahoo.com)*
***Department of Science & Technology,Eastern Visayas State University, the Philippines***

**OVERVIEW**

**REPUBLIC ACT NO. 7638 (RA 7638)** – an act creating the Department of Energy, rationalizing the organization and functions of government agencies related to energy, and for other purposes. This act is also known as the “department of energy act of 1992”.

**The Department of Energy (DOE)** shall prepare, integrate, coordinate, supervise, and control all plans, programs, projects, and activities of the Government relative to energy exploration, development, utilization, and conservation.

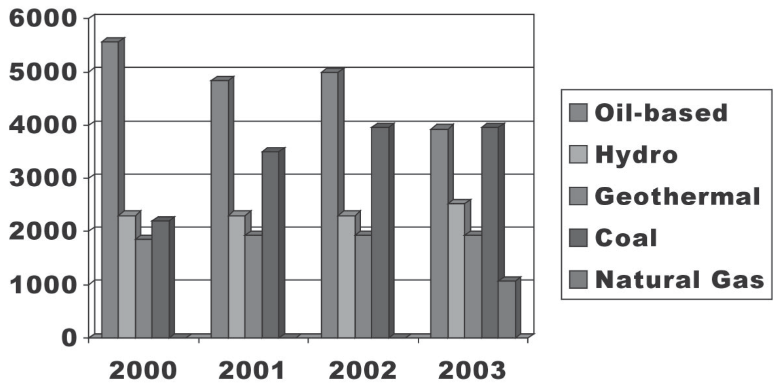
**The Renewable Energy Management Division (REMD)** is a newly-created division of the DOE Energy Utilization Management Bureau. REMD main function is to formulate policies, plans, and programs related to the accelerated development, transformation, utilization including the commercialization of renewable energy resources (e.g. biomass, hydro, ocean, solar, and wind) and technologies and effective implementation thereof.

**REPUBLIC ACT NO. 7156 (RA 7156)** – an act granting incentives to mini-hydroelectric power developers and for other purposes. this act is also known as the “Mini-hydroelectric Power Incentives Act of 1991”.

**TAX INCENTIVES UNDER RA7156**

* Special Privilege Tax
* Tax and Duty-Free Importation of Machinery, Equipment, and Materials
* Tax Credit on Domestic Capital Equipment
* Special Realty Tax Rates on Equipment and Machinery
* Value-Added Tax (VAT) Exemption
* Income Tax Holiday

**Philippine Power Generation** **Installed Generating Capacity, in MW**




**Installed Generating Capacity, in MW**

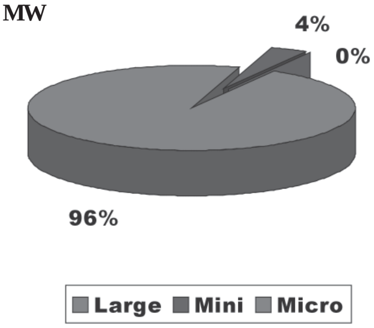
| Plant Type | 1999 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|
| Oil-based | 5,973 | 5,568 | 4,839 | 4,987 | 3,927 |
| Hydro | 2,301 | 2,301 | 2,301 | 2,301 | 2,518 |
| Geothermal | 1,819 | 1,856 | 1,931 | 1,931 | 1,931 |
| Coal | 1,600 | 2,200 | 3,493 | 3,963 | 3,963 |
| Natural Gas | - | 3 | 3 | 3 | 1,063 |
| TOTAL | 11,693 | 11,928 | 12,567 | 13,185 | 13,402 |

**Hydropower Generation**

Classification of Hydro Power in the Philippines:

* Micro-Hydro
  - up to 100 kW
* Mini-Hydro
  - 101 kW to 10, 000 kW
* Large-Hydro
  - > 10,000 kW (10 MW)

**Hydropower Installed Capacity, in MW**




**Hydropower Installed Capacity, in MW**

| | 2001 |
|---|---|
| Micro-Hydro | 0.63 |
| Mini-Hydro | 89.07 |
| Large-Hydro | 2,434.10 |

**Power Sector Performance Assessment**

| | 2000 | 2001 | | Percent Change | |
|---|---|---|---|---|---|
| | | Actual | Target | 2001 vs. 2000 | 2001 Actual vs. Target |
| **Gross Generation in GWh** | | | | | |
| **Oil-based** | 9,185 | 9,867 | 8,050 | 7.43 | 22.57 |
| **Hydro** | 7,799 | 7,104 | 5,649 | -8.91 | 25.76 |
| **Geothermal** | 11,626 | 10,422 | 9,664 | -10.36 | 7.84 |
| **Coal** | 16,663 | 18,789 | 23,924 | 12.76 | -21.46 |
| **Natural Gas** | 17 | 848 | | 4,888.24 | |
| **TOTAL** | 45,290 | 47,030 | 47,287 | | |
| **Installed Capacity in MW** | | | | | |
| **Oil-based** | 4,987 | 3,927 | 4,949 | -21.26 | -20.65 |
| **Hydro** | 2,301 | 2,518 | 2,519 | 9.43 | -0.04 |
| **Geothermal** | 1,931 | 1,931 | 1,931 | 0.00 | 0.00 |
| **Coal** | 3,963 | 3,963 | 3,825 | 0.00 | 3.61 |
| **Natural Gas** | 3 | 1,063 | 3 | 35,333.33 | -99.72 |
| **TOTAL** | 13,185 | 13,402 | 13,227 | | |

**EXISTING LARGE HYDROELECTRIC POWER PLANTS IN THE PHILIPPINES**

| REGION | LOCATION | PLANT NAME | CAPACITY (MW) | DEVELOPER/ OPERATOR |
|---|---|---|---|---|
| | Alilem, Ilocos Sur | Bakun A | 35.00 | Luzon Hydro |
| | Alilem, Ilocos Sur | Bakun B | 35.00 | Luzon Hydro |
| II | Maddela, Quirino | Casecnan | 140.00 | N P C - N I A |
| | Ramon, Isabela | Magat | 360.00 | N P C |
| CAR | Bokod, Benguet | Ambuklao | 75.00 | N P C |
| | Itogon, Benguet | Binga | 100.00 | N P C |
| III | Pantabangan, Nueva Ecija | Pantabangan | 100.00 | N P C |
| | Norzagaray, Bulacan | Angat | 246.00 | N P C |
| | Pantabangan, Nueva Ecija | Masiway | 12.00 | N P C |
| IV | Kalayaan, Laguna | Kalayaan | 300.00 | N P C |
| | Majayjay, Laguna | Botocan | 17.00 | N P C |
| | Lumban, Laguna | Caliraya | 32.00 | N P C |
| X | Maramag, Bukidnon | Pulangui 4 | 255.00 | N P C |
| ARMM | Saguiaran, Lanao del Sur | Agus 2 | 180.00 | N P C |
| | Marawi City, Lanao del Sur | Agus 1 - Unit 1 | 40.00 | N P C |
| XII | Baloi, Lanao del Norte | Agus 4 | 158.10 | N P C |
| | Ditucalan, Iligan City | Agus 5 | 55.00 | N P C |
| | Fuentes, Iligan City | Agus 6 | 200.00 | N P C |
| | Fuentes, Iligan City | Agus 7 | 54.00 | N P C |
| | Lanao del Norte | Agus 1 - Unit 2 | 40.00 | N P C |
| | | **TOTAL** | **2,434.10** | |

## EXISTING MINI-HYDROPOWER PLANTS IN THE PHILIPPINES

| REGION | LOCATION | PLANT NAME | CAPACITY (MW) | OPERATOR/ DEVELOPER | STATUS |
|---|---|---|---|---|---|
| I | Pagudpud, Ilocos Norte | Agua Grande/Mabogabog | 4.55 | INEC | Operational |
| | Sudipen, La Union | Amburayan | 0.20 | LUELCO | Not Operational |
| | Suyo, Ilocos Sur | Dawara | 0.53 | ISEC | Not Operational |
| | Natividad, Pangasinan | Batchelor | 0.75 | PANELCO III | Not Operational |
| CAR | Sablan, Benguet | Bineng 1 | 2.90 | HEDCOR | Operational |
| | Sablan, Benguet | Bineng 2 | 1.90 | HEDCOR | Operational |
| | Sablan, Benguet | Bineng 2b | 0.75 | HEDCOR | Operational |
| | Sablan, Benguet | Bineng 3 | 4.50 | HEDCOR | Operational |
| | Sablan, Benguet | Amphohaw | 8.00 | HEDCOR | Operational |
| | Tuba, Benguet | Asin 1 | 1.20 | HEDCOR | Operational |
| | Tuba, Benguet | Asin 2 | 1.00 | HEDCOR | Operational |
| | Tuba, Benguet | Asin 3 | 1.50 | HEDCOR | Operational |
| | Tuba, Benguet | Irisan | 1.20 | HEDCOR | Operational |
| | Itogon, Benguet | Sal-angan | 2.40 | HEDCOR | Operational |
| | Itogon, Benguet | Philex | 0.50 | Philex Mining | Operational |
| | Bakun, Benguet | Lower Labay | 2.50 | NMHC | Operational |
| | Bakun, Benguet | Lon-oy | 3.20 | NMHC | Operational |
| | Bakun, Benguet | Engr. F. L. Singit | 6.40 | NMHC | Operational |
| | Baguio City | Club John Hay | 0.56 | Club John Hay | Not Operational |
| II | Ramon, Isabela | Magat A | 1.44 | ISELCO I | Operational |
| | Ramon, Isabela | Magat B | 1.08 | ISELCO I | Operational |
| | Ramon, Isabela | Baligatan | 6.00 | NIA-Region II | Operational |
| | Tumauini, Isabela | Tumauini | 0.25 | ISELCO II | Not Operational |
| III | Gapan, Nueva Ecija | Peñaranda | 0.30 | NEECO I | Not Operational |
| IV | Baco, Oriental Mindoro | Dulangan | 1.60 | ORMECO | Operational |
| | Nagcarlan, Laguna | Balugbog | 0.65 | PHILPODECO | Operational |
| | San Pablo City, Laguna | Palacpaquin | 0.40 | PHILPODECO | Operational |
| | Kalayaan, Laguna | San Juan River | 0.15 | Kalayaan Ice Plant | Operational |
| V | Naga City, Camarines Sur | Inarihan | 0.96 | BHC | Operational |
| | Sañgay, Camarines Sur | Coyaoyao | 0.35 | CASURECO IV | Not Operational |
| | Pili, Camarines Sur | Yabo | 0.20 | PROMASAPI | Operational |
| | Buhi, Camarines Sur | Barit | 1.80 | NPC | Operational |
| | Sorsogon, Sorsogon | Cawayan | 0.40 | NPC | Operational |
| | Bato, Catanduanes | Balongbong | 1.80 | NPC | Operational |
| VII | Barili, Cebu | Mantayupan | 0.50 | CEBECO I | Operational |
| | Barili, Cebu | Basak | 0.50 | CEBECO I | Operational |
| | Badian, Cebu | Matutinao | 0.72 | CEBECO I | Operational |
| | Loboc, Bohol | Loboc | 1.20 | NPC | Operational |
| | Balilihan, Bohol | Janopol | 5.00 | BOHECO I | Operational |
| | Amlan, Negros Oriental | Amlan | 0.80 | NPC | Operational |
| VIII | Lawaan, Eastern Samar | Amanjuray | 1.00 | ESAMELCO | Operational |
| | Calbayog City, W. Samar | Ton-ok Falls | 1.08 | SAMELCO | Operational |
| | St. Bernard, So. Leyte | Henabian | 0.81 | SOLECO | Not Operational |
| IX | Lamitan, Basilan | Balactasan | 0.27 | BASELCO | Operational |
| | Lantawan, Basilan | Kumalarang | 0.68 | BASELCO | Operational |
| X | Agusan, Bukidnon | Agusan | 1.60 | NPC | Operational |
| | Baungon, Bukidnon | Bubunawan Falls | 7.00 | BPC | Operational |
| | Valencia, Bukidnon | Mountain View 1 | 0.30 | MVC | Operational |
| | Valencia, Bukidnon | Mountain View 2 | 0.50 | MVC | Operational |
| XI | Calinan, Davao | Upper Talomo | 1.20 | HEDCOR | Operational |
| | Calinan, Davao | Talomo | 2.50 | NPC | Operational |
| ARMM | Malabang, Lanao del Sur | Matling | 1.50 | MICC | Operational |
| | | **TOTAL** | **89.07** | | |

| EXISTING MICRO-HYDROPOWER PLANTS IN THE PHILIPPINES | | | | |
|---|---|---|---|---|
| REGION | LOCATION | APPLICATION | CAPACITY (kW) | STATUS |
| I | Pansian, Pagudpud, Ilocos Norte | Lighting | - | Not Operational |
| | Pansian, Pagudpud, Ilocos Norte | Lighting | - | Not Operational |
| CAR | Mallag, Kabugao, Apayao | Battery Charging | - | Not Operational |
| | Naguillan, Calanasan, Apayao | Lighting | 1.50 | Operational |
| | Dulao, Malibcong, Abra | Lighting | 7.50 | Operational |
| | Gacab, Malibcong, Abra | Lighting | 20.00 | Operational |
| | Capuyoan, Buguias, Benguet | Battery Charging | 0.10 | Operational |
| | Gadang, Kapangan, Benguet | Battery Charging | 0.10 | Operational |
| | Gadang, Kapangan, Benguet | Battery Charging | 0.10 | Operational |
| | Tawangan, Kabayan, Benguet | Lighting | 10.00 | Operational |
| | Camandag, Asipulo, Ifugao | Coffee Milling | 0.05 | Operational |
| | Bangaan, Banaue, Ifugao | Rice Milling | 3.00 | Operational |
| | Batad, Banaue, Ifugao | Battery Charging | 0.10 | Operational |
| | Cambulo, Banaue, Ifugao | Battery Charging | 0.07 | Operational |
| | Ubuag, Hingyon, Ifugao | Battery Charging | 0.03 | Operational |
| | Umalbong, Hingyon, Ifugao | Battery Charging | 0.06 | Operational |
| | Abatan, Hungduan, Ifugao | Battery Charging | 0.10 | Operational |
| | Ba-ang, Hungduan, Ifugao | Lighting | 3.00 | Operational |
| | Ba-ang, Hungduan, Ifugao | Battery Charging | 0.75 | Operational |
| | Bokiawan, Hungdua, Ifugao | Battery Charging | 0.30 | Operational |
| | Gode, Hungduan, Ifugao | Lighting | 3.00 | Operational |
| | Polod, Hungduan, Ifugao | Battery Charging | 0.10 | Operational |
| | Tiiwan, Hungduan, Ifugao | Rice Milling | 4.50 | Operational |
| | Inwaloy, Mayoyao, Ifugao | Battery Charging | 0.10 | Operational |
| | Magulon, Mayoyao, Ifugao | Battery Charging | 0.10 | Operational |
| | Liwo, Mayoyao, Ifugao | Lighting | - | Not Operational |
| | Binablayan, Tinoc, Ifugao | Lighting | 0.75 | Operational |
| | Poblacion, Tinoc, Ifugao | Lighting | 5.00 | Operational |
| | Balantoy, Balbalan, Kalinga | Battery Charging | 0.10 | Not Operational |
| CAR | Balbalasang, Balbalan, Kalinga | Lighting | 25.00 | Operational |
| | Bulalayao, Balbalan, Kalinga | Lighting | 7.50 | Operational |
| | Dalayap, Balbalan, Kalinga | Lighting | 3.00 | Not Operational |
| | Sesec-an, Balbalan, Kalinga | Lighting | 10.00 | Operational |
| | Talalang, Balbalan, Kalinga | Lighting | 10.00 | Operational |
| | Dao-angan, Balbalan, Kalinga | Lighting | 20.00 | Operational |
| | Gawaan, Balbalan, Kalinga | Lighting | 10.00 | Operational |
| | Poswoy, Balbalan, Kalinga | Lighting | 10.00 | Not Operational |
| | Lower Uma, Lubuagan, Kalinga | Lighting | 10.00 | Operational |
| | Upper Uma, Lubuagan, Kalinga | Lighting | 10.00 | Operational |
| | Western Uma, Lubuagan, Kalinga | Lighting | 10.00 | Operational |
| | Ableg, Pasil, Kalinga | Lighting | 2.00 | Operational |
| | Ngibat, Tinglayan, Kalinga | Lighting | 5.00 | Operational |
| | Tulgao, Tinglayan, Kailnga | Lighting | 25.00 | Operational |
| | Bagumbayan, Tabuk, Kalinga | Lighting | 0.70 | Operational |
| | Bagumbayan, Tabuk, Kalinga | Lighting | 1.00 | Operational |
| | Bulanao, Tabuk, Kalinga | Lighting | 2.00 | Operational |
| | Guilayon, Tabuk, Kalinga | Lighting | 2.00 | Not Operational |
| | Bail, Poblacion Mangali, Tanudan, Kalinga | | 20.00 | Operational |
| | Guisang, Salegseg, Balbalan, Kalinga | | 2.00 | Not Operational |
| | Balintaugan, Bauko, Mt. Province | Battery Charging | 0.10 | Operational |
| | Poblacion, Natonin, Mt. Province | Lighting | 1.20 | Operational |
| | Poblacion, Natonin, Mt. Province | Battery Charging | 0.10 | Operational |
| II | San Jose, San Mariano, Isabela | Battery Charging | 0.10 | Operational |
| | San Jose, San Mariano, Isabela | Battery Charging | 0.15 | Operational |
| | Lipuga, Castañeda, Isabela | Lighting | 3.00 | Operational |
| | Lipuga, Castañeda, Isabela | Lighting | 3.00 | Operational |
| | Abaca, Dupax del Sur, Nueva Vizcaya | Battery Charging | 0.04 | Operational |
| | Tabec, Dupax del Sur, Nueva Vizcaya | Battery Charging | 0.04 | Operational |

| EXISTING MICRO-HYDROPOWER PLANTS IN THE PHILIPPINES | | | | |
|---|---|---|---|---|
| REGION | LOCATION | APPLICATION | CAPACITY (kW) | STATUS |
| III | Labi, Carranglan, Nueva Ecija | Battery Charging | 0.04 | Operational |
| | Manicla, San Jose City, Nueva Ecija | Lighting | 2.00 | Operational |
| IV | DSAC, Indang, Cavite | Lighting | 1.00 | Not Operational |
| | Kayquit, Indang, Cavite | Water Lifting | 1.00 | Not Operational |
| V | Cagmaslog, Buhi, Camarines Sur | Sugar Milling | 2.00 | Operational |
| | San Vicente, Buhi, Camarines Sur | Sugar Milling | 2.00 | Not Operational |
| VI | Gella, Patnongon, Antique | Lighting | 3.25 | Operational |
| | Flores, Culasi, Antique | Lighting | 10.00 | Operational |
| | Imparayan, Sibalom, Antique | Lighting | 2.00 | Operational |
| | Badiangan, Pandan, Antique | Lighting | 2.00 | Operational |
| | Villa Flores, Patnongon, Atinque | Lighting | 2.00 | Operational |
| | San Vicente, Culasi, Antique | Lighting | 4.00 | Operational |
| | Aningalan, San Remegio, Antique | Lighting | 6.00 | Operational |
| | Agmailig, Libacao, Aklan | Lighting | 4.00 | Operational |
| | Bao-bato, Libacao, Aklan | Lighting | 2.00 | Operational |
| | Ortega, Libacao, Aklan | Lighting | 2.00 | Operational |
| | Aparicio, Ibajay, Aklan | Lighting | 4.00 | Operational |
| | Mina-a, Ibajay, Aklan | Lighting | 6.00 | Operational |
| | Balunos, Anilao, Iloilo | Lighting | 2.00 | Operational |
| | Talo-ato, San Dionisio, Iloilo | Hybrid Solar & Micro | 1.00 | Operational |
| | Lico, Alimodian, Iloilo | Lighting | 2.00 | Operational |
| | Alegre, Sebaste | Lighting | 3.00 | Operational |
| | Lombuyan, Barbaza, Antique | Lighting | 7.50 | Operational |
| | Agbobolo, Ajuy, Iloilo | Lighting | 6.00 | Operational |
| | Badiangan, Ajuy, Iloilo | Lighting | 6.00 | Operational |
| | Balcon Milleza, Jordan, Guimaras | Battery Charging | 0.30 | Operational |
| | Puey, Sagay City, Negros Occidental | Wood Working | 0.50 | Not Operational |
| | Puey, Sagay City, Negros Occidental | Lighting | 5.00 | Not Operational |
| VII | Kanagahan, San Remigio, Cebu | Rice Milling | 3.00 | Operational |
| | Candabong, Manjuyod, Negros Oriental | Battery Charging | 0.15 | Operational |
| | Sandulot, Siaton, Negros Oriental | Battery Charging | 0.15 | Operational |
| | Guincalaban, Tayasan, Negros Oriental | Battery Charging | 0.50 | Operational |
| | Candigum, Larena, Siquijor | Wood Working | 1.00 | Operational |
| VIII | Visca, Baybay, Leyte | Abaca Striping | 10.00 | Operational |
| | Cansiboy, Burauen, Leyte | Lighting | 3.00 | Not Operational |
| | Mahagnao, Burauen, Leyte | Lighting | 65.00 | Operational |
| | Mangatas, St. Bernard, Southern Leyte | Lighting | - | Not Operational |
| | Henabian, St. Bernard, Southern Leyte | Lighting | 10.00 | Not Operational |
| IX | Bagong Baguio, Josefina, Zamboanga del Sur | Rice Milling | 0.20 | Operational |
| | Langapud, Labangan, Zamboanga del Sur | Rice Milling | 0.20 | Operational |
| | Tuburan, Mahyag, Zamboanga del Sur | Rice Milling | 0.20 | Operational |
| | Upper La Paz, Zamboanga City | Lighting | 0.20 | Not Operational |
| X | Kalabugao, Impasugong , Bukidnon | Lighting | 0.10 | Operational |
| | Cabadiangan, Kadingilan, Bukidnon | Lighting | 3.00 | Operational |
| | Tawas/Buda, Kitaotao, Bukidnon | Lighting | 6.50 | Operational |
| | Aninto, Mambajao, Camiguin | Lighting | 1.50 | Operational |
| XI | Mintal, Davao City | Lighting | 10.00 | Operational |
| XII | Poblacion, Magpet, North Cotabato | Rubber Processing | 50.00 | Operational |
| | | Grand Total | 629.75 | = 0.63 MW |

| Committed and Indicative Hydropower Capacity Additions | | | | |
|---|---|---|---|---|
| Target Year | Name of Plant | Classification | Capacity (MW) | Location |
| 2003 | Kalayaan P/S HEP | Large Hydro | 350.00 | Laguna |
| 2004 | Hinubasan MHP | Mini-Hydro | 0.40 | Loreto, Dinagat Island |
| | Cantingas MHP | Mini-Hydro | 0.90 | Sibuyan Island, Romblon |
| 2005 | San Roque HEP | Large Hydro | 345.00 | San Manuel, Pangasinan |
| | Lower Dapitan MHP | Mini-Hydro | 3.80 | Zamboanga del Norte |
| | Batang-Batang MHP | Mini-Hydro | 3.50 | Narra, Palawan |
| | Kapipian MHP | Mini-Hydro | 3.00 | Catanduanes |
| 2006 | Liangan HEP | Large Hydro | 11.90 | Lanao del Norte |
| | Pacuan HEP | Large Hydro | 33.00 | Negros Oriental |
| | Amandaraga MHP | Mini-Hydro | 4.00 | Eastern Samar |
| | Taguibo MHP | Mini-Hydro | 7.00 | Agusan Norte |
| 2007 | Lake Mainit HEP | Large Hydro | 22.00 | Agusan Norte |
| | Catuiran HEP | Large Hydro | 24.00 | Mindoro Oriental |
| | Kanan HEP | Large Hydro | 113.00 | Infanta, Quezon |
| | Middle Dapitan MHP | Mini-Hydro | 4.40 | Zamboanga del Norte |
| | Colasi MHP | Mini-Hydro | 1.00 | Mercedez, Camarines Norte |
| 2008 | Timbaban HEP | Large Hydro | 29.00 | Aklan |
| | Sicopong HEP | Large Hydro | 17.80 | Negros Oriental |
| | Bugtong MHP | Mini-Hydro | 1.00 | Calbayog, Samar |
| | Dugui MHP | Mini-Hydro | 4.00 | Catanduanes |
| | Langogan MHP | Mini-Hydro | 6.80 | Palawan |
| 2009 | Tagaloan HEP | Large Hydro | 68.00 | Bukidnon |
| | Addalm HEP | Large Hydro | 46.00 | Quirino |
| | Libungan MHP | Mini-Hydro | 10.00 | North Cotabato |
| | Igbolo MHP | Mini-Hydro | 4.00 | Igbaras, Iloilo |
| 2010 | Aglubang HEP | Large Hydro | 13.60 | Mindoro Oriental |
| | Agus III HEP | Large Hydro | 225.00 | Lanao del Norte and Sur |
| | Diduyon HEP | Large Hydro | 332.00 | Quirino |
| | Upper Dapitan MHP | Mini-Hydro | 3.60 | Catanduanes |
| | Siaton MHP | Mini-Hydro | 5.40 | Negros Oriental |
| 2011 | Bulanog Batang HEP | Large Hydro | 150.00 | Bukidnon |
| | Agbulo HEP | Large Hydro | 360.00 | Apayao |
| | Hitoma MHP | Mini-Hydro | 3.00 | Catanduanes |
| 2012 | Pulangi V | Large Hydro | 300.00 | North Cotabato |
| | Abuan HEP | Large Hydro | 60.00 | Isabela |
| | Cabinbin MHP | Mini-Hydro | 0.80 | Palawan |
| | | TOTAL | 2,566.90 | |

**Hydropower Challenges**
- Socio-environmental concerns
- Type of development
- Commercialization of technology

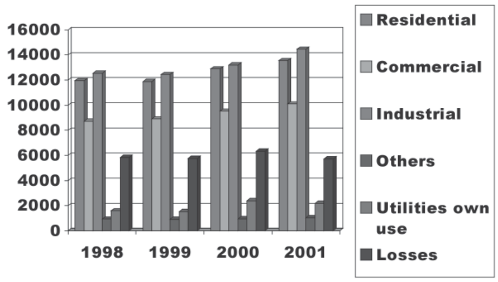
**Hydropower Programs**
- Enhanced public acceptance
- Formulation of comprehensive programs
- Commercialization of technology
  - – Creation of hydropower database
  - – Pursuit of technical cooperation with other countries
  - –Rehabilitation program for existing hydropower plants

**Philippine Transmission System**

| Summary of Existing Transmission Lines and Substations Per Grid | | |
|---|---|---|
| Grid | Transmission Lines (ckt.-km.) | Substation Capacity (MVA) |
| **Luzon** | | |
| 500 kV | 1,052.94 | 9,000.00 |
| 350 kV | 358.94 | 516.00 |
| 230 kV | 4,894.84 | 8,570.00 |
| 115 kV & Below | 3,759.45 | 1,042.00 |
| *Sub-total* | 10,066.17 | 19,128.00 |
| **Visayas** | | |
| 300 kV | 564.00 | 516.00 |
| 230 kV | 311.00 | 420.00 |
| 138 kV | 1,213.00 | 1,058.00 |
| 69 kV | 2,346.50 | 43.00 |
| Below 69 kV | 64.55 | |
| *Sub-total* | 4,499.05 | 2,037.00 |
| **Mindanao** | | |
| 138 kV | 3,146.01 | 1,410.00 |
| 69 kV & Below | 2,375.90 | 42.00 |
| *Sub-total* | 5,521.91 | 1,452.00 |

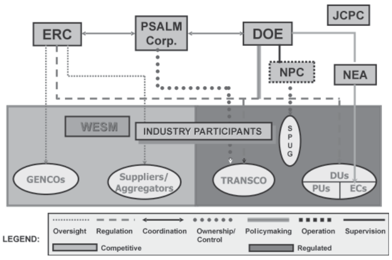
| Summary of Existing Transmission Lines and Substations | | |
|---|---|---|
| Grid | Transmission Lines (ckt.-km.) | Substation Capacity (MVA) |
| **Philippines** | | |
| 500 kV | 1,052.94 | 9,000.00 |
| 350 kV | 922.94 | 1,032.00 |
| 230 kV | 5,205.84 | 8,990.00 |
| 138 kV | 4,359.01 | 2,468.00 |
| 115 kV | 300.81 | 1,127.00 |
| 69 kV (VIS) | 2,346.50 | |
| 69 kV & Below | 5,899.09 | |
| Grand Total | 20,087.13 | 22,617.00 |

**Philippine Electricity Sales**
Power Consumption by Sector, in GWh




| Power Consumption by Sector, in GWh | | | | |
|---|---|---|---|---|
| Sector | 2000 | 2001 | 2002 | 2003 |
| Residential | 11.936 | 11.875 | 12.894 | 13.547 |
| Commercial | 8.725 | 8.901 | 9.512 | 10.098 |
| Industrial | 12.543 | 12.444 | 13.191 | 14.452 |
| Others | 934 | 921 | 957 | 1.042 |
| Utilities own use | 1.590 | 1.536 | 2.390 | 2.196 |
| Losses | 5.849 | 5.754 | 6.345 | 5.713 |
| TOTAL | 41.577 | 41.431 | 45.289 | 47.048 |

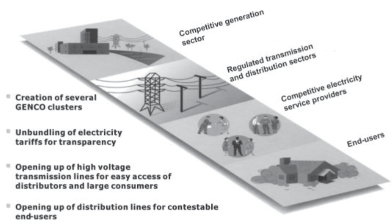
**New Industry Relationships**
under Republic Act No. 9136




**Philippine Electric Power Industry**

**Republica Act No. 9136 (RA 9136)** – an act ordaining reforms in the electric power industry, amending for the purpose certain laws and for other purposes. This Act is also known as the "Electric Power Industry Reform Act of 2001".

**The New Structure of the Industry**



# Small Hydropower in Benin

*(2004 TCDC Training Workshop on SHP Equipment Hangzhou, China)*

*By Edoun Claudius E. A*
*Energizing Work Engineer,*
*General Direction of the Energy*

The Republic of Benin is situated on the coast of West Africa, in the tropical zone, between the Equator and the Tropics of Cancer (between the 6° 30 and 12° 30 parallels of Northern latitude and 1° and 30°40 meridians of Eastern longitude). It is bordered, in the North, by the river Niger that separates it from the Republic of Niger, in the North West by Burkina Faso, in the West by Togo, in the East by Nigeria and in the South by the Atlantic Ocean.

The total land area of Benin is 114, 763 km$^2$. From North to South, it stretches over 700 km; its width varies between 125 km (along the coast) to 325 km (at the level of Tanguieta - Segbana).

**Benin is blessed with numerous rivers and waterways:**
The Niger River Basin, which includes tributary rivers namely:
MEKROU:440km
ALIBOR:338km
SOTA: 250 km and
PENDJARI:380km
The Coastal Basin whose rivers run into the sea, namely:
OUEME:510km
COUFFO:120km
MONO:350km.
There are also many other waterways in the prominent amongst which are:
NOKOUE Lake. 138km$^2$
AHEME Lake. 78 km$^2$ and .
PORTO-NOVO Lagoon .35 km$^2$ .

During the period going from 1990 to 2002, its economic growth accelerated relatively.
So the GDP to constant price of 1985 passed from 513.4 billions to 874 billions of CFA francs between 1990 and 2002. The evolution of the economic growth became sensitive since 1990. The economic growth passed from 3.4% in 1990 to 6.4% in 2002.
Benin imports commercial energies (electricity, hydrocarbon…). The national electric production is especially thermal; a small part is from Yeripao hydropower station, which belongs to Society Beninese of Electric Energy (SBEE).
The national production is in complement to the importation from Electric Community of Benin (CEB) that is a public company of Togo and Benin.
The relative data to the national production and to the consumption of electricity are presented below in the table 1.

**Table 1 Production and import of electricity in Benin**

| Années | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | Rates yearly means of growth (%) |
|---|---|---|---|---|---|---|---|---|
| National production(in MWH) | 46890 | 48674 | 52869 | 41895 | 52234 | 54319 | 51339 | 1.5 |
| *Power thermal station SBEE | nd | 8614 | 23971 | 27719 | 30113 | 10003 | 10003 | 3.0 |
| ***Self producer** | 87 | 1525 | 1896 | 1926 | 1634 | 1569 | 1519 | -0.1 |
| * Hydro<br>*Production in Yéripao | 46977 | 58813 | 78736 | 71540 | 83981 | 65891 | 62861 | 5.0 |
| *Total national production<br>Import CEB | 264138 | 283663 | 255461 | 326966 | 374275 | 456157 | 532682 | 12.4 |
| Total offer (national production + import) in MWH | 311115 | 342476 | 334197 | 398506 | 458256 | 522048 | 595543 | 11.4 |
| Rate (%) of self-sufficiency in electric energy | 15.1 | 17.2 | 23.5 | 17.9 | 18.32 | 12.6 | 10.5 | |

# UN Symposium calls on financing agencies to accelerate sustainable hydropower

A major international symposium has called for developing countries to be given easier access to financing in a new drive to encourage sustainable hydropower throughout the world.

The United Nations Symposium on Hydropower and Sustainable Development in Beijing, attended by more than 500 participants from government and non-governmental organisations, business and industry representatives, environmental and social scientists and financing agencies, culminated in a consensus statement. The 'Beijing Declaration' will now be submitted to the UN Commission on Sustainable Development.

The Declaration calls for tangible action to help developing countries finance sustainable hydropower through loans and grants. It recognizes the World Bank and regional development banks' plans to re-engage, but called for similar commitments from bilateral agencies to assist in the development of affordable and sustainable hydropower. It also urged developing-country governments to create a favourable environment for co-financing from private investors, including strengthening "a transparent regulatory framework".

Participants noted that some two billion people, around one third of the world's population, have no access to electricity, which blights their prospects for improvement in water, energy, health, agriculture and biodiversity. Hydropower can play a major role in meeting this need, if developed in an economically, socially and environmentally sustainable manner.

The October 27-29 Symposium was co-hosted by the World Bank, the United Nations Department of Economic and Social Affairs (UNDESA), and the Chinese government's National Development and Reform Commission.

The scene was set by a statement from UNDESA Under-Secretary-General, J.A. Ocampo: "Johannesburg's Plan of Implementation, adopted at the World Summit on Sustainable Development in 2002, calls for an increase in the share of renewable energy, including hydropower". UNDESA Energy and Transport Chief, Kui-Nang Mak, further observed that, while much work needed to be done to add capacity in the developed world, "the majority of the world's untapped hydropower potential exists in the developing countries".

The Declaration calls on governments and hydro developers to disseminate and observe guidelines on good practice.

Noting that only five per cent of Africa's hydropower potential has been tapped, compared to 75 per cent in Western Europe, the conference called for regional meetings to foster better appreciation of hydropower and sustainable development, especially in Africa. This was supported by the head of the African Union, the UN Economic Commission for Africa, and several African ministerial representatives attending the Symposium.

In the closing session of the Symposium, Jamal Saghir, World Bank Director of Energy and Water, congratulated the International Hydropower Association on its role in demonstrating the sector's commitment to sustainable development. ■

☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆☆

The curves of evolution of the national production of electricity, the imports of electricity, and the rate of self-sufficiency.

The data of the table 1 permit to note above that in spite of a faster growth of the national production of national production is less than 20%.

Benin's experience is only in a small hydropower named Yéripao, which has the capacity of 500 kW installed extensible at 1 MW. Its first phase was achieved in 1998.

As one can note it Benin has very few experiences in the domain of hydropower.

Several reasons can explain this state of things but the main one is insufficiency of financial resources.

There is an inventory currently besides 85 flexible sites in small hydropower achieved by the General Direction of the energy in the setting of the rural electrification. Financings are sought-after to do of feasibility studies. ■

# Beijing Declaration on Hydropower and Sustainable Development

1. We, the representatives of national and local governments, representatives of utilities and the private sector, United Nations agencies, multilateral financial institutions, other international organizations, non-government organizations, the scientific community and academia, and international industry associations, having met at the United Nations Symposium on Hydropower and Sustainable Development from 27 to 29 October 2004, in Beijing, China, reaffirm our shared resolve to achieve Millennium Development Goals (MDG) and the Sustainable development goals and targets contained in Agenda 21 and the Johannesburg Plan of Implementation (JPOI).
2. We reiterate that access to energy is essential to achieving sustainable development and is critical for meeting the MDGs and JPOI targets and commitments.
3. Noting with concern that 2 billion people do not have access to electricity, we call upon all stakeholders to work in concert to deliver energy services to all in a reliable, affordable and economically viable, socially acceptable and environmentally sound manner.
4. We emphasise that improving access to energy will generate opportunities for economic growth, enhanced education, better health care, more training and employment, as well as higher productivity in business, thereby contributing to sustained poverty reduction.

**Strategic importance of hydropower for sustainable development**

5. Recalling that the JPOI calls for a diversification of energy supply and a significant increase in the global share of energy from renewable energy sources, including hydropower, we note that hydropower offers potential for contributing to these goals.
6. We further recall that the Political Declaration adopted at the Bonn International Conference for Renewable Energies acknowledged that renewable energies, including hydropower, combined with enhanced energy efficiency, can contribute to sustainable development, to providing access to energy, especially for the poor, and to mitigating greenhouse gas emissions.
7. Hydropower represents an important source of renewable energy, accounting for some 20 % of world electricity supply. Hydropower has made a contribution to development, as shown in the experience of developed countries where the majority of technically and economically feasible hydropower potential has been exploited, and in some developing countries, where hydropower has contributed to poverty reduction and economic growth through regional development and expansion of industry. In this regard, we note that two thirds of economically viable hydropower potential is yet to be tapped and 90% of this potential is in developing countries. In Africa, less than 5 % has been developed. We agree the large remaining potential in developing countries, as well as in countries with economies in transition, can be harnessed to bring benefits to these countries, bearing in mind that the world's poor use only one twenty-fifth of the energy consumed by the world's rich.
8. While we are convinced of the need to develop sustainable hydropower, along with other options, including the rehabilitation of existing facilities and the addition of hydropower to present and future water management systems, we emphasise that such development should be sustainable from social, economic and environmental standpoints.
9. We underscore the importance of an integrated approach to dam construction, bearing in mind that other than generating electricity, dams often perform multiple functions, including supplying water for irrigation, industrial production, and residential use, as well as flood prevention and habitat maintenance. We note with concern that demands for water in these areas are already on the rise and competition for water resources is most likely to intensify in future.

**Promoting hydropower development that is environmentally friendly, socially responsible and economically viable**

10. Having heard expert presentations on social and environment aspects, we acknowledge that progress has been made by governments, financing agencies and industry in developing policies, frameworks and guidelines which are relevant to individual country contexts for evaluation of environmental and social impacts of hydropower, for mitigation of such impacts, and

for addressing the concerns of vulnerable communities affected by hydropower development. We also note the many instances of good practice presented, and call on governments and the hydropower industry to disseminate good practice, policies, frameworks and guidelines, and build on it to mainstream hydropower development that is economically, socially and environmentally sustainable.

11. With respect to social aspects, we note that the key ingredients of successful resettlement include minimization of resettlement, commitment to the objectives of the resettlement by the developer, rigorous resettlement planning with full participation of affected communities, with particular attention to vulnerable communities. We are encouraged by the trend of some governments to go beyond good practice resettlement by providing benefit sharing with host communities and call on governments to consider incorporating such approaches in their legal and regulatory frameworks. We further call upon Governments and regional and local authorities to accord special consideration to culturally sensitive areas.

12. With respect to environmental impacts, we recognize that some hydropower projects have had substantial adverse impacts on the environment. Rigorous environmental impact assessment and mitigation and management plans are an essential part of sustainable hydropower development. We note that norms are now in place for such assessments and planning, but that rigorous application of such norms is not universal. We call on project owners and governments to strive for good practice in this important area.

13. We call upon Governments to put in place procedures that emphasise the need to plan hydropower developments in a river basin context and in the context of the full range of alternatives for energy production, and that planning should give due weight to environmental and social factors, as well as economic and financial factors.

**Hydropower development: investment challenges and opportunities**

14. Noting that hydropower projects are highly capital intensive, we call for tangible action to assist developing countries to finance sustainable hydropower. This should include both conventional multilateral and bilateral loans and guarantees, credits and grants as appropriate to the level of development of the country concerned.

15. Further noting that four-fifths of investment in hydropower in developing countries in the 1990s was financed by the public sector, we recognize the World Bank and regional development banks' plans to re-engage in financing sustainable hydropower projects.

16. We urge Governments to create a favourable environment to attract investment for co-financing sustainable hydropower projects. We further urge Governments to establish and strengthen a transparent regulatory framework for private investment, both domestic and international, in hydropower development.

17. Developing country Governments at the meeting call on bilateral agencies to also re-engage in sustainable hydropower development.

**Hydropower and sustainable development: the way forward**

18. Having considered the social, economic and environmental dimensions of hydropower and its potential contribution to achieving sustainable development goals, we firmly believe that there is a need to develop hydropower power that is economically, socially, and environmentally sustainable.

19. Having shared perspectives, experiences and best practices from all regions of the world, we invite Governments, United Nations agencies and other international organizations, international industry associations, and non-governmental organisations, the private sector, and civil society, to further address the issue of hydropower and sustainable development in appropriate forums, including through regional meetings, in Africa in particular.

20. We invite Governments, United Nations agencies and other international organisations and non-governmental organisations, the private sector, industry associations, and civil society, to report back to the Commission on Sustainable Development in 2006 on their actions in sustainable development of hydropower.

We express our gratitude to the Government of the People's Republic of China for successfully organising the Symposium and to the Government and people of the People's Republic of China for the hospitality and warm welcome extended to all participants. We pledge to work in determined and concerted action to ensure that sustainable hydropower be harnessed for poverty reduction and for achieving the MDGs and JPOI targets and commitments. ■

*Adopted at the United Nations Symposium on Hydropower and Sustainable Development, Beijing, China, 29 October 2004*

# Colorado Springs Utilities Small Hydroelectric Project

## I Background Information

Colorado Springs Utilities has identified potential small hydroelectric power development sites as a result of an earlier reconnaissance study on candidate projects which use the existing utility raw water supply system.

Five (05) sites were selected to pursue further as they appear to offer benefits to both electric generation and water system operation, and are identified as follows:

**1. Manitou Hydro #3 (~500 kW, construction planned for 2005):** This site is located just north of the Manitou Hydro Plant and substation, just below the parking lot for Barr Camp Trail. The pipeline here is 24-inch diameter. Upstream pressure is about 250 psig to 270 psig. Flow rate is continuous at about 7 MGD (10.8 CFS). Pressure is reduced to atmosphere with a 16-inch sleeve valve located in a small concrete building upstream of the afterbay within a concrete vault. A manual bypass valve and needle valve are located in a small brick building adjacent to the concrete vault. Transmission line voltage at the adjacent substation is 34.5 kV. This site has great potential for development of a small hydro due to its ideal location and continuous flow. Based on information from water operation, flow rate normally ranges from about 6 CFS to 11 CFS and averaged 9 CFS during the period from 1995 to 2000.

**2. Cascade Hydro (~500 kW, construction planned for 2006):** This site is located on the east side of Cascade, just south of Highway 24. Road access is good and a transmission line is near the site. The pipeline is 24-inch diameter. Flow rate during our inspection was 3.4 MGD and maximum flow rate here is 7 MGD. Inlet pressure was 250 psig but can be as high as about 500 psig when the upstream reservoirs (Crystal and Catamount's) are at normal levels. The pressure is reduced to atmosphere with a 14-inch diameter Bailey Polyjet located within the blue vessel that surrounds the polyjet. The upstream shutoff valve is stamped with 440 psig maximum working pressure which suggests that inlet pressure should not normally be allowed to exceed 440 psig for any extended periods. A manual needle valve functions as the bypass. The bypass can flow no more than 5 MGD. Flow is continuous and will be less than that at the above Manitou location due to additional flow from French Creek pulled into the pipeline just downstream of the Cascade Polyjet.

**3. Pine Valley Hydro #1 (~1 MW):** This PRV station works in series with Pine Valley No. 1 and Pine Valley No. 2 pressure reducing valves both located above this station. The pipeline here is 30-inch diameter. The PRV is a vertical Bailey Polyjet in service since about 1968. Estimated maximum flow rate is 80 MGD, with the potential for short term flows as high as 100 MGD. Inlet pressure is about 220 psig and outlet is atmospheric. This pipeline serves as a backup to the Stanley Canyon Tunnel from Rampart Reservoir to Tesla Hydro and is therefore not normally in service. This station could be placed in service during high water demand summer months to allow power regulation with Tesla Hydro. Currently Tesla Hydro runs at full capacity during high water demand periods and cannot be used for power regulation during these periods. Transmission lines are located immediately adjacent to this site and road access is excellent.

The inlet shutoff valve is a 30-inch, Class 300 ball valve with a maximum working pressure of 740 psig (1700 feet). Since the Bailey PRV is vertical with an existing afterbay, this station has good potential for installation of a small Pelton turbine. Discussion was held on the possibility of eliminating PV No. 1 and PV No. 2, taking all pressure drop through a Pelton runner located in place of the PV No. 3 Bailey Polyjet. However, the existing piping may not be designed to handle the higher pressures. Note that any flow through this station would bypass Tesla Hydro Facility.

**4. Pine Valley Hydro #2 (~900 kW):** This station is on a 24-inch pipeline within about 200 feet of site 3 above. Pressure is reduced with a horizontal 12-inch Bailey Polyjet. Inlet pressure is 360 psig and outlet is near atmospheric. Flow rate during our inspection was about 200,000 gal/day (0.3 cfs). Flow is continuous and can be as high as 13 MGD (20 cfs). This station has no manual bypass. Primary purpose of this pipeline is to supply firewater to the Tesla Hydro Facility. The continuous flow is directed from this station into Tesla Reservoir via the 108-inch pipeline from Tesla Hydro tailrace to Tesla Reservoir. Water to this station originates from Northfield Reservoir which is fed from Rampart Reservoir via Wildcat Gulch.

**5. Existing Ruxton Hydro (~1 MW, Built ~ 1926):** This existing hydroelectric facility will be evaluated for possible upgrade or complete replacement by a new unit to be constructed adjacent to the existing site. CSU desires to maintain the historical value of Ruxton hydro powerhouse, and the associated equipment if replacement is the preferred option.

All These small hydroelectric facilities will be connected to the utility grid and operated in a fully automatic mode from a remote control room. Also of prime importance is ensuring that sizing and operation of these facilities will be economically optimized within the operating patterns of the water supply system; therefore close coordination with water operation is essential.

**II Goals and Guidelines**

Our guidelines for developing small hydro facilities are summarized as follows:

1. Develop hydroelectric generation at existing pressure reduction station in the existing raw water delivery system at sites that offer the most favorable rates of return on initial capital investment.
2. Include the developed hydroelectric generation sites as a key component in CSU renewable energy portfolio.
3. Conduct public process to ensure agency and citizen-owner involvement and support.
4. Minimize environment impacts at each location by using existing infrastructure, and minimize civil construction. No dams or diversions are included in this project.
5. Maximize safety, simplicity, and reliability at each new hydroelectric generation site.
6. Maintain existing water delivery capacities and pressure reductions at each location. Reduce maintenance requirements for water delivery.
7. Secure FERC license exemption and any agency approvals or permits prior to any development work.

**III Engineering Services Requested**

The following is a brief description of the engineering work scope solicited:

**PHASE I**

1. **Reconnaissance Study Review:** Review existing reconnaissance study report and confirm findings (MW capacity, cost estimates).
2. **FERC License Exemption Application:** Assist the owner in the preparation and support of an application to FERC for an exemption. CSU currently has an exemption for Ruxton hydro (site 5 above).
3. **Preliminary Engineering:** Develop preliminary design of the project and plan for implementation. Prepare cost estimates and project schedules .

**PHASE II**

1. **Detailed Engineering:** Prepare final designs, drawings, specifications, construction documents for furnishing and installing the hydroelectric equipment for the power plant facility.
2. **Construction and Start up Support:** Provide assistance as needed to support construction and start up activities.

■

# Rural Energy Development Programme-Nepal

On 16 Auguest 1996 the Rural Energy Develoment Programme (REDP) was initiated with the aim of improving livelihoods of rural people and pressrving the environment through the promotion of rural energy systems. The Programme is run by the United Nations Deelopment Programme and His Majesty's Government of Nepal.

As of July 2004, the Programe has been directly responsible for the installation of 132 micro-hydro systems,3,486 bio-gas facilities with attached toilets, 1,666 solar home systems, 7,407 improved cooking stoves and 12,111 toilets. It has also been responsible for establishing a number of enterprise development and institutional development matters.

In addition to the local supply of power, this Programme has benefied the rural communities of Nepal in many other ways. Some examples include enhancing rural livelihoods by increasing income for families, improving health, improving education and awareness, helping villagers with capital formation to put to towards income generating enterprises, reducing greenhouse gas emissions, and community building.

To find out information about this highly successful Programme, vistit the Rural Energy Development Programme website.

http://www.redp.org.np/.

■

# Design Considerations for Hydropower Development In a Water Distribution System

*By*
*David P. Chamberlain, Ed Stewart, Fei-Fan Yeh and Michael T. Stift*
*San Diego County Water Authority, San Diego, California, USA*

**ABSTRACT**
*Installation of a hydraulic turbine in a water distribution system involving long pipeline reaches requires several unique design considerations. For a fixed speed unit, the selection of design points for head and flow needs to be optimized to provide an operating envelope that would maximize the return on the investment given the widely varied flow and pressure conditions imposed by the water distribution system. The selection of a turbine design speed is essential in facilitating runner design, which must minimize the hydraulic pressure transients on turbine runaway that may result in overstressing the existing pipelines. Method and approach to evaluate these considerations are outlined. Relevant results for the selected design are presented using the 4.3 MW Rancho Penasquitos Pressure Control/Hydroelectric Facility as an illustrative example. Licensing requirements for small inline hydroelectric facilities are also briefly discussed.*

## Introduction

The potential for power recovery from a water distribution system exists whenever water flows from a high pressure to a low pressure in such a manner that throttling occurs. San Diego County Water Authority (Water Authority) currently imports about 320,000 acre-feet of untreated water per year through a gravity flow distribution system consisting of about 270 miles of pipeline. As a result, this system requires several in-line pressure control facilities designed to regulate pressure and flow. These in-line facilities are potential sites for the installation of an inline hydropower recovery turbine. The Water Authority's Rancho Penasquitos Pressure Control/Hydroelectric Facility (PCHF) is the largest facility of this kind in the system.

The PCHF is geographically located in the central part of San Diego County, within the northern city limits of the City of San Diego. The PCHF is connected to the Water Authority's Pipeline 5, which is a 108-inch diameter cement mortar lined and coated steel pipeline having an overall length of about 21.6 miles. Pipeline 5 supplies untreated water to a number of local municipal water treatment plants under gravity flow, and is vented to atmosphere at several high points. As part of the PCHF project, Pipeline 5 will be converted to pressurized flow raising the hydraulic grade line upstream of the facility.

The Water Authority has developed the PCHF, currently under design, to consist of three 42- inch diameter sleeve valves and one 4.3 mega-watt (MW) Francis turbine (Black & Veatch, 1996). Three sleeve valves will provide the required pressure and flow control up to 620 cubic feet per second (cfs). Additionally, the hydroelectric turbine generator will provide flow control up to 315 cfs and also recover the energy either for sale to the electric grid or used to offset the energy requirements of operating the Water Authority's and its member agencies' pumping and filtration facilities. The earned power revenue would be used to amortize the capital cost of the generating facility and to offset the Water Authority's operating and maintenance costs.

The operating flow and available pressure gradient at the PCHF will be a function of the upstream hydraulic control facility and the untreated water demands in the Water Authority's aqueduct pipeline system located north and south of the PCHF. During normal operations, either the sleeve valves or the turbine generator (or both) would be used to control the flow and pressure. The planned PCHF configuration will allow the turbine to tap only the flows south of the PCHF in Pipeline 5, which serves primarily the demands at the Miramar, Alvarado, Otay and Sweetwater filtration plants. The upstream hydraulic control is the Twin Oaks Valley Diversion Structure, which is a 22 million gallon reservoir with a normal operating water surface elevation of 1088 feet above mean sea level (MSL). Downstream hydraulic grade line control is provided by an open vent structure (the Miramar Hill Vent Structure), which is maintained at a constant operating elevation of 825 feet MSL. Therefore, the normal maximum gross available head for the turbine generator at the PCHF would be 263 feet.

**Maximum Power Available**

The available power $P$ for a turbine is the product of the net head $H$ and flow $Q$. As the net head is the gross head $H_g$ minus the friction head loss $H_f$ that is a function of the flow squared $Q^2$ in accordance with either the Darcy-Weisbach formula or the Manning formula, the available power $P$ is then a function of $Q$. Taking the first derivative of $P$ with $Q$ and equating to zero, an arithmetical derivation for a constant $H_g$ determines that the maximum power $P_{max}$ is available when $Q$ is equal to the square root of 1/3 times the maximum flow $Q_{max}$ , which is defined as the flow that would result in $H_f$ equal to $H_g$.

Using the PCHF data as an example:

Gross head, $H_g$ = 263 feet,

Length of Pipeline 5, $L$ = 21.6 miles,

Diameter of Pipeline 5, $D$ = 9.0 feet, and

Darcy's $f$ = 0.0108 or Manning's $n$ = 0.0110

The maximum flow $Q_{max}$ that can be sustained by the 263-foot gross head is found to be 710.5 cfs using either the Darcy-Weisbach or Manning formula. The maximum power would occur when the flow, $Q_{max\ power}$, is:

$$Q_{max\ power} = \frac{Q_{max}}{\sqrt{3}} = \frac{710.5}{\sqrt{3}} = 410.2 \text{ cfs}$$

At a flow of 410.2 cfs, the corresponding net head at the PCHF is 175.3 feet, and the maximum generator output would be 5.16 MW if the design full-gate efficiency of the turbine and the generator efficiency at the full-gate power were 0.87 and 0.975, respectively. This design would maximize the power and energy production if, and only if, the operating flow can be set at a near constant rate of about 410.2 cfs. In fact, this ideal design scenario may apply if a sizable downstream reservoir would exist and the constant power inflow could be regulated to meet the variable downstream demands. Furthermore, in this situation the turbine could be oversized to allow the constant power flow operated at or near to the best efficiency point if the marginal benefit-cost ratio were greater than one, i.e. the incremental power revenue would be greater than the incremental cost of additional capital investment.

Unfortunately, the downstream hydraulic grade line control for the PCHF is set at the Miramar Hill Vent Structure with zero storage capacity. The flows at the PCHF vary significantly on a daily basis and are stochastically dependent upon the daily demands and the availability of local water resources at the municipal filtration plants located upstream and downstream of the PCHF. A turbine designed to generate the maximum power may not be economically justified because numerous low flows would have to bypass the turbine and allow the energy of highpressure heads being wasted through the sleeve valves.

**Considerations in Turbine Selection**

For a fixed speed unit, the turbine can only operate within a certain operating envelope, in which the allowable ranges of heads and flows are prescribed. Theoretically, a variable speed unit or two units of equal or different size would increase the operating ranges and efficiencies to maximize the power and energy production. However, these arrangement would increase unit capital cost and overall complexity in operation. In this context, the criterion requirement is that the selection of turbine capacity and number of units needs to be optimized to maximize the return on the initial investment, and not the maximum power and energy production.

The ultimate turbine selection is an economic decision that depends on the range of expected operating flows and heads based on future water demand projection and the percent of time that these heads and flows are expected to occur. Economic justification, including the required return or payback for the capital investment, is determined by comparing the projected value of the energy generated during the economic life of the facility to the capital cost of procuring, installing, and maintaining the facility for the same period of time. The process used is essentially an iterative process, which requires a computer simulation of power operation for a number of turbine design alternatives, and follows with a cash-flow analysis of the cost and benefit for each alternative to identify the ultimate selection that best meets the criterion requirement.

The following outlines the method and approach employed by the Water Authority to confirm the selection of a 4.3 MW Francis turbine at the PCHF.

*1. Economic Life*: The economic life was set at 20 years, which represents the book life over which the capital cost of construction would be recovered from the debt service payments. Whereas the physical life of the hydroelectric facility may be over 50 years, the choice of 20 years reflects the insignificant economic value discounted over a longer period, the limited faith in long-term projection, and the Water Authority's conservative fiscal policy.

*2. Daily Flow Projection and System Hydraulic Analysis:* The average daily flow is considered adequate for the power operation study at the PCHF, as the diurnal variation of the daily untreated water demand is small and practically nil. Historical daily flows and demands in recent years were collected. Future water demand projections were developed from the historical data, population growth projections, and regional development plans. The future demand projections were prorated based on the historical daily data to generate the future daily flow sequences for use in the power operation. As the friction loss is a vital design consideration for long upstream conveyance pipelines of large diameter, the Darcy-Weisbach equation, was used to provide the needed accuracy. Values of Darcy's *f* vary with the pipe rugosity, diameter, flow and water temperature, and can be calculated using spreadsheet formula considering each variable. Ranges of rugosity values for a variety of pipe materials were published elsewhere (US BuRec, 1977) and are supported with extensive field and experimental evidence. As Pipeline 5 is a mortar-lined steel pipe, an average rugosity of 0.000325 feet was adopted for the purpose of power operation study, while the maximum and minimum rugosity values were often used for required conservatism for designs and hydraulic transient analysis.

*3. Development of Turbine Design Alternatives and Operating Envelopes:* Based on the ranges of operating heads and flows expected over the 20-year period, a number of viable turbine design alternatives were developed to include number of units, unit design head, flow and rotational speed. An operating envelope (or a head-flow-capacity-efficiency relationship) was then established for each design alternative considering the specific speed and the operating limits due to cavitation and low efficiency. Preliminary engineering was also prepared to estimate the turbine dimensions and the civil/structure space requirements needed for the cost estimate.

*4. Power Operation Study:* A FORTRAN computer program was coded to simulate the daily power operation using the operating envelope and the projected daily flow sequences as the inputs. The program calculated, on a daily basis, the power flow, bypass flow, net head, turbine efficiency and turbine output capacity for each design alternative. The output data were then transferred to a spreadsheet for reprocessing the monthly and yearly summaries.

*5. Economic Analysis:* This is a cash-flow spreadsheet program, which analyzes the cost and benefit streams over the 20-year economic life to evaluate the economic parameters, including internal rate of return (IRR), net present value (NPV) and payback period. A 20- year municipal bond issue with a coupon rate of 5.0 percent was assumed to finance 100 percent of the incremental capital cost. Incremental capital cost was calculated by first estimating the direct cost of the equipments and civil/structure features at the level of vendors and contractors, and then applying allowances to cover the indirect costs. Incremental costs are defined as those additional costs that would result from incorporating hydroelectric generating capability into the planned pressure control facility at the PCHF. Annual operating and maintenance (O&M) costs were estimated based on the experience of similar installed capacity, and then escalated 3 percent annually. Market clearing prices forecast by California Energy Commission for the years 2000 through 2010 were used as the values of the energy for the initial seven years of operation starting in 2004. The energy values after the year 2010 were assumed to increase at an annual escalation rate of 1.5 percent.

Using the above methodology, a single 4.3 MW Francis unit has been selected for the PCHF operating conditions. The operating envelope used for this selection, together with the daily generation data for selected years are shown in Figures 1 and 2. The power operation assumed a conservative limit of operating capacity up to 110 percent of the design capacity at full gate and a limit of operating flow up to 105 percent of the design discharge. The generation data for year 2023 in Figure 2 tend to spread into the lower head region because the increase of future untreated water demands effectively reduce the net heads available for generation.The pertinent design data

***Table 1 – Design Data***
***Rancho Pensaquito Pressure Control Hydroelectric Facility***

| | English Units | Metric Units |
|---|---|---|
| Rated generator output | 4736 kva (pf=0.9) | 4735 kva (pf=0.9) |
| Rated turbine output | 5863 horsepowers | 5862 horsepowers |
| Generator output | 4.26 MW | 4.26 MW |
| Turbine output at ($H_d$, $P_d$) | 4.37 MW | 4.37 MW |
| Design discharge, $Q_d$ | 300.0 Cfs | 8.50 $m^3/s$ |
| Design head, $H_d$ | 198.0 Feet | 60.4 meters |
| Selected speed, *N* | 720.0rpm (at 60 Hz) | 720.0rpm (at 60 Hz) |
| Selected specific speed, *Ns* | 74.2(in US HP unit) | 283.0(in kw-m unit) |
| Discharge diameter of runner, $D_3$ | 3.3 Feet | 1.01 meters |
| Generator/turbine, $WR^2$ (for pf=0.9) | 66603 lb-$ft^2$ | 2813 kg-$m^2$ |
| Average runaway speed, *Nr* | 1320 Rpm | 1320 rpm |
| Spiral case longitudinal dimension | 11.2 Feet | 3.4 meters |
| Spiral case transverse dimension | 9.6 Feet | 2.9 meters |
| Draft tube length | 15.3 Feet | 4.7 meters |

***Table 2 – Economic Results***
***Rancho Pensaquito Pressure Control Hydroelectric Facility***

| Year | 2004 | 2013 | 2014 | 2015 | 2018 | 2023 |
|---|---|---|---|---|---|---|
| Avg. Annual Generation (MWHr) | 33307 | 33114 | 33029 | 32944 | 32127 | 30765 |
| Avg. Annual Energy Value ($/MWHr) | 24.8 | 43.8 | 44.4 | 45.1 | 47.2 | 50.8 |
| Operating Income | 825 | 1449 | 1467 | 1486 | 1515 | 1563 |
| O&M Costs | 48 | 55 | 56 | 57 | 59 | 64 |
| Net Operating Income | 777 | 1395 | 1412 | 1429 | 1456 | 1499 |
| Debt (beginning balance) | 8801 | 5866 | 5453 | 5020 | 3585 | 673 |
| Debt Service Payment | 706 | 706 | 706 | 706 | 706 | 706 |
| Interest Expense | 440 | 293 | 273 | 251 | 179 | 34 |
| Principal Reduction | 266 | 413 | 434 | 455 | 527 | 673 |
| Debt (ending balance) | 8535 | 5453 | 5020 | 4564 | 3058 | 0 |
| Cumulative Cash Flow | -8464 | -1552 | -413 | 765 | 4494 | 11430 |
| Investment Cash Flow | 777 | 1395 | 1412 | 1429 | 1456 | 1499 |
| IRR | | 3.5% | 5.2% | 6.5% | 9.2% | 11.2% |
| NPV | -8596 | -1133 | -386 | 315 | 2138 | 4391 |
| Debt Service Coverage Ratio | 1.10 | 1.97 | 2.00 | 2.02 | 2.06 | 2.12 |

***Figure 1***
***Francis Turbine Operating Envelope***
***(including simulated generation in year 2004)***

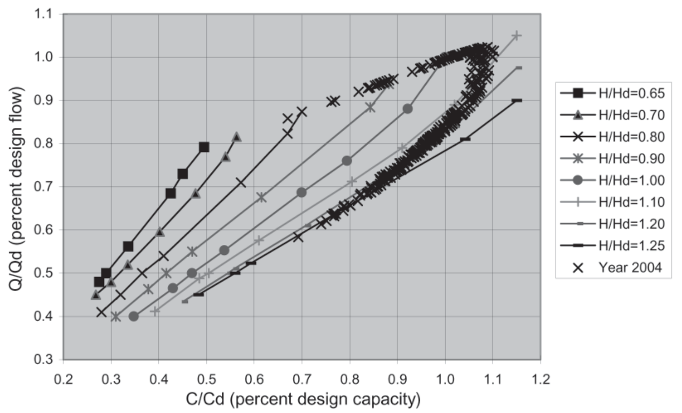
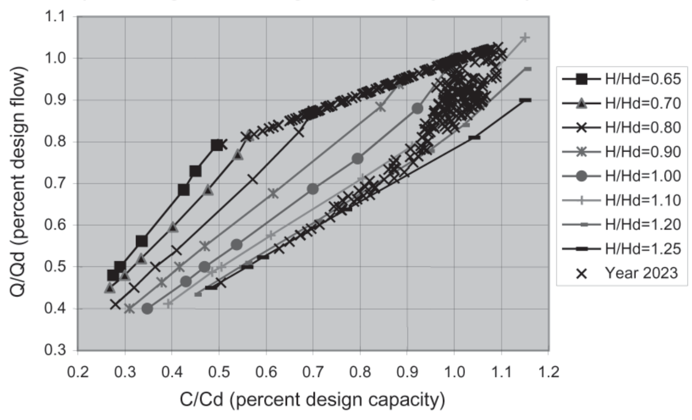



***Figure 2***
***Francis Turbine Operating Envelope***
***(including simulated generation in year 2023)***




and dimensions for the selected turbine are given in Table 1.

The economic results for a cash-flow analysis including energy values, O&M costs, debt service, interest payment, internal rate of return (IRR), and net present value (NPV) are summarized for selected years, as shown in Table 2. Capital investmant for the facility is estimated at $8.8 million. All monetary values are in $1,000 increment with the exception of energy values, which is in $/MWHr. The resulting payback period is between 11 and 12 years, or when the NPV or the cumulative cash flow becomes positive.

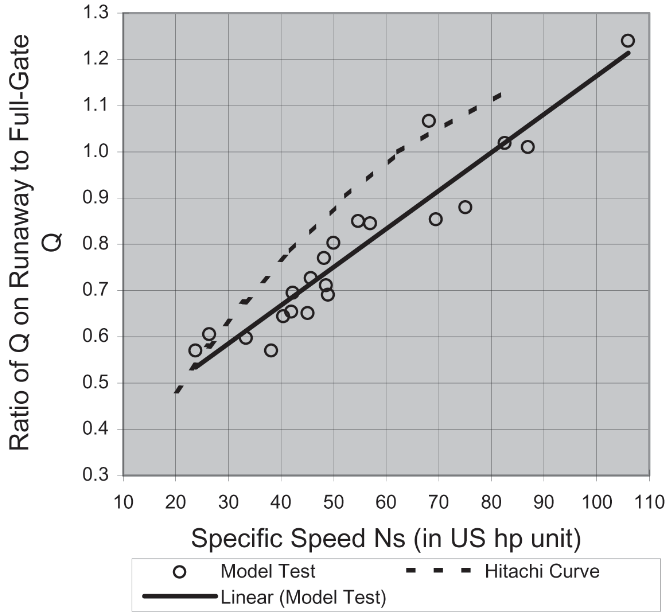
The power operation study results show that the average annual generation ranges from 33,007 MWhr in year 2004 to 30,765 MWhr in year 2023. These values represent a plant factor varying from 87 percent to 80 percent. High plant factor implies high utilization of the available flow, and is another indication that the turbine selection has been reasonably optimized.

**Considerations in Hydraulic Transients**

Transient flow can generally be divided into controlled and uncontrolled transient flows. The controlled transient flows are planned flow changes, such as line startup by opening and closing of control valves, valve stroking to adjust flows, turbine startup, turbine shutdown, or adjustments in turbine flows for increasing or decreasing power generation. Planned flow changes are considered orderly changes of the turbine or control valve settings, and will take the operation from one steady state condition to another steady state condition through transient flow in a controlled manner.

During normal startup and shutdown of the turbine unit at PCHF, one or two of the 42-inch sleeve valves will be used to close or open in synchronous operation with the turbine wicket gates. Ideally, the net change in flow may be reduced to zero by matching the discharge characteristics of the sleeve valve with that of the turbine. However, this is usually not possible because of the non-linear flow characteristics of the turbine and valves, and because of the dead time, or delay time, between the opening (or closing) of the valves and the closing (or opening) of the wicket gates. A preliminary computer simulation of this operation at the PCHF indicated that if the valve full stroke time is longer than 15 - 20 minutes, then the transient pressure rise or drop can be minimized.

*Figure 3*
*Discharge of Francis Turbines at Runaway Speed*




Uncontrolled transient flows are unplanned flow changes, such as caused by a sudden load rejection of the turbine due to earthquake or other events, when the generator is disconnected from the electric grid while power is being generated. Because the small inertia of the turbine/generator in relation to the water column in a long pipeline, the rotational speed of the turbine will increase from the synchronous speed to a runaway speed that could approach nearly 180 percent of the synchronous speed. Runaway is generally not a significant problem to the turbine or generator, since both can be designed to withstand this condition. However, the flow through a Francis turbine may be seriously affected by the high runaway speed. This flow change upon runaway could produce critical transient pressure conditions in the upstream and downstream pipelines since most water distribution systems are not routinely designed for such event. Surge tanks could be incorporated in the design to limit the hydraulic transients effect, but they are expensive and an appropriate site for the tank may not be obtainable. Synchronized flow bypass using control valves is not considered reliable for the emergency operation because of an unacceptable risk of mechanical failure.

Study (Harza, 1976) has shown that the change in turbine discharge on runaway depends on the design specific speed at full gate. A low specific speed turbine causes a throttling effect on flow, which would create high transient pressure upstream of the turbines. Similarly, a high specific speed turbine would cause a flow increase, which would create high transient pressure downstream of the turbine. The following is a plot of Hitachi experience curve, together with Francis turbine model test data and the associated trend line.

It appears that the zero change in flow could be technically feasible for a specific speed ranging from 62 – 80 at full gate, which depends on individual manufacturer's runner design. Therefore, one way to minimize the transient pressure impacts would be to require in turbine bid specifications a special provision for limiting the discharge change upon runaway, such as ± 5 percent to ±10 percent of full-gate design discharge. The bid documents should describe the turbine setting and the upstream and downstream head variations, and the design rotational speed should be left open to the bidders' choice, to allow manufacturers full flexibility to offer designs that will best meet the special provision on flow change. Model test should be required to provide testing data points near the runaway speed, which must have the discharge characteristics within the specified limits. A computer simulation using the model test characteristics should be performed, prior to a field test, to confirm that the transient pressures generated by a full-load rejection without synchronous bypass operation would not exceed the pipe design limits.

As the mechanical and electrical equipments constitute up to 85 percent of the total construction cost, it is also necessary to have thorough, complete, and unchanged specifications for the turbine generator prepared well in advance of the final design for civilstructure components. Vendor drawings are required for the completion of the civil-structure design so that all civil-structure components would accommodate the turbine and other equipment design.

**FERC Licensing Considerations**

The Federal Energy Regulatory Commission (FERC) may issue a conduit exemption license for a generating capacity up to 40 MW for a municipal project on an existing conduit. The PCHF would qualify for a conduit exemption not only under the capacity criterion, but also meeting the other criteria in that: (1) the conduit would be constructed even if the hydroelectric facility were not; (2) the project will be located on property in which the Authority holds real property interest; (3) the project will discharge into a water supply pipeline and will not rely on the construction of a dam; and (4) power generation will be a secondary usage of the project water.

The exemption process will require an initial consultation, in which an Initial Consultation Package (ICP) would be prepared in accordance with 18 CFR 4.38, and a Draft Exemption Application would be prepared in accordance with 18 CFR 4.92. The ICP and the Draft Exemption Application would be distributed to the resources agencies for review and comments. If all the issues can be settled and the Draft Exemption Application is revised to incorporate agencies' substantive comments, the revised Draft Exemption Application represents the Final Exemption Application, which will be filed with FERC. FERC would then issue a public notice, and if there were no intervention, the conduit exemption license may be issued in a matter of few months. Recent consultation with FERC staff has indicated that an application for exemption for a 39.6 MW installed capacity plant was approved by FERC in about two months.

**Conclusion**

Development of small hydroelectric facilities on water distribution systems is a small but significant step to promoting renewable sources of pollution-free power. A conduit hydroelectric facility is environmentally preferable to many other types of generation because it does not produce carbon dioxide, NOx, SOx, or other potentially harmful particulates that are major contributors to various pollution problems in an urban environment, and therefore, should be considered a genuine "green power" project. Fast implementation, long project life, zero fuel cost, and freedom from price volatility of fossil fuels should make similar conduit hydroelectric facilities an economic project in a competitive open market.

**References**

*Black & Veatch Corporation, "Hydroelectric Feasibility Study for Pipelines 6 and 5EII", a draft report prepared for the San Diego County Water Authority, 1996.*

*US Bureau of Reclamation, "Friction Factors for Large Conduits Flowing Full", Engineering Monograph No. 7, July 1977.*

*Harza Engineering Company, "Discharge of Francis Turbines at Runaway Speed", a study report prepared for the Metropolitan Water District of Southern California, June 1976*

**Authors**

*Dave P. Chamberlain, P.E., is a senior engineer at the San Diego County Water Authority. He is the Project Manager for the Rancho Penasquitos Pressure Control/Hydroelectric Facility and is responsible for managing other major Capital Improvement Projects.*

*Ed Stewart, P.E., is a principal engineer at the San Diego County Water Authority. He is a manager of projects, responsible for the Rancho Penasquitos Pressure Control/Hydroelectric Facility and other Capital Improvement Projects.*

*Fei-Fan Yeh, P.E., is a contract consultant from Washington Infrastructure Services, Inc. to the San Diego County Water Authority, providing technical assistance in the planning, design, engineering and construction of hydropower and pumped storage facilities.*

*Michael T. Stift, P.E., is the Assistant Director of Engineering at the San Diego County Water Authority. He is responsible for the administration of the Engineering Department and management of all aspects of the Capital Improvement Program.* ■

# Letter to the Editor

***The Editor, SHP News***
***HRC, China.***

**Dear Sir**

I will be delighted if you could offer me a space in your quarterly publication (SHP NEWS) to express my sincere appreciation and gratitude, firs to my employer, National Electric Power Authority ( Nigeria) for giving me the opportunity to be in China as a participant for the 2004 TCDC International training Workshop on Small Hydro Power and Equipment at HRC. My Sincere appreciation also goes to the Government of the People's Republic of China by her mutual thinking to provide financial support to this Center, through the Ministry of Water Resource of China and Ministry of Foreign Trade and Economic Cooperation, to be organizing this International Workshop since 20 years ago.

I will not forget to mention the eminent financial support given by the UNDP, UNIDO since establishment of this Center in 1981. I hope they will give more support to the Center, because the world community especially the developing countries will never forget the important role HRC played in providing technical information on small hydropower design which now leads to finding solution to the rural electrification problems in the developing nations. People says seeing is believing who ever is opportune to attend this international training will believe me that China has made a tremendous progress in the area of small hydro, how ever China being No.1 in the world in small hydro power development is not just by chance I will repeat once again seeing is believing.

During the training workshop I was highly impress with the lectures delivered by both the HRC engineers and the invited guest lecturers, also the facilities in placed for the training are relatively ok for such a training, the study tour is well organized, we have received a warm welcome by all the small hydro power stations visited, plant and electrical manufacturers, I want to be specific here the CHINT electrical and equipment manufacture deserve a credit for their kind gesture.

A credit marks also goes to all HRC staff especially the coordinators in person of Mr. Pan Daqing, Ms. Shen Xuequn, Mr. Wuhao is not left behind he gave us a company all the time, the HRC Deputy Director Ms. Cheng Xialei which despite of her official commitment also traveled with us during the study tour and then the chief overall coordinator, the Director HRC, Mr. Chen ShengShui. In conclusion I congratulate HRC for the successfull coordination of 2004 TCDC international training workshop, the course is not only a medium for information exchange between China and the developing countries, but also it enhance cordial relationship/friendship among the developing countries, the participant and the entire Chinese community.

Thanks
Mamuda Abdullahi
National Electric Power Authority
Cooperate Headquarters
Nigeria
Nov., 11, 2004