# 2002 TCDC Training Workshop on Small Hydro Power



*TCDC(Technical Co-operation among Developing Countries) SHP Training Workshop was closed at Hangzhou Regional Center for Small Hydro Power (HRC) on 18 Nov 2002. Attended altogether 23 participants from 14 Asian and Oceanic countries.*

HRC's certificates were issiued to them. With their national dresses, the international participants were excited and active in presenting comments or speeches on the SHP training at HRC at the closing ceremony. Though the duration of 40 days is short, the participants benefited much from the training. The monitor of the class, Mr.Wongsavasdi from Thailand addressed: "We all feel to have learnt a lot from the SHP training workshop implemented by HRC. The subjects covered were just appropriate for our countries. We'll apply the SHP technology and experience we have learnt here in China into our work back home. The kindness and hospitality shown by the friendly Chinese people were unforgettable. On behalf of all the class, I am here to say: "Thank you, HRC!" Some of the participants burst into tears when they reluctantly left HRC for their home countries.

During the training, the participants were arranged to visit some SHP stations of various types and hydropower equipment manufacturers. They went to Nanjing Hydraulic Research Institute to visit the Experi-

ment Base which is the largest base of the kind in East China. There, participants were very much impressed with the detailed and vivid introduction by Mr.LiuHeng, Vice Director of Nanjing Hydraulic Research Institute. In Shanghai all the participants were surprised by the development level, vigor and by its skyscrapers of the city. They concluded China is such a dynamic country that it'd contribute more to the world peace and development.

Upon the end of training workshop, HRC arranged a forum for the exchange of SHP experience and technology. Representatives from the 14 countries presented their country reports, introducing the experiences and lessons learnt in the practice of developing SHP in their own countries. The computer aided presentations were well prepared and informative, often interwoven by the heated discussions. Some presentations introduced the fast development of SHP and addressed the SHP policies of their own countries, attracting the attention of many listeners, as the legal issues are actually a very important aspect of SHP exploitation.

This training workshop is sponsored by Chinese Ministry of Foreign Trade and Economic Cooperation, as one of the technical collaborative projects among the develping countries. All the lodging, boarding, training, pocket money and the domestic transportation fees are borne by the Chinese government. This is part of the Chinese contribution to South-South cooperation.

In 2003, HRC is planning to conduct 2 international training workshops on small hydro power based on the actual need of the vast developing countries. The one already fixed is to be implemented from 9 May to 18 June 2003. ●

# Speech at the closing ceremony of 2002 TCDC SHP Training Workshop

*Prof. Chen Shengshui*

**Director of HRC**

Good morning,
Ladies & Gentlemen,

I am honored to be with you this morning. You all came far away from Asia, Oceania to Hangzhou! On behalf of all HRC staff, I'd like to extend my warm welcome to you for attending the 2002 TCDC SHP Training Workshop.

This training workshop has been sponsored by Chinese Ministry of Foreign Trade and Economic Cooperation, as part of China's contribution to South-South Cooperation or TCDC activities. TCDC means technical cooperation among the developing countries, to share the expertise, the facilities and the financial cost among the developing countries.

HRC has been active in promoting the global SHP development in the past years and you have become part of this process! So far over 600 international participants from nearly 70 countries attended the training programs that HRC conducted. Our SHP missions for SHP feasibility study, design or construction supervision have been implemented over 30 countries in the world.

Early this year I have been appointed by the Chinese government as Director of HRC and I will do my best with my colleagues including you — our international friends committed to promoting the SHP construction in the developing countries.

China is vast and rich in hydropower resources, accounting for 680 mil kW, of which 380 mil kW is the exploitable resources. The SHP exploitable resource is around 87 mil kW. However, the installed capacity of SHP exploited only reached around 30% of the total exploitable SHP resource. The three batches of constructing over 600 counties of primary rural electrification program in China have been completed. Now, Chinese government has decided to set up 400 rural electrification counties during 2000 and 2005 as the fourth batch. With the increase of SHP installed capacity and the development of local grids, the SHP in China has become a new and proven industry with unique features. In the recent years, the State advocates reducing the electricity price for the rural farmers and reforming the electricity supply as a commodity into market oriented operation. A series of favorable policies that the Chinese central and local governments adopted to stimulate the exploitation of SHP have resulted in the large-scale SHP construction, rural grid improvement, SHP station technical renovation and cultivated the market of SHP technology and equipment.

SHP is a sort of renewable and environmentally sound energy. It has a bigger role to play if combined with environment improvement, poverty-alleviation, flood prevention, fresh water supply, rural irrigation, navigation, fishery and tourism. Thus, more and more countries in the world are beginning to pay attention to harnessing it.

We belong to the developing countries and we share much in common. There is a bright future of SHP cooperation ahead of us.

Participants, Hangzhou is a well-known city of long standing in China and it served as capital of China for over 200 years in the Chinese history. With the implementation of reform and opening policy during the past 20 years in China, tremendous changes have taken place around the city. Apart from your study of SHP technology to serve your own country in the promotion of SHP development after going back, you'll have chances to see and experience what is going on in Hangzhou and in the other Chinese coastal areas.

Over one month study here at HRC is not long, however, I do hope you could benefit from the exchange of SHP experience and technology, and strengthen the international cooperation of SHP among various countries. We share the same objective: To stimulate the exploitation of SHP which is a renewable and environmentally sound energy appropriate for the vast rural areas in the developing countries.

Finally, I wish your study fruitful and your stay pleasant! ●

# MINI AND MICRO HYDRO POWER DEVELOPMENTS

*Arieta Gonelevu*
Senior Scientific Officer
*Fiji Department of Energy*

**General Introduction of the Republic of the Fiji Islands**

The Republic of the Fiji Islands is made up of more than 300 islands that is located in the South Pacific Ocean at latitude $15^{o}$22S and longitude 174E$^{o}$177W. The group extends over a total area of about 104,000 sq. km of which land occupies approximately 18,300 sq.km. The two main islands are Viti Levu and Vanua Levu accounting for 58% and 34% respectively of the total land mass. The total population of Fiji is 740,000 and it enjoys a tropical climate with both dry and wet seasons over certain periods in a year. Fiji's economy depends mainly on sugar and tourism.

The Fiji Department of Energy (FDOE) is responsible for national energy policies, energy efficiency and renewable energy development, and rural electrification. Its mission is to facilitate the development of a resource efficient, cost effective and environmentally sustainable energy sector in Fiji.

The Fiji Electricity Authority is responsible for the development, generation, transmission and distribution of electricity on the islands of Viti Levu, Vanua Levu and Ovalau. Since the commissioning of the Monasavu Hydro-electric Scheme on Viti Levu in October 1983, 90% of Fiji's total electricity demand was met from hydropower resources generation from the 80 MW Wailoa Power Station. Hydropower is a proven and mature form of renewable energy but its future expansion in any form will have to take into account both environmental and social issues.

**Hydropower**

It has always been in the interest of FDOE to promote the use of renewable energy resources and exploit these resources to provide high quality energy. For the island populations, options for electricity generation will be limited to finding local island solutions. FDOE has, over the

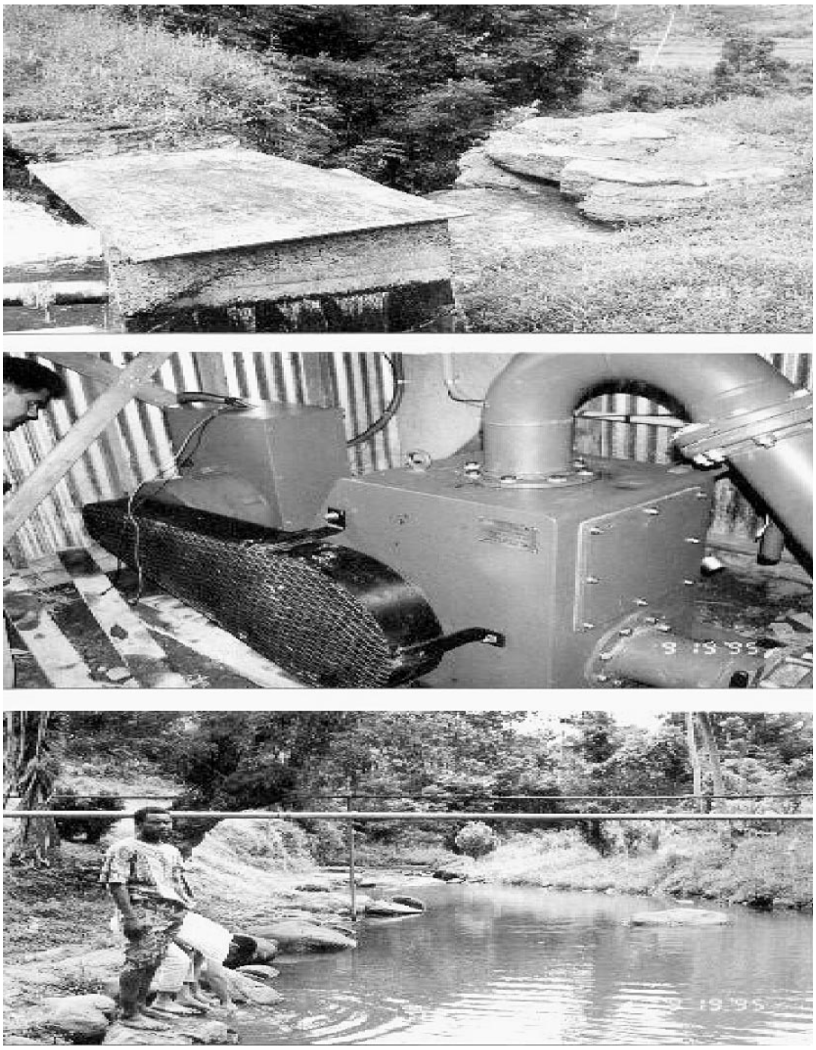

**Photo 1: Vatukarasa Mini Hydro**

decade, explored options for electrification of rural areas.

Due to its tropical climate, Fiji is well endowed with hydropower resources for development of both large and small-scale hydropower projects. FDOE's Hydropower Assessment Programme focuses on the following objectives:

- To assess all potential mini/micro hydropower sites throughout Fiji and determine their feasibility
- To rank all potential sites within Fiji which would facilitate a more detailed examination and subsequent development
- To ascertain the viability of the sites that have been identified and
- To prepare pre-feasibility study reports for viable sites.

A countrywide study, undertaken by FDOE through ADB funding, identified close to 100 small-scale hydropower project potentials. These sites are now being studied by FDOE to confirm their development potential for meeting small electricity demands. Needless to say, Fiji has a significant large-scale hydropower resource potential. Fiji's next best option for hydropower development is Vaturu Water Catchment Scheme followed by Wainisavulevu/Wainikasou diversion. Significant hydropower development potential lies in Fiji's largest rivers such as Sigatoka, Ba and Navua.

Based on the results of our Hydropower Assessment Programme, hydropower was incorporated into the RE policy as an electrification option. The most recent hydropower project, undertaken by FDOE, is the 30 kW Muana Hydropower Scheme that was funded by the Korean Government through the Korean International Cooperation Agency (KOICA), at a cost of $US200, 000. The Government of Fiji met the local costs. The project is for the electrification of three villages of Naqaravutu, Wailevu and Muana in the southern coast of Vanua Levu in the Natewa Bay. The three villages have approximately 136 households with a population of 600. The three villages also host a primary school, a health center, grocery shops, community halls, etc.

**Developments of Mini/Micro Hydropower**

Hydropower systems use the kinetic (motion) energy in flowing water to produce electricity or mechanical energy. The water flow via channel or penstock to a waterwheel or turbine where it strikes the buckets of the wheel, transforming the kinetic energy into mechanical energy by causing the shaft of the waterwheel or turbine to rotate. When generating electricity, an alternator or generator, which is connected to the rotating shaft, converts the mechanical power in the motion of the shaft into electrical energy. The electrical energy may be used directly, stored in batteries or converted from direct current (DC) to alternating current (AC).

Mini hydropower systems generate between 100 and 1500 kW. Micro hydro systems generate up to 100 W. The power available in a flow of water depends on two factors:

- The vertical distance the water "falls" referred to as

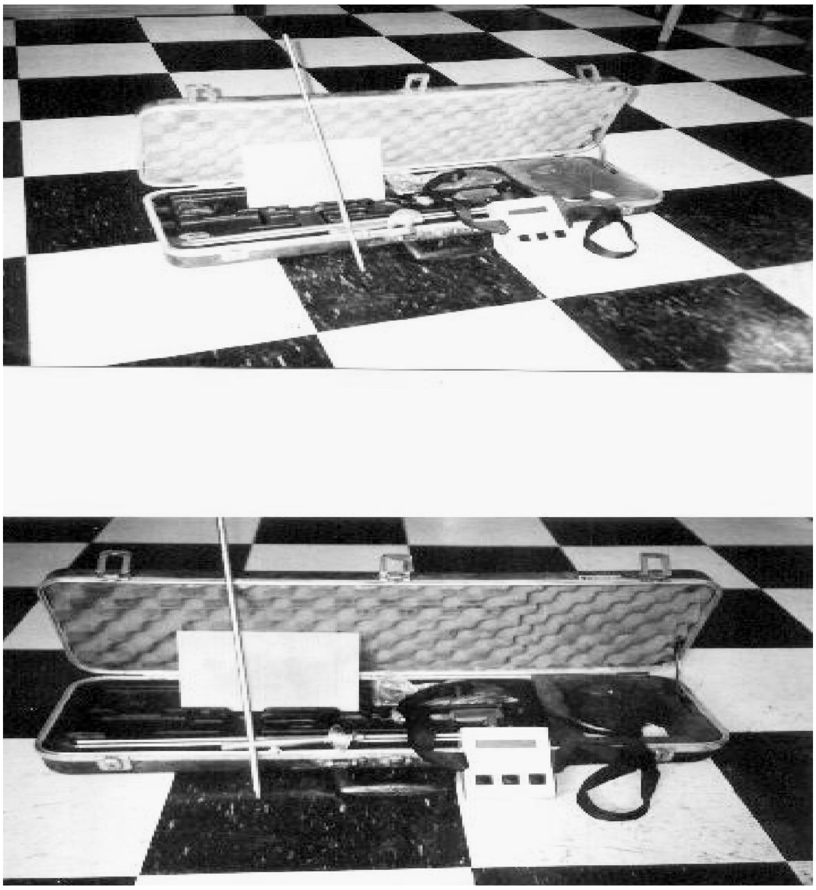

**Photo 2: Hydro Monitoring Equipments**

head (measured in feet or meters)

· Flow rate, which is the volume of water flowing past a point in a given time (measured in cubic feet or cubic meters per second)

Mini/micro hydropower electricity is an ideal energy option for the rural areas because of its low operational, maintenance and repair costs. It produces clean energy and also it is more secure and reliable when compared to other options especially for areas where transmission of grid power is difficult.

Hydrological data have been supplied by the PWD Hydrology Section at locations where gauging of stream flows has been carried out in the past. However, in most instances no previous stream gauging has been undertaken and flows at time of site inspections were estimated and used in the design. Some of the sites have been examined in more detail on the ground and approximate survey checks have been made to check available heads, etc. for the preliminary designs of some of the schemes.

At all sites further survey will be required before final design work can commence and more accurate cost estimates derived. Likewise, more stream flow data should be gathered, particularly during dryer periods to assess the firm energy available at the individual sites.

Environmental impact as a result of the implementation of any of these schemes would be marginal. Although the sites are relatively close to village centers, the village themselves are remote. The aqueduct and penstock routes have been chosen to avoid unstable ground and to avoid the occurrence of landslides, etc.

**Survey Procedure**

When villages request for hydro survey through the provincial office or to DOE, the survey team list the villages and undertake field survey at the potential sites. Contents of investigation are to measure the discharge at potential site and gross head between the potential site and the proposed powerhouse site –the main purpose of this part of the investigation is to collect the data in this dossier and data collected via these surveys and investigations.

**Table 1. In operation, undr designing and monitoring project in Fiji**

In Operation

| | NAME | PROVINCE | HEAD | CAPACITY | INSTALLED |
|---|---|---|---|---|---|
| 1 | Nasdiga | Taievin | 30 m | 4 kW | 1994 |
| 2 | Marist Tutu | Cakaudrovs | 155 m | 20 kW | 1975 |
| 3 | Wairiki | Cakaudrove | 50 m | 8 kW | 1930/1986 |
| 4 | Bukuya | Ba | 161 m | 100 kW | |
| 5 | Wainikeu | Cakaudrove | 122 m | 800 kW | 1992 |
| 6 | Vatukarasea | Talievu | 10 m | 3 kW | 1993 |
| 7 | Kadavu-koro | Kadavu | 40 m | 20 kW | 1994 |
| 8 | Muaria | Cakaudrove | 40 m | 30kW | 1999 |

Designing

| | Village | Province | Head | Capacity |
|---|---|---|---|---|
| 1 | Abaca | Ba | 81m | 10kW |
| 2 | Raviravi | Ra | 50m | 7kW |
| 3 | Nalkorokore | Kadavu | 74m | 15kW |

Monitoring

| | Village | Province |
|---|---|---|
| 1 | Koroboya | Ba |
| 2 | Buca | Cakaudrove |
| 3 | Naqarawa | Namosi |

Following the filed survey, all potential min/micro hydro sites in the county will be ranked to prioritize the sites for long-term hydrology (water level, rainfall, flow rate, etc.) data accumulation for the three-year monitoring period.

**Problems associated with small hydro development in Fiji**

The Fiji Islands generally have topographical and meteorological characteristics that present a number of problems regarding small hydroelectric developments. Most parts of the islands are subject to dry seasonal periods or dry periods between heavy rainfalls. With the generally steep topography in areas where hydro sites might be expected there is a rapid runoff and unless there is a considerable ground water feed to the stream, discharge falls off rapidly to some base flow which may be very limiting as far as firm power production is concerned.

On the other hand all parts of the island are subject to occasional very high rainfalls and intensities, particularly during the passage of tropical cyclones near or over the islands, which result in very sever flooding in the streams. These floods introduce certain problems affecting the design, operation and maintenance of diversion and intake structures. Although most streams considered fro these small scale hydro electric developments convey naturally clear water during dry weather or even medium flows, during flood discharges they carry a bed load of cobbles, gravel and sand as well as floating debris which cause potential problems in small intake works. Furthermore during high rainfall periods most catchments are subject to landslips in steeper areas and this adds to debris carried down by the flood.

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# Electrification of Lao P.D.R

—— **COUNTRY PAPER**

*Lao P.D.R is a land locked country in South East Asia, between China in the north, Vietnam in the East, Thailand and Myanmar in the West and with Cambodia in the South.*

**Mr. Sithanh Vongsiry,**
**Mr. Khamphanh Vanlasy**

Vientiane
**Lao P.D.R**

**1 General Condition**

Population of Lao P.D.R is about 5,5 million.

- Capital city is Vientiane, which is located in the central part of the country.
- Land area is 236,800 Sq.km, of which two-thirds is mountainous area.
- Our country is divided into three major zones, as follows:

1. Northern zone is comprised of sloping and mountainous land, that varies in altitude between 500 to 2000 meters above sea level.
2. Eastern zone is the same condition with altitude 500 to 2000 meters above sea level.
3. Western zone generally ranges from 100 – 300 meters above sea level.
4. The Lao P.D.R has a tropical climate with average temperature of 26 degrees, there are two seasons: the wet and dry season.

The wet season is from May – October and the dry season is between November – April, the mean annual rainfall is 1600 mm-2000 mm or more in mountainous area, of which 75% to 90%, occurs during the wet season.

There is abundance of water resources in my country. The main basin of water resources in Lao P.D.R comes from the 17 major rivers of the country. They flow from north to south with a distance of 1870 km, traverse through country's total land mass. Abundant rainfall combined with high density river system (with a total water course length of 30,000 km), produces an annual runoff volume discharge into the sea of 223,000 million cubic meters.

From the geography and water resources available of the Lao P.D.R, we have great potential for development of hydropower, even small, medium and large hydropower projects. Development of these resources can contribute to the supplying of electricity to households, offices, hospitals and schools in the mountainous area. Energy is also available for agricultural processing such as rice mills, handicraft and cottage industries.

Most of the people in these areas depend heavily on "slash and burn" for their living. As a result, the natural ecology and environment is quickly destroyed. So the quantity of water in upland streams in dry season is diminishing at a high rate. On the other hand during the wet season, when rainfall is heavy, the land is being destroyed by soil erosion thus causing flooding in the low lands. To solve those problems we have to develop hydropower projects in our country.

**2 Hydro-Power Development in Remote Rural Areas**

At present, the main purpose of energy supply to the rural people is for developing their living standards, like in the city areas. The plan for supplying electricity to rural and remote areas will be carried out by means of expanding transmission lines from existing substations, setting up diesel generating plants and generating electricity from renewable energy resources, for example: micro hydropower. However problems encountered in the development of this plan could be described as follows.

1. High investment cost for the expansion of transmission lines to the scattered villages, but the power consumption and the load factor of the systems are relatively low. This is due to the fact that electricity is mostly used for domestic purposes.
2. Generally the investment required for setting up the diesel generating plants is relatively low, but because of the high operating costs including fuel and O & M, the cost of electric power production is rather high.
3. Generation of electricity from hydropower is very desirable because hydropower is indigenous, renewable and it can be developed near the area where the load demand is.

In the past, however only a small number of micro hydro generating plants have been built as a result of high development costs, as compared to the major hydro generating plants. The power produced from these big projects are used mainly in the municipality areas of towns, districts and some spots along the transmission line route, and some are exported to the neighbouring country.

At the present it is necessary to find a solution, which would reduce the development costs.

**3 National Energy Plant**

As Lao.P.D.R. has plenty of renewable energy resources such as coal, wood, etc, recently we are highlighting hydropower as the best option for electricity development for country with combination of a mountainous terrain and heavy rainfall. This will provide extensive potential for the generation of hydro electricity in the country.

- For the medium and large hydropower station, at present we have a total installed capacity of 615 MW.
- The small hydropower station in the country has a total capacity of about 12 MW.
- The micro-hydro power station has a capacity of 2 MW.

And the diesel generating plants have a total capacity of about 16 MW. The total capacity of the energy plant of my country is 645 MW.

**4 Energy Requirement and Supply in Lao P.D.R**

1. Energy Requirement

- In 1985 the country total energy demand ***213.2 GWh***
- The 1990 energy required ***289.4 GWh***
- The 1995 energy required ***465.9 GWh***
- The year 2000 energy required ***657.1 GWh***

2. Forecast of Energy Demand of Country

- In the year 2005 energy demand ***858.3 GWh***
- In the year 2010 energy demand ***1,963.00 GWh***
- In the year 2020 energy demand ***2,798.00 GWh***

3. Forecast of Peak Power Demand

- In the year 1995 peak power demand ***128.2 MW***
- In the year 2000 peak power demand ***216.0 MW***
- For in the year 2005 peak power demand ***320.1 MW***
- For in the year 2010 peak power demand ***464.2 MW***
- For in the year 2020 peak power demand ***700.0 MW***

4. Policy and Development Plan (for Electrification in Lao P.D.R)

The government of Lao is aiming to develop about 16 small hydro sites, 22 medium and 30 large hydropower sites.

In 2001 to 2010 the government of Lao has projected 6 medium hydro plants as follows.

1. Nam Mang-3 (2002-2004) with installed capacity ***35 MW***
2. Xeset-2 (2003-2006) with installed capacity ***76 MW***
3. Xepon (2004-2006) with installed capacity ***75 MW***
4. Nam Ngum-5 (2005-2007) with installed capacity ***100 MW***
5. Xeset-3 (2006-2008) with installed capacity ***20 MW***
6. Houay Lam Phan (2008-2010) with installed capacity ***60 MW***

With the total investment cost of about ***548.70 million USD***

The hydropower resource development in Lao .P.D.R is very important for the development of the whole country. ●

# Prospect Of Small Hydro Power Development In Indonesia

**——Country Report**

***Suroso***

YAYASAN BINA USAHA LINGKUNGAN(YBUL)

JAKARTA

**INDONESIA**

## 1.INTRODUCTION

### 1.1. Background

The Republic of Indonesia is the world's largest island nation, with a population of more than 200 million spread over more than 17,000 islands (about 6,000 of which are permanently inhabited). The nation lies astride the equator, and stretches for more than 5,000 km from the west to east. The principal island areas of Indonesia include densely populated Java, with 58 percent of the nation's population on 7 percent of the land; Sumatra; Kalimantan sharing the island of Borneo with Malaysia and Brunei; Sulawesi; and Irian Jaya sharing the island of New Guinea with Papua New Guinea. Other islands include Bali, the densely populated tourist destination; Batam and Bintan in Riau Province near Singapore; and Lombok, Sumbawa, Flores, West Timor, Ambon, Seram, and Halmahera in the eastern provinces.

Indonesia comprises extensive coastal plains with mountainous terrain inland, formed by volcanic action and tectonic uplift. Smaller islands have been formed by volcanic activity, coral growth and uplift. The climate is tropical, with hot and humid weather year round. Temperature decreases with elevation in the mountains. Rainfall is heavy in most areas, with seasonal patterns influenced by monsoon winds from Australia and the Indian Ocean. Precipitation generally increases with elevation, and is heaviest in most parts of Indonesia from December to March.

The collapse of the Rupiah in late 1997 and early 1998 caused Indonesia's GDP to contract by 14% in 1998 as a result of Indonesian firms' reliance on short-term dollar-denominated debt and high levels of non-performing loans in the banking sector. The Indonesian government is committed to implementing an extensive series of reforms and a bank capitalization program, but progress has been slow, leading to further losses in investor confidence and outflows of capital. Inflation, which peaked at 77% per annum, is now significantly lower. Signs of slow economic recovery are now appearing. To date, however, political uncertainty continues in Indonesia, corruption is still rampant and the banking system remains in tatters, with defaulted loans totaling many billions of US Dollars to be restructured and new credit still almost unavailable.

### 1.2. Electric Power Sector Characteristics

The electrical power sector in Indonesia is dominated by the government-owned electric company PT. PLN (Persero). Another important issue to be discussed is how this monopoly will affect the deployment of renewable energy resources in bulk power markets. There is a need, for example, for regulation of retail electricity. Suppliers should create economic incentives that promote full consideration of renewable technologies for bulk power, distributed generation, and demand-side applications. On the other hand, wholesale competition is not likely to favor renewable energy in bulk power markets. Compared with long-term bilateral power purchase agreements, short-term or spot markets make it more difficult to finance and develop renewable generation options.

At present, the electric power sector in Indonesia is heavily subsidized. The subsidies on energy were originally established as part of a social development policy. The monetary crisis in 1997/98, however, completely unbalanced this system of subsidies: while the retail electricity selling tariffs could only be raised marginally due to the difficult political situation in the country, the power production cost increased tremendously. One reason is that PLN had signed power purchase agreements with 27 Independent Power Producers (IPPs), under which it had agreed to pay for power supplies in US Dollars.

The sharp drop of the Indonesian Rupiah against the US Dollar has rendered PLN unable to meet the financial obligations to the IPPs and, as such, it is now seeking to renegotiate the contract terms. Another reason is that PLN has to purchase the gas for its power plants, as well as most spare parts at world market prices in US Dollars.

This has left PLN in a highly uncomfortable situation with huge foreign debts and unable to serve its loans in US Dollars on one hand, and legal suits by a number of IPPs and lenders on the other hand. The ongoing restructuring process within PLN, and the uncertainty regarding its ownership (governmental or private) further complicate PLN's situation. As a result, PLN is currently unable to implement new projects and to add to its power generating capacity.

As of March 2001 the state company PLN had identified 29 critical areas prone to rotating power cuts due to a lack in generating power. PLN is currently unable to add to its power generating capacity due to its financial constraints. The lingering disputes between PLN and the IPPs over contracts have damaged the bankability of the state company in the eyes of the world's financial community and made it almost impossible for PLN to raise offshore financing for its investments.

**1.3. Rural Electrification**

Indonesia has been committed to rural electrification for many years. Into the 1990's, PLN maintained an aggressive campaign to extend its main grids and to establish small grids in isolated areas to serve an increasing percentage of the population.

Progress in electrification is reported on a village basis. As of March 2001, about 79 percent of villages had been electrified. The rural household electrification percentage on the other hand is only 41 percent. These figures indicate that, although PLN has achieved a fairly high village electrification rate, a large number of households still remain without electricity supply. This is mainly due to the large distance of many houses from the main line and the lack of funds by PLN to expand their distribution lines within each village system.

The PLN grid extension program has become increasingly costly as a result of: 1) the increasing cost per customer for transmission and distribution as more remote areas are electrified; 2) the high cost of supplying fuel to diesel generators serving isolated small grids; 3) the small amount of electricity consumed by customers in rural areas and the subsidized rates, making recovery of capital expenses using the traditional electrification model very difficult.

As of March 2001, the total number of villages still not connected to a PLN grid was more than 10'000, with an estimated 20 million people. As a result of the continuing economic crisis and PLN's financial collapse, the government has now been forced to reduce annual expenditure in the village electrification program.

**1.4. Privatization**

The current centrally planned, state-owned electric power system will gradually give way to privately owned and managed generation, transmission and distribution companies. These changes are intended to reduce public debt, enhance accountability, and improve consumer service. Privatization is unlikely by itself to increase the market share of renewable energy. Privatization can promote renewable energy by introducing new capital. On the other hand, higher discount rates and short time horizons of private investments may favor non-renewable energy-based business endeavors.

**1.5. Power and Energy Cost Structure**

At present, the price of electricity to end-users (retail tariff) is heavily subsidized in Indonesia. The average long-run marginal cost (LRMC) of electricity supplied to the costumers by PLN for production cost is estimated at IDR 600 (USD 0.060) per kilowatt-hour (kWh). At the same time, the national selling price for power averages at IDR 350 (USD 0.035) per kWh. Retail tariffs are uniform throughout Indonesia, without regard to the variation in costs of generation, transmission, and distribution in different regions.

PLN currently purchases excess power from captive or community power plants on a case-to-case basis at up to 80% of the retail electricity tariff. Being aware of its inability to increase its production capacity and meet the growing demand, PLN currently also shows interest to purchase electrical power from IPPs. The purchase tariff offered, however, is not taking into consideration the real long-term production cost of PLN's own generation in the respective area, and currently is far too low to be attractive for IPPs.

**1.6 Hydropower Resources**

Hydro power potential in Indonesia is 75.000 MW, potential for small hydro power is 7,500 MW (10%) and 200 MW has been developed. Small hydro potentials is distributed around the islands, can be develop as Local Energy Resources especially in remote areas for Rural Independent Power Supply. Several small hydropower projects have already been identified in the country.

A study of JICA conducted in the early nineties has identified around 10 small-scaled hydropower projects for the Ministry of Cooperatives.

PLN mini-hydro has identified and studied 75 mini-hydro projects (generally smaller than 1,000 kW), and constructed a small number.

Generating equipment suppliers have identified at least 40 projects for captive users.

**1.7 Previous and Ongoing Development Efforts**

In the past, numerous efforts have been made by both the Indonesian government and cooperatives to generate electricity using small-scale hydropower technologies, but the results are still minimal. The Department of Public Works, Directorate General for Water Resources Development, has been including micro-hydro in its projects for a number of years, whenever flow and head conditions are favorable. Unfortunately, these limited attempts to exploit Indonesia's vast hydropower potential have almost come to a complete halt, after the rural development programs had to be suspended in the face of the country's severe economic and financial crisis.

**1.8 Models for Hydropower Development**

Three models for hydropower development: captive power plants, small plants that sell power to the PLN grid, and isolated plants operated by community groups for rural electrification. It will broaden the nation's awareness of the benefits of smaller hydro developments, and will mobilize and enhance Indonesian resources so that hydro development becomes a viable, long-term alternative to fossil fuels for electric generation.

## 2. BARRIERS TO SHP DEVELOPMENT

With its mostly hilly terrains and high precipitations distributed over a large part of the year, Indonesia is blessed with an abundant potential for small-scale hydropower development. Due to various reasons, however, this potential remains still largely untapped. Based on experience gained in previous attempts to exploit this potential, the common barriers to sustainable small-scale hydropower development.

### 2.1. Structural and policy-related barriers

Currently, one of the most important common barriers to broader small-scale hydropower development in Indonesia is the tariff structure in the energy sector. The actual electricity retail sales tariffs – which are fixed below production cost and thus are heavily subsidized – make it very difficult to develop hydropower projects on a purely commercial basis in areas that are already reached by the PLN grid. In remote and isolated regions, due to the also subsidized price for diesel fuel, diesel generators often appear economically and financially more attractive than hydropower schemes that normally do not benefit from any subsidies.

Legal, policy, and financial conditions currently are perceived as negative for projects touching on PLN in any way. Information needed to make rational business decisions in the power sector is often unavailable, due to a lack of transparency regarding procedures at PLN, DGEEU[1], and Pertamina, the state oil and gas company. Development planning information has been closely held, and detailed financial information (including cost of production in different areas and at specific plants) is unavailable.

There are no standardized procedures and technical codes and standards existing for renewable energy development in general, and for small-scale hydropower development in particular.

Lengthy and not standardized procedures to obtain power purchase agreements, as well as a lack of technical support impede inter-connection of small-scale hydropower schemes with the PLN grid, frequently cause project failure.

Imported equipment for hydropower schemes is expensive, and spare parts are often difficult to obtain. This situation has been accentuated by the monetary crisis and the resulting devaluation of the Indonesian Rupiah, generally disfavoring any imports.

A consistent and transparent government policy supporting renewable energy development is still greatly lacking. As opposed to other rural electrification options, such as grid extension or diesel generators, there are no subsidies, nor any other financial incentives supporting renewable energy development. There is also no target set by the government regarding the share of renewable energy in the country's overall energy mix.

Development plans (such as plans for extension of electric lines into new areas) are not coordinated among PLN, local governments, local residents and cooperatives, other government companies and agencies, and private businesses. Political and outside business motives are often suspected to play a role in development decisions.

There is often a lack of productive end-uses for power in rural areas. As a consequence, load factors of small-scale hydropower schemes often are low, with demand peaking during only a few hours in the evening. The revenues from electricity sales of such schemes often are not sufficient to cover overall production cost.

**2.2. Barriers related to technical and institutional capacities**

Stakeholder involvement is often neglected during project selection, planning, and implementation. Active stakeholder participation is especially important for community-based systems, where the stakeholders will be managing and paying for a project upon completion. If stakeholder involvement is neglected, the project acceptance and sense of ownership by the stakeholders is often low, resulting in short project lifetime.

The quality of project selection and evaluation studies is in many cases insufficient.

Pre-investment financial evaluations are often poor quality or are lacking altogether. Many businessmen and other potential developers are not familiar with the advantages and importance of preparing good business plans, as well as cash flow and cost benefit analyses.

Technical problems, resulting from poor design and construction quality (civil, mechanical, and electrical), are common with many small-scale hydropower schemes, and mostly have the same effects as described in the previous paragraph.

Local equipment design and manufacturing capability is limited, and is mostly concentrated on Java.

There are no mechanisms in place (e.g. product liability, quality assurance, technical control institution) that warrant the quality of small-scale hydropower development.

Plant operation and maintenance is often haphazard, with little preventative maintenance. The result are frequent and often long-lasting power outages, which in the case of isolated plants require the customers to possess redundant equipment for lighting, cooking, etc. This hampers the trust in the technology in general, as well as the willingness to pay for the electricity supplied by such schemes.

Project development organizations often have a poor financial record keeping and revenue collection. The consequence is in many cases the inability to recover investment and production cost, leading to poor project performance and hindering replication.

Project owners often lack in managerial and organizational capacities required to sustainable operate a mini or micro hydropower scheme.

**2.3. Barriers related to financing mechanisms**

Financing for small-scale hydropower development is unavailable or difficult to locate. Prior to the financial crisis, banks were not lending for hydro or other renewable energy projects, because they were not familiar with the technology, and because the returns did not appear to be as high as for other investments. Currently, Indonesian and international banks are usually not willing or able to lend for any type of project.

Private energy suppliers face higher interest rates than government entities, and will prefer conventional energy options with lower capital costs, shorter payback periods and lower up-front investment cost.

There is a lack of micro-credits for the rural population to purchase electric appliances other than for lighting and thus to invest in productive activities based on electricity end-use.

**2.4. Barriers related to awareness and information**

Many institutions and decision-makers are not aware of the possibilities for small-scale hydropower development. The result is often that conventional energy options are preferred, where the potential for hydropower would be promising.

Regional government involvement in development decisions is becoming increasingly important as increased local autonomy is implemented. Up to date, however, there is little understanding of the electric business at that level.

There is no center or network existing that collects and disseminates information on all aspects of small-scale hydropower development. The lack of broadly available information on past experience with hydropower development – for example in the form of lessons learnt and best practices – often results in the repetition of the same mistakes and shortfalls in the efforts to implement projects.

Basic data needed for project evaluation (maps, surveys, hydrology, geology) is often missing or difficult to obtain, especially for more remote regions.

A frequently updated and easily accessible inventory with potential small-scale hydropower sites is currently still inexistent. Potential project developers therefore often have to take a lengthy way through many institutions to identify hydropower investment opportunities. At the same time, attractive sites may remain undeveloped, because they are not known to potential project developers.

The public awareness on the implications of global warming in that every country is responsible to reduce its $CO_2$ emissions and the rapid depletion of the country's fossil fuel resources, as well as the importance of the development of renewable energy resources on the other hand is still greatly lacking.

Many of the barriers mentioned above not only impede small-scale hydropower, but renewable energy development in general.

## 3. SOLUTIONS

The barriers to sustainable Small Hydro Power development in Indonesia will be addressed with a number of activities, that are expected to solutions in the following main activities.

### 3.1 Policy support and energy sector restructuring

Review of existing policy, legislation and regulatory framework in the renewable energy sector in Indonesia, with focus on small-scale hydropower;

Provision of advice to governmental institutions concerned on policy, legislation and regulatory issues that affect renewable energy development in general, and small-scale hydropower development in particular;

Initiation and provision of support to attempts to level the playing field for renewable energy development in general, and small-scale hydropower development in particular, in the course of the restructuring of the Indonesian energy sector;

Development and introduction of technical standards, guide specifications, and guidelines for planning, design, and construction supervision of small-scale hydropower projects;

Design and promotion of the introduction of a standardized power purchase agreement for the inter-connection of small-scale hydropower schemes with the PLN grid.

### 3.2 Technical and institutional capacity building

Development and implementation of special business management training programs for small-scale hydropower project development organizations, owners and operators, to improve their managerial capabilities, especially with respect to financial administration;

Design and implementation of technical training and capacity building programs, covering topics such as project selection, evaluation, planning and designing, construction, operation and maintenance, as well as electrical distribution, metering, and structure wiring to increase the quality and sustainability of small-scale hydropower installations;

Conduct of on-the-job-training of local hydropower equipment designers and manufacturers, to further reduce the dependence of small-scale hydropower developments on equipment imports;

Promotion of the structuring of formal regional "business incubators", where continuing technical and management advice and assistance can be provided to project developers. One target of such incubators would be entrepreneurs interested in forming operation and maintenance (O&M) contractors or project management contractors, which could provide services to several plants located in certain regions. Such organizations could provide a higher level of expertise than would be affordable for single-project O&M and management staffing.

Design and promotion of local, village-based implementation arrangements and organizational mechanisms for effective local participation in developing and operating off-grid hydropower systems;

Design and promotion of the implementation of incentive-based arrangements to encourage good O&M, and revenue collection; and

Formulation and promotion of private/community cost sharing models to be applied at all stages of the development and operation of small-scale hydropower projects.

### 3.3 Facilitating financing of small hydropower projects

Design and establishment of appropriate and sustainable financing mechanisms for small-scale hydropower projects, based on an analysis of requirements and forms of financial intermediaries available;

Establishment of a special "revolving fund" for small-scale hydropower development for off-grid rural electrification. This revolving fund will grant loans for the implementation of selected hydropower schemes, and will continuously be refilled by the installment payments of the loans. It is clear, however, that as long as Indonesia's energy sector is heavily subsidized, some form of subsidies will also be required for hydropower development to level the playing field with conventional energy options. Different models will be devised and proposed for testing, such as a replenishment of the revolving fund by governmental subsidies that are based on the amount of electricity actually produced by the schemes implemented with loans out of the revolving fund. ●

# HYDRO POWER DEVELOPMENT IN TAJIKISTAN

*Djouraboi Djouraev*

**Barki Tojik Company**

**Tajikistan**

**1. Brief introduction of Tajikistan**

Tajikistan is locating in Central Asia, western of China, and borders with Afghanistan, China, Kyrgyz Republic and Uzbekistan.

Tajikistan is a mountain country (about 93% of territory are mountains), filled by Tian-Shan Alay and Pamir mountain systems. The territory of Tajikistan covers 143.1 sq. kilometers and the population exceeds 6.2 mill., capital city – Dushanbe.

The republic boasts hundreds of large industries. Rapidly developing industries: including power engineering, mining and ore- dressing, chemical, nonferrous metallurgy, mechanical engineering, light, foodstuffs, etc.

Tajikistan is richly endowed with high-water and rapid rivers whose potential is widely used for power generation and irrigation of farm lands. Most of the rivers drain into the Aral Sea Basin, the largest courses being those of the Amu Darya, the Kafirnigan, the Panj, the Syr Darya, the Vakhsh and the Zarafshan rivers- all fed by the melting mountain snows and glaciers. The Panj, one of the main streams of the republic, runs for 921 kilometres along the national border. The chief water artery of Tajikistan, the Vakhsh is 525 kilometres long.

The hydropower is the main domestic (80%) source of power in Tajikistan. In terms of its potential water power resources, which amount to 32.3 million kW (output capacity) or 286 billion kWh (electricity generation), out of which 19 million kW and 144 billion kWh can be produced technically. The republic ranks second in the former Soviet Union after the Russian Federation.

The economic effectives 85 billion kWh. At present used only 17% the economic effectives power resources.

Besides the largest rivers Tajikistan have considerable plenty of the small rivers of its potential water power resources could product energy 14 billion KWh.

**2. The power industry: stages of development**

The construction (in 1936 to 1952) of the three Varzob hydroelectric station with a capacity 25 MW marked the first major step in promoting the power industry of the republic.

By the same year, the first 35 kV transmission line was built connecting the station 1 with the Glovnaya (Chief) substation in Dushanbe. The completion of the line started the beginning of the power grid of the republic.

Before the construction of cascade Varzob hydroelectric station total installed capacity electric station in Tajikistan was to 690 kW.

With the aim of accelerating electrification in the processing agriculture, government was built many projects of Small Hydro power plants of country. The finally in 1950 was built about 100 Small Hydro Power plants with the installed capacity amounted to 95000 kW.

After the year 1960, of the country started to development the large hydro power plants, the small hydro power plants stopped to run because the large power plants more economic development than the small hydro power plants.

In 1957 became operational the Kayrakkum hydroelectric station on the Syr Darya , with a 126 MW capacity. The latter, with its active storage amounting to 2.6 billion cubic meters, made an important contribution to the development of power industry and irrigated farming in the in the republic.

Three more hydroelectric stations with an installed aggregate capacity of 258 MW were built in the southern part of the republic from 1957 to 1965. The first of the three stations, the Perepadnaya hydroelectric station, with a capacity of 30 MW, became operational in 1958, marking the beginning of efforts aimed at harnessing the water power resources of the Vakhsh river. The then largest hydroelectric station, the Golovnaya station, was commissioned on the Vakhsh in 1962- 1963. It has an installed capacity of 210 MW. In 1964 the Central hydroelectric station was built on the tail race of the Perepadnaya station, with 18 MW capacity.

The development efforts, however, were not limited to the construction and expansion of power plants; much emphasis was laid on transmission lines and substations all over Tajikistan. The first, 110 kV, transmission line was built there in 1948.

Transmission lines and substation of 220 kV and higher voltage classes have been built since 1958.

Tajikistan was one of the fist to introduce cable-suspended wires on the 110 kV mountain transmission line in the Varzob valley.

The network of transmission lines in the republic is such that we can now speak about the existence of two power grids in Tajikistan which are conventionally called the southern and northern grids, the watershed being the Gissar Range.

The then largest hydroelectric station, the Nurek station, was commissioned on the Vakhsh in 1979. It has an installed capacity of 2700 MW, average annual production – 11,2 billion kWh, with its active storage amounting to 4,5 billion cubic meters.

More than forty ethnic groups participated in the construction of the power station.

This chain includes the functioning Baipaza hydroelectric station. It has an installed capacity of 600 MW.

In the 1985 Government was plan to development electrification to remote and mountains Area with the local resources. By small hydro power and another renewable energy plants.

After 10 years on small hydro power plants the country was completed with the total installed capacity – 15.400 kW could provide.

The present, republic has 17 the small hydro power plants, with the installed capacity 31.400 kW with annually energy supply 130 GWh.

The developing small hydro power plants in the country were very usefully and effectively for developing Social-Economic condition in mountainous area.

The installed capacity of power generating facilities in the republic amounted to 4.412 thousand MW in 2001, producing 14.336 billion kWh of electricity, and over 98% out of that is produced by hydropower station.

The energy system of Tajikistan is a part of the Central Asia /Southern Kazakstan regional network and is designed for 500 kV and is coordinated from the dispatcher center in Tashkent.

**2. Perspective of development.**

Further development of the power industry in the republic relies heavily on its abundant water power resources.

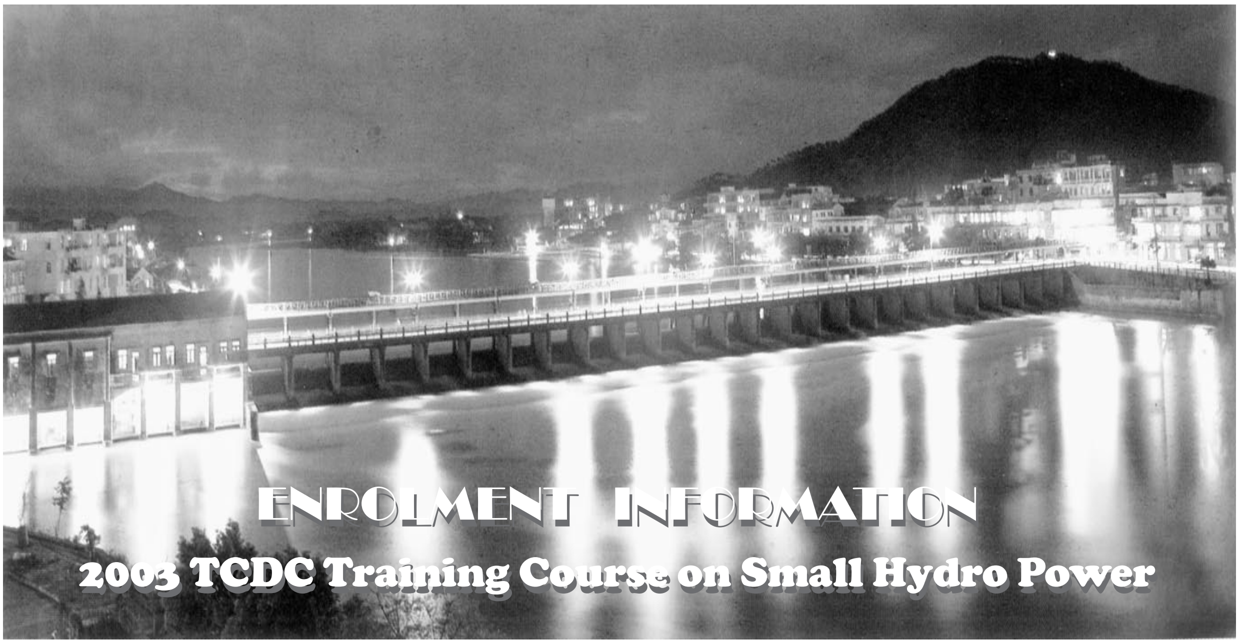
The hydroelectric power industry of Tajikistan, which depends on the operation of the Vakhsh chain of power stations, is inseparably linked with irrigation of new farm lands in the south of the republic, Uzbekistan, and Turkmenia. Therefore, the Rogun (3600 MW) and Sangtuda (670 MW) hydroelectric stations, which are currently under construction, have tremendous importance for entire Central Asia. The Sangtuda hydroelectric station will be followed by the construction of the Shurab, and Dashtijum plants.

The Gorno-Badakhshan Autonomous Region occupies an exceptional place in the republic. Here, high in the mountains, all the main rivers of Tajikistan originate. It is feasible to construct here a hydroelectric station with a capacity up to 100.000 kW, since the geography of the region prevents their interconnection with the national grid.

In 1997 Government has appointed the small hydro power Association of country, which looks and develops :

- the small hydro power plant of country;
- the main thing of this Association works on investigation, design, construction and exploitation of the projects;
- the association supply technical support and equipment for the small hydro power plants on country.

All of problem in mountainous Area of country should solve and approve on the real constructing program with small hydro power project for developing mountainous Area in future time. ●




Sponsored by the UN and Chinese government, Hangzhou Regional Center for SHP (HRC) aims at promoting the SHP development in the world. China has most SHP stations and has gained much experience in SHP development. In order to disseminate SHP technology, HRC has already held with success 36 training workshops for over 600 participants from 70 countries.

**1.Objectives:** To master the basic theory and principles of SHP development, feasibility study, operation, maintenance etc..

**2.Date:**From 9 May to 18 June 2003, Hangzhou, P.R. China.

**3.Venue:**Hangzhou Regional Center for SHP, Hagnzhou, China.

**4.Course Contents:** Procedures of SHP development, feasibility study, hydrological analysis, low-cost civil structure, turbo-generator units and auxiliary, electric design, automation, economic evaluation, operation, maintenance.

**5.Training Methods:**Lectures, discussions, field trips & seminar.

**6. Medium of Instruction:**English

**7.Source of Trainees:**SHP personnel or officials worldwide

**8.Methods for Evaluation:** presenting country report on SHP

**9.Participant's Qualifications and Requirements for Admission:**The applicants should be under 45 years old, graduated from technical schools with two years' SHP practice, be in good health with no infectious diseases and not handicapped, be proficient in English; prepare a review paper or report on SHP development of the participants' country, not to bring family members to the training course, to observe all the laws, rules and regulations of P.R. China and respect the Chinese customs.

**10.Training Expenses:**The expenses of training, boarding and lodging, local transportation, pocket money of RMB 30 Yuan per person per day during the training period in China will be borne by the Chinese government and distributed by HRC. The international travel costs including round trip tickets, transit fares, the expenses of medical care, insurance for the participants are covered by the participants themselves.

**11.Application and Admission:** Nominated by their respective governments, applicants are requested to fill up the Application Forms, which should be endorsed by the departments concerned of their respective governments, and submit with valid Health Certificate provided by authorized physicians or hospitals to the Economicand Commercial coun-sellor's Office of Chinese Embassy (ECCOCE) for examination and endorsement; If endorsed, Admission Notices will be issued to the accepted participants by ECCOCE through the related government departments. With Admission Notices, participants should go through all necessary formalities with all the mentioned documents to China on the registration date.

**12.Insurance:**The training course organizer dose not hold any responsibility for such risks as loss of life, accidents, illness, loss of property incurred by the participants during the training period.

**13.Liaison Address:**Attn:Mr.D.Pan & Ms. Shen Xuequn

***Hangzhou Regional Center (Asia-Pacific) for Small Hydro power***
***Hangzhou, P.R. China, 310012;***
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# 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 105 issues (bimonthly), allocated with the International Standard Serial Number ISSN 1007-7642, and China Standard Serial Number CN33-1204/TV. It was published in Chinese and with English titles. 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.

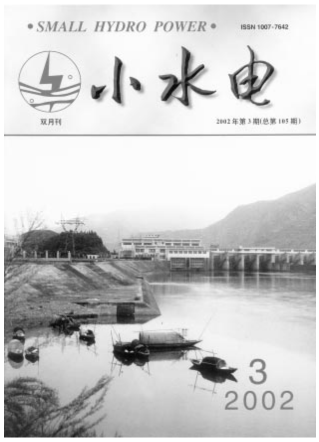
This magazine has carried news, views and articles on all aspects of small hydro power. It is useful to those who are intersted in technical experience of SHP development in China.

"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.

**Subscription rates (1 year):USD40.00**

***The main contents of the 105th issue (2002 No 3) read as follow.***





# A Chinese Magazine "Small Hydropower" by HRC

## *The main contents of the 104th issue (2002 No 2)*

***Working Research***

Open up a new prospect for water power electrification in Sichuan province
Development of electrification construction in fifteen years
Development of rural water power and electrification

***Management and Administration***

Comment on electrical price in rural area
Development idea and methods of Guanyinshan reservoir
Technical measures for cutting down network loss in rural area

***Programme and Design***

Programme of Laoguanhe Shimeng key water power project
Development and construction of Luoqingjiang river
Cascade exploitation of Qianshanhe river basin
Optimization of development plan of Longtan second power station
Conduit design of SHP station in mountainous area

***Project Construction***

Collapse treatment in tunnel of Bu'ao power station

***Renewal and Reconstruction***

Relaying protection of low-voltage turbine-generater and its improvement
Enlarge capacity improvement of Erkou power station
Technical renewal of water colling system of turbine-generator in canal headworks power station
Renewal of oil leakage at blade pivot in adjustable blade propeller turbine
Benefits by renewal of flexible cupling of No1 unit in Panjiakou power station
Improvement of self-start loop of oil pump motor of YJ-regulator
Points for attention in fixed directly position of scroll case by winding engine

***Service and Maintenance***

Abrasion resistance and cavitation preventive of bottom flood-discharge outlet of Fenghe second reservoir dam
Relay non-operation caused by parallel resistane loss of intermediate relay
Construction technics and maintenance of curtain grouting for dam of Fengtan reservoir

## *The main contents of the 106 issue (2002 No 4)*

***Rural Electrification***

SHP construction and development in Rongshui Miao autonomous county
Make mountainous area poor county prosperous out of poor by rural electrification construction

***Working Research***

Subsistence and development of SHP under main supply network
Optimizing operation of Yaotian SHP station
Engineering supervise system of SHP project
Optimum administration mechanism for speeding up basin exploitation

***Programme and Design***

Structural design of small low head tubular water workshop
Bodily form of shaft pillway in Xiamen reservoir
Selection of electrical main connection and switchyard in 110 kV substation
Comprehensive evaluation and suggestion of construction elements of Ximen power station
Calculation loans in financial evaluation of Bailianxia reservoir

***Computer Application***

Regulator with microcomputer and its application in SHP station
Communication system based on peer to peer LAN for the water tuibine test

***Renewal and Reconstruction***

Renewal of runner in Dongfanghong SHP station
Enlarging capacity of Lianhua SHP station
Improvement of automation loop in regulator
Technical renewal of guide bearing in SHP station

***Service and Maintenance***

Servise and maintenance of bulb water turbine generator out of opetation for long time
Killing snail in cooling water system of power station by killing snail paint
Fixed blade axial flow water turbine is not suited for running with low load
Removal earthed breakdown in direct current system
Treatment of breakdown by reactor in SHP station

## *The main contents of the 107 issue (2002 No 5)*

***Working Research***

Development and prospect of local hydropower in Gansu province
Improve organisms'habits environment with development of clean energy sources
Speed up hydropower industry with waterpower resources exploitation

***Management and Administration***

Operational management of dam of Mingyangguan SHP station
To be liminated in the end in Xinzhuang SHP station

***Technology Exchange***

Crack treatment of dam of Taojinping SHP station engineering
Crack epoxy resin grouting in stone masonry arch dam of Maotan SHP station
Construction technique for treating channel collapse in Duojiashan SHP station
Application of local material in hydroelectric power engineering
Controlled parts of air rubber dam and its operation management

***Mechanical and Electrical Equipment***

Lightning protection of microcomputer monitoring and communication system in Shafan second step power station
Economic benefits of Zhoutou 35kV transmision project development
Improvement of governor auto-circuit in Panjiakou flood control power station

***Computer Application***

Renewal of governor system in Shimenkan SHP station
Rural electrification database management system in Yinzhou area

***Renewal and Reconstruction***

Selection of technical renewal programme of Muchang SHP station
Capacity increase of turbine unit in Jingkou SHP station
Technique renewal of turbine-generator in Jiaokou SHP station
Capacity expanding-a measure for increasing economic benefits of SHP station

***Service and Maintenance***

Loosened reason of magnetic yoke key of 25MW turbine-generator and its service
Application of high grade granolithic concrete in wash channel
Inspection and maintenance of excitation transformer fuse frequently blew
Turbine isn't stop statically-Reason analysis and its service
Fault analysis of generator in Dongfanghong No 1 SHP station

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# A Big Promotion in China's Medium & Small-sized Hydropower

Recently the vice Minister of Water Resources in China, Mr. Jing Zhengshu released that, during the forthcoming 5 years China's central government will put priority into the medium & small-sized hydropower development, especially SHP with the installed capacity of less than 25MW shall be enlisted as one of those renewable energies which are strongly supported by the government with favorable policies. China is a country with abundant water resources, and there is a huge potential for its development. By the end of 1999, in China almost l/2 of the territory, l/3 of the counties which equal to l/4 population mainly account on the electric power from hydropower stations, thus make over 300 million people benefited. But now the installed capacity of hydropower exploited is only 19.3% of the exploitable, a small portion compared to the total amount of rich water resources. Especially in those western regions where 72% of the total potential is located, the exploitation rate is less than 10%.

As a renewable and environmentally sound energy, the development of the medium & small-sized hydropower is to be strongly supported by the central government. During the "10th Five-year Plan", China will further promote SHP development, and it is planned to newly increase the installed capacity of SHP by 6GW in those 5 years, with 400 rural counties hydro-electrified, so that more than 99% of the villages can be accessible to the electric power, and the per capita power consumed and the power per household can be 400kW and 600kW respectively. ●

# 5 Billion RMB Yuan into Rural SHP in Hubei Province

From the Department of Water Resources in Hubei Province, it is noticed that 5 billion RMB yuan shall be put into the development of rural SHP there, and by the end of 2005 each village will have access to the electric power. The water resources sectors in Hubei are always sticking to the policy of the rural hydropower development combining the river conservancy, the ecological protection and the poverty relief. Presently, the rural hydropower development has already been an important pillar industry in modernizing the hilly regions of Hubei as well as the key project in poverty alleviation. According to the statistics, recently Hubei Province devoted a lot to the rural hydropower development and the installed capacity has totaled l.46GW with the annual generation of 4.29 billion kWh, which makes l/5 of the total population, l/3 of the agricultural and industrial sectors accessible to the electric power. In those 27 rural counties with the preliminary hydro-electrification, the GDP, financial income, the per capita income of farmers and the per capita power consumed doubled in past five years. ●

**China to spend billions on small hydro upgrades**

China's State Council has approved a five-year program to spend 70 billion renminbi (US ＄8.4 billion) to upgrade small hydro plants in 400 counties.

The government-backed ***China Daily*** quoted water officials announcing the program to boost rural economies. provide power to mostly western off-grid communities, and to reduce air pollution from burning of wood and fossil fuels. Up to 30 percent of the total funds are to come from the state, with the remainder raised by local units.

China has implemented small hydro plants of capacities up to 50 MW to provide electricity to millions of rural homes. One fourth of China's population is served anually by the 80 billion kWh from small hydro. The rural electrification program has provided power to 653 rural counties. In the latest program, 400 counties' hydro plants are to be upgraded through 2005. ●

**Proposal for western China projects advances**

Several off-grid hydroelectric plants ranging from 10MW to 20 MW are to be built in China's Gansu Province as part of a proposed Western Region Small Hydropower and Rural Electricfication Program to increase electricity supply to rural areas near Langzhou.

The Asian Development Bank completed a fact-finding mission earlier this year to help determine whether to provide US$950,000 to review and upgrade a feasibility study for the program.

In addition to the several off-grid hydro plants ranging from 10MW to 20MW each, the program calls for construction of two run-of-river hydro plants, 90MW Chaijiaxia and 90MW Hekou. ●

# Micro hydro in Sri Lanka

***A strategy for empowering disadvantaged rural communities in Sri Lanka is now gaining both national and international recognition. The objective of the Electricity Consumers' Society-is to enable communities to have their own renewable energy source, of which they have control in all aspects. M.A.LAHIRU PERERA and TILAK W.KARUNARATNE report.***

Sri Lanka has been an agricultural country for over 2500 years. Water being a prerequisite for agriculture, the country has long possessed a highly developed irrigation system. Consisting of hundreds of storage tanks, this system collects water from rain and streams and uses it to grow rice, the nation's staple food. Yet the irrigation system was never used as an energy source or to run machines.

Historically, the energy source for Sri Lankans was fuel wood, which was available in abundance. There was no central system to supply firewood-finding it was the individual family's responsibility, but the needs of each family were not great. There is no archaeological evidence that points to the existence of a centralized system for provision of energy, or for the use of fuel oil, coal or electricity in the country. This situation, however, started changing in the nineteenth century. The establishment of a public electricity system (1895) and the introduction of micro hydro power to process tea leaves in the plantation sector (1940) were the main turning points.

Soon, the number of micro hydro power units started increasing, gradually, and by the 1940s, there were about 500 such units-all using imported equipment-in operation. The average plant size was about 75kW, and matched a factory's annual demand for power. The 1940s and 1950s also saw a vast development in the major hydro power sector in Sri Lanka. Several of the large-scale storage hydro schemes, such as Laxapana and Gal Oya, commenced operation during this period. These major hydro schemes produced electricity in such quantities that the Government encouraged factories running on village hydro to switch to the grid, with transformers provided on favourable terms. Another reason they switched to the main grid electricity was that it had greater capacity, and so allowed for expanding production.

The changes in people's lifestyles in the post-colonization period made them look for efficient and less cumbersome ways of doing their work. This compelled them to use energy sources other than biomass, for both domestic and industrial purposes, creating a new dependence on energy sources such as electricity and fuel oil.

By 1985, 35% of the population had access to the national electricity grid, while major hydro schemes accounted for around 85% of the country's electricity supply-although only 5% of the estate-owned hydro schemes that had been functioning in the 1940s were still operating. Seeing the importance of alternative energy in the future, ITDG-South Asia started work on village hydro in 1990.

However, the position of hydro power changed in 1996, when the long drought that prevailed in hydro-reservoir areas resulted in power cuts for up to six hours a day. The inadequate power compelled the government-monopoly Ceylon Electricity Board(CEB) to increase power generation, mainly through use of thermal and gas sources, since almost all big hydro power potential was tapped. The use of imported fuel caused electricity price hikes and adverse environmental effects. These developments emphasized the need for alternative energy sources, which would be environmentally friendly and can serve the poor. This latter consideration is very important in a country where over 50% of the population are recipients of government subsidy.

**Context**

Today, Sri Lanka has a population of 19.1 million, of which 70% live in rural communities. In meeting the people's energy needs, indigenous sources of biomass account for 71% of all energy (a survey revealed 98% of rural houses use fuel wood for cooking). Oil, meanwhile, which is entirely imported, accounts for 19%, with kerosene used for lighting most of the rural houses. The other main source-electricity-only provides 10% of the total consumed.

About 54% of the population has access to grid electricity, with most of this figure living in urban areas. A far smaller proportion of the rural population has grid access, the low population density and the high transmission costs making power supply for remote areas unviable. Many rural families are without electricity at present and for the next few years at least, if not more permanently. In the wake of annual demand for electricity growing at 10%, the main supplier, CEB, is faced with a necessary evil-thermal power-which has long-term consequences for the environment, health and the government coffers.

**ITDG intervention**

It is this context that there has been a renewed interest in non-conventional and renewable sources of energy. The Energy Programme of the ITDG-Sri Lanka (now 'ITDG-South Asia') identified this need, and took the following measures:

- introduction of micro hydro (MH) power as a decentralized source of energy
- developing a strategy to promote this form of energy publicly
- establishment of a sustainable system that can be implemented, managed, operated and maintained by the people, to continue the project's role.

The result was the formulation and implementation of a specific project, Village Hydro, from 1994, as an alternative to conventional energy sources. The project, which aimed to implement micro hydro in a village setting, possessed the following components:

- development of local capacity
- resolving the engineering and technical issues pertaining to the MH projects
- designing and implementing MH projects
- availability of subsidies and funding
- improving the quality and benefits of the project outputs
- replication of village hydro
- capacity-building of public and private sector organizations
- collection and dissemination of information
- influencing policymakers to promote micro hydro power generation concepts
- international networking to share experiences.

**The strategy-an Electricity Consumers' Society**

The process began by identifying remote villages without access to electricity but with the potential for hydro power. Once the villages were located, the Energy Programme of ITDG-South Asia and its Technical Advisory Committee conducted further studies with the support of villagers. If there were sufficient resources for a village hydro unit, the Energy Programme visited the village and discussed the coummunity's energy needs with regard to the means to fulfil them. The possibility of using the water power was also taken up, leading to the topic 'village hydro'. Such visits and long discussions, supported by visits to existing village hydro projects, eventually convinced the people that they could utilize water power.

Driven by the desire to have electricity, villagers formed themselves into a social organization called the Electricity Consumers' Society (ECS). The ECS then took time to discuss and develop an action plan for initiating a village hydro unit. In addition, the ECS prepared an estimate of costs for setting up a unit, and started raising funds through contributions.

More often than not, it was the women and children that were involved in meetings, in planning the project activities, and in the implementation. For example, women and children decided the dates for some construction activities for which they provided labour. When deciding as to which rooms are to be lit in a particular house, it is again women and children that take the lead in decision-making rather than the men, who were instead involved in the heavy work component.

ITDG-South Asia's role was specific and limited to facilitation. It assisted people by giving technical information at ECS's discussions and by being a referee when the clearance from government authorities, to utilize water sources, was sought after. ECS consists of members of the village community. The team from ITDG-South Asia was composed of a few staff members, assisted by a volunteer Technical Advisory Committee (TAC). With the ECS and ITDG-South Asia together, the process of initiating village hydro began.

Because the prospective locations of village hydro were in remote and hilly terrain, accessing the location was very difficult. The ECS faced this at all stages of the work-constructing the power house, transporting the machinery and laying the transmission lines, etc. It took months, sometimes even years, of working and overcoming setbacks, for the ECS to complete the whole exercise. Often, it was only the sheer determination of both parties that made hydro a reality.

In this way, village hydro units were built and started operating. They are owned, managed, operated and maintained by the community-run ECSs. Being a collective of people, the ECS enabled the beneficiaries to develop and control hydro power as a local resource, increasing the people's autonomy. For instance, it was the ECS that developed institutional mechanisms and the tariff structures for each village hydro scheme, with ITDG-South Asia's support. These tariff structures regularized the levies and became a useful tool in assessing various aspects, such as economic viability, members' welfare, end-use products, sizing and design of the schemes.

The tariff equation is deliberately designed to include factors like number of houses, because this helps make socially beneficial decisions. For example, it is possible to choose between one design approach which links more houses to the hydro, and another that links fewer houses but offers employment to a few poorer villagers.

ITDG-South Asia's experience is that all hydro power equipment used in plantations was of foreign manufacture which, although it generated power, did not help in building local technical capacity. Furthermore, the local manufacture of small hydro equipment was inhibited. Nobody had specialist expertise in village hydro, so improving the local capabilities thus became imperative to the development of village hydro. Accordingly, several on-the-job training programmes were conducted by ITDG-South Asia, and the capacity to design, install, maintain and operate units was established. Two major achievements of these programmes have been:

- the capacity-building of six local mechanical workshops to manufacture hydro turbines and the affiliated components with locally available materials, and to produce and adapt equipment from existing designs
- the development of a village hydro model in which the technology, cost and management components were simplified sufficiently enabled the villagers to handle most of the work locally.

In developing the technical capacity, the approach was to train some technicians whose potential had been identified through comprehensive screening. The training covered several areas, including the redesign and manufacture of the equipment-turbines and the generators, single-phase induction generators (rewired from three-phase induction motors, locally assembled and available in the market), induction generator controllers (manufactured from electronic components found in the local market) and so forth. As Sri Lankans are familiar with maintaining and operating these machines, this was found to be a more sustainable approach to village hydro than using the imported equipment.

With technical skills developed, a village hydro model made and a mechanism for people's involvement (i.e. ECS) established, the project initiated four pilot village hydro sites, and then moved into the village hydro replication process. This too was a difficult and time-consuming process, since a little modification was required when installing a village hydro unit, to suit it to its location and water source. The outcome was the construction and operation of 75 village hydro schemes by August 2000. Of these village hydros, one is in a tea estate serving the estate labourers' families, and another is of low-head technology, a pilot scheme initiated for testing purposes. The schemes possess an accrued capacity of over 400kW, and provide electricity and the associated benefits to 2000 poor and under-served families in 75 underprivileged villages.

Generally, the ECS members have contributed over 40% of total costs by carrying out civil works, wiring, installation and laying the transmission lines for all village hydro schemes. Skilled, indigenous casting technology was moulded into the manufacture of turbines. Masonry expertise was easily available, nor was it difficult to procure an electrician's service for the work. The village contribution as a whole consisted of cash, materials and labour. The main part of the funding for the schemes, however, came from various sources such as the government's Energy Conservation Fund and the Janasaviya Trust Fund, local government authorities and Provincial Councils. ITDG-South Asia and a TAC (technical advisory committee), consisting of experts from research institutions and the private sector, rendered the technical support.

Since the entire project process was new to the country, the experience earned from the work was considered valuable to both ITDG-South Asia and the donors that funded the project. The lessons learned were thus documented and shared with the others concerned, at seminars, workshops and at staff exchange visits, at local, regional and international levels. At present, the subject of village hydro is addressed by several publications, including evaluation reports. In fact, the Sri Lankan experience in village hydro contributed in no small measure in the production of ITDG's publications on the subject.

The experience showed that the initial investment for village hydro is, from the villagers' perspective, high enough to seem unaffordable. This necessitates the provision of initial capital, or at least a part of it, externally, to make village hydro affordable to the people that most need it. This can either be a subsidy or a loan at low interest rates, depending on the project and the community capacity. In fact, as a result of the successful development of village hydro by ITDG-South Asia, the DFCC Bank (formerly known as Development Finance Corporation of Sri Lanka) has already introduced a credit scheme that provides loans for village hydro, of which a quarter is a grant through the Global Environment Facility (GEF), with the support of the World Bank.

A factor worth considering in provision of incentives is hydro's financial viability, which partly depends on the ability to convert the generated energy into revenue. Village hydro can be more productive and therefore, more affordable, if it can power a community-run machine, as with the Katepola village hydro project, for instance, where a rice mill is operated.

The average electricity supply from village hydro is about 100W per household. This enables the lighting of five 20W fluorescent lamps, two of which are switched off when a black-and-white television is switched on. The members' main responsibility is to adhere to the ECS's regulations governing power distribution, including the payment of a monthly fee. Defaulting on payments and the unauthorized use of power in excess of allocation invariably leads to a fine, and, in extreme cases, the disconnection of supply, though recourse to the latter is rare.

The ECS and the village hydro have, in most cases, improved social cohesiveness among the beneficiary families. Hydro power distribution was no exception to the village culture, based as it is on the generation-long concept of sharing. Despite the very limited capacity of village hydro, beneficiaries shared their allocation of power when the neighbours were in need of more energy, for instance, during weddings or funerals. The ECS's regulations partly helped, too, in creating a bond among beneficiaries themselves. It was heartening to note that some ECSs provided free or subsidized connection to the most deserving amongst themselves, and continued doing so in similar cases.

The tariff collected from beneficiaries has formed a community fund. The ECS has managed this fund, which was used mainly in paying the bank loan, if there was one, and in the maintenance and repairs to village hydro, when required. Some of the ECSs have invested a part of the fund in leisure and income-generation activities, displaying their inventiveness in maximizing the benefits. One example is the purchase of musical instruments from the ECS fund, training a number of villagers to play the instruments and hiring out the trained musicians with the equipment, for functions and on payment. This was part of the ECS of Isanawatte village hydro scheme, which enabled each musician to earn 150 Rupees (US$1.65) per function-day.

One other outcome of the ECS was the growth of environmental awareness in the beneficiary community, especially among children. There were communities that carried out tree-planting in the catchment areas to prevent soil erosion and to increase the shade. Some others became alert to illicit timber-felling, and protected the tree cover that affects the water source of village hydro. The mandatory requirement for permission from the Forest Department and the Central Environmental Authority(CEA) when setting up village hydro projects preserves the relationship between the forest cover, the environment and the village hydro. Besides, each ECS, and the village hydro that were developed by ITDG-South Asia, took pains to protect the environment and preserve the climate and ecology. Efforts have always been made to leave the natural beauty of the sites intact.

**Project results**

The 'Village Hydro' project had established and monitored 75 village hydro installations by August 2000, and the figure rose to 89 installations by 31 December of that year. The first 75 installations, for which data is available, have an accrued capacity of 415kW and work, on average, for 9 hours each day for 30 days a month-i.e. only for lighting-with the results that can be seen in table 1.

- 2562 households-i.e. approximately 12,810 individuals-who previously had no access are now provided with electricity
- provincial councils, local governments and the banks (six in total) included village hydro in their work plans and programmes
- several publications-including the ITDG annual and international journal on renewable energy 'E-net' –were disseminated among about 5000 individuals and agencies in 25 countries
- each village hydro installation consists of three constructions: a small weir, forebay tank and a power house to accommodate the machinery and electricity distribution panels. Sometimes very rarely, civil works are required for the tailrace
- innovative solutions were found

by way of enhancing local understanding of aspects of village hydro-such as local survey, designing, manufacturing, operation and maintenance capabilities, and the participatory project implementation-which all proved a success

- innovative products sold included current cut-out switches, induction generation controllers(IGC), energy-saving lamps and electric ballasts for fluorescent(tube)lights
- the ITDG country programme has undertaken a considerable number of renewable energy projects other than village hydro; for example, solar-hydro energy mix sites, wind-biogas hybrid systems and individual wind, biogas, estate hydro projects and grid-connected micro hydro projects.

## Conclusion

Through several years of hard work with the rural communities in Sri Lanka, ITDG-South Asia has identified and proved a novel and sustainable strategy for empowering the disadvantaged communities. The objective of the strategy-the Electricity Consumers' Society-is to enable communities to have their own renewable energy source, of which they have control in all aspects. The most significant aspect of the strategy is that ECS has, while finding an effective and alternative energy source like village hydro, made the energy supply a community responsibility, thereby making the community independent.

The experience gained has been shared with the governmental officers, the NGOs, banks, multilateral agencies and the individuals interested, through seminars and observation visits to village hydro sites. The result was that ITDG-South Asia's work and the strategy in the village hydro sector has been recognized by many, both nationally-by the Government of Sri Lanka-and internationally, after further research on the work. The World Bank has for the first time accepted the ECS approach, by including village hydro in its Energy Service Delivery Project(ESDP). This is in addition to the ITDG-South Asia's own achievements, such as developing and sustaining the village hydro technology, and inclusion of village hydro in the National Energy Policy.

The next important steps for the ECS's future are as follows:

- to review its efforts to produce and share energy, and get the same replicated
- to develop the grid-connected village hydro schemes, managed and maintained by the ECSs as an income-generating project for other village development work
- continuous monitoring of the project.

Essentially, this is an effort to share its capabilities with others, while consolidating the current achievements.

Despite all these efforts, it is still the bottle lamps that provide light for over a half of the 3 million students in Sri Lanka as they study; it is still the imported mineral oil that provides fuel for over a half of Sri Lanka's population of 19 million. The time has now come to put a stop to that dependency through use of locally available energy sources. A new era of empowerment has dawned, which will be fully realized only when this 'powerless' 46% of the people has gained access to an environmentally friendly and efficient power source, perhaps through the implementation of many more village hydro schemes.

**Table 1. Energy generated and fuel use/emissions avoided (diesel thermal energy content assumed to be 42 MJ/kg)[1,2]**

| Result | Per month | Per year |
|---|---|---|
| Electricity generated(MWh) | 112.05 | 1,344.60 |
| Energy saved(kWh) | 112,050 | 13,446.00 |
| Fuel diesel saved(kg) | 28,812.86 | 345,754.32 |
| Fuel diesel saved-tons of oil equivalent(ToE) | 28.80 | 345.60 |
| Carbon dioxide($CO_2$)avoided, in tons | 90.41 | 1,084.92 |

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***Source: Renewable Energy World***

# SMALL HYDRO POWER: AN INDIAN EXPERIENCE

V Bakthavatsalam*

*India has a history of 100 years in Small Hydro. However the country switched on early to large hydro and pursued the same reaching an installed capacity of 21,000 MW with only 500 MW of Small Hydro. Of late, environment driven awareness seems to have reminded us that what India needs is not the mass production but production by masses. The advantages of small hydro is so large that planners see investment in its development as prudent. IREDAs efforts in this direction has seen capacities develop among the stakeholders, justified in the World Bank's second line of credit.*

Of all the non-conventional renewable energy sources, small hydro represents 'highest density' resource and stands in the first place in generation of electricity from such sources throughout the world. Global installed capacity of Small Hydro is around 50,000 MW against the estimated potential of 780,000MW.

Small Hydro is environmentally benign, operationally flexible, suitable for peaking support to the local grid as-well-as for stand alone applications in isolated remote areas. Even if we ignore the $CO_2$ abatement costs and 'acid rain' abatement costs etc., of conventional thermal route, small hydro is benevolent on the following known hard facts of economics.

Short gestation and limited investments of Small Hydro are affordable by the private sector, enabling quicker electricity and economic returns. Fiscal incentives by Central Government and policy framework by State Governments are attracting private initiatives in Small Hydro. Satisfied by the progress made in implementation of the first line of credit for a target of 100 MW of capacity addition, World Bank has extended an additional line of credit amounting to US $ 110 million for development of 200 MW Small Hydro Power Capacity. The World Bank second line of credit which is operated in an entrepreneur friendly environment is likely to spin off an entirely new techno-commercial scenario paving the way for attractive business opportunity in Small Hydro.

**INDIAN POTENTIAL OF SMALL HYDRO**

India has one of the world's largest irrigation canal networks with thousands of dams. It has monsoon fed, double monsoon fed as well as snow fed rivers and streams with perennial flows. An estimated potential of 15,000MW of Small Hydro exists in India. The data base created by MNES includes 4,096 potential sites with an aggregate capacity of 10,071 MW as given in table 1.

**SMALL HYDRO DEVELOPMENT IN INDIA**

The first Small Hydro Project of 130 kW commissioned in the Hills of Darjeeling in 1897 marked the development of Hydro Power in India. The Sivasamudram Project of 4500 kW was the next to come up in Mysore district of Karnataka in 1902, for supply of power to the Kolar Gold Mines at 25 Hz. The pace of power development including hydro was rather tardy. The planned development of Hydro Projects in India was taken up in the post independence era. This means that the 1362 MW capacity (including 508 MW hydro) installed in the country before independence was mainly coming from Small and Medium size projects. The status of implementation as of March 2001 is shown in table 2.

**GOVERNMENT SUPPORT TO SMALL HYDRO**

Government of India, through its full-fledged Ministry of Non-Conventional Energy Sources (MNES) formed in the year 1992-the year of Rio Summit on Environment and Development, is extending multidimensional support to the development of mini hydels (upto 25 MW) as one of the environmentally benign renewable energy technologies, keeping in tune with the Government's overall thrust on liberalisation of economy and private sector participation in power development. Fiscal incentives available for 'Small Hydro' sector are given below.

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**FISCAL INCENTIVE FOR SMALL HYDRO SCHEMES**

-  Schemes involving capital upto Rs 500 Million need no Environmental Clearance from Ministry of Environment & Forests (MoEF)
-  Five years Income Tax holiday on grid interactive power generation projects
-  Term loans through IREDA for schemes upto 25 MW
-  Customs duty exemption for Electro-mechanical Equipment
-  Excise duty exemption for Electromechanical Equipment

**Table 1. STATE WISE DETAILS OF IDENTIFIED SMALL HYDEL SITES UP TO 25 MW CAPACITY IN INDIA**

| S.No. | Name of the State | Identified Number of Sites | Total Capacity in MW |
|---|---|---|---|
| 1. | Haryana | 22 | 30.05 |
| 2. | Himachal Pradesh | 323 | 1624.78 |
| 3. | Jammu and Kashmir | 201 | 1207.27 |
| 4. | Punjab | 78 | 65.26 |
| 5. | Rajasthan | 49 | 27.26 |
| 6. | Uttar Pradesh & Uttaranchal | 445 | 1472.93 |
| 7. | Gujarat | 290 | 156.83 |
| 8. | Madhya Pradesh & Chhatisgarh | 125 | 410.13 |
| 9. | Maharashtra | 234 | 599.47 |
| 10. | Andhra Pradesh | 286 | 254.63 |
| 11. | Karnataka | 230 | 652.61 |
| 12. | Kerala | 198 | 466.85 |
| 13. | Tamil Nadu | 147 | 338.92 |
| 14. | Bihar & Jharkhand | 171 | 367.97 |
| 15. | Orissa | 161 | 156.76 |
| 16. | Sikkim | 68 | 202.75 |
| 17. | West Bengal | 145 | 182.62 |
| 18. | Arunachal Pradesh | 492 | 1059.03 |
| 19. | Assam | 46 | 118.00 |
| 20. | Manipur | 96 | 105.63 |
| 21. | Meghalaya | 98 | 181.50 |
| 22. | Mizoram | 88 | 190.32 |
| 23. | Nagaland | 86 | 181.39 |
| 24. | Tripura | 8 | 9.85 |
| 25. | Andaman & Nicobar Islands | 6 | 6.40 |
| 26. | Goa | 3 | 2.60 |
| | ***Tatal*** | ***4096*** | ***10071.81*** |

***Sources: MNES Annual Report, 2000-01***

**Table 2 INSTALLED CAPACITY (MW) OF SMALL HYDRO IN INDIA**

| Project Status | Total No. of Projects | Total Capacity in MW |
|---|---|---|
| Commissioning | 387 | 1341.05 |
| Under Implementation | 170 | 498.28 |
| Total | 557 | 1,839.33 |

***Sources: MNES Annual Report, 2000-01***

**ADDITIONAL INCENTIVES OFFERED BY MNES**

-  Promotional Incentive Scheme to carry out Detailed Survey & Investigation (DSI) and preparation of Detailed Project Report (DPR)
-  Interest Subsidy scheme for setting up of commercial small hydro power projects especially in the private sector
-  Capital subsidy scheme for setting up of small hydro power projects in the State sector
-  Scheme for Renovation, Modernisation & capacity, uprating of small hydro power projects
-  Promotional incentive scheme for development and upgradation of water mills

In addition to the above fiscal incentives, MNES has issued guidelines for off-take of power from renewables on concessional terms by the State Electricity Boards in respect of power wheeling, banking and buy-back. Following the model guidelines, several states of India have announced their Private Sector Policy.

**PRIVATE SECTOR PARTICIPATION**

The States where small hydro potential is available have come out with attractive policies for private sector participation, in line with MNES guidelines. The pioneering efforts of the Karnataka State Government in establishing a Single Window Agency for clearance of SHP projects to private sector and the Karnataka Power Corporation (KPCL) as the nodal agency has sparked the growth of the sector and has become an example for other States to follow. Some of the success stories of private sector projects in the new era in the State are 18 MW Shivapur project of Bhoruka Power Corporation, Bangalore and 1 MW Gokak Falls Scheme of Gokak Mills, Belgaum and 3.9 MW Shahpur Branch Canal project of Bhoruka Power Corporation, Bangalore and 2.8 MW Dhupdal Hydro Scheme of Gokak Mills, Belgaum. The neighbouring States like Kerala and Andhra Pradesh followed the example and many SHP sites were allotted to private sector companies mainly to meet their captive requirements. The first private sector project in Kerala namely' Maniyar 12 MW SHP, was completed in a record time of two years. The northern States of Uttar Pradesh and Himachal Pradesh, which have tremendous potential of hilly hydel schemes also announced their policies and their projects are under allotment for captive as well as power sale options.

**WORLD BANK INITIATIVE THROUGH IREDA**

A pre-investment study was carried out under the auspices of the Energy Sector Management Assistance Programme (ESMAP) jointly supported by UNDP and World Bank in the years 1998-1990 in association with the Indian Govt. agencies. The principal objective of this study was to apply techno-economic criteria to improve the design and economic viability of irrigation based mini-hydro schemes in India, and to identify and prepare a medium term investment programme to develop a series of irrigation based hydro schemes in India. This study covered more than fifty prospective small hydro sites in five states. Detailed tech no-economic analysis and cost-effective designs were made for some of these sites.

Consequent to the ESMAP study, World Bank (WB) offered a line of credit worth US $70 million to be utilized during 1993-1997 with a target capacity sanction of 100MW.

The credit line has moved fast enough and IREDA could sanction 47 projects with an aggregate capacity of 145.16 MW, exceeding the target one year ahead of schedule. The enthusiasm shown by the private promoters as well as their understanding that the small hydro is the most attractive long term option not only for their captive needs but also as a business opportunity by way of selling power at commercial rates have given a fillip to the sector and there is going to be a steady growth in the small hydro sector. Out of the World Bank package, a capacity of 84.40 MW has been commissioned by March 2001. Satisfied by the progress made in implementation of the first line of credit, the World Bank has extend an additional line of credit (second line of credit) amounting to US$110 million for development of 200 MW Small Hydro Power Capacity.

**SECOND LINE OF CREDIT FROM WORLD BANK**

Satisfied by the progress made in implementation of the first line of credit, the World Bank has extended an additional line of credit amounting to US$110 million for development of 200 MW Small Hydro Power Capacity.

**UNDP-GEF INITIATIVE ON HIMALAYAN SMALL HYDRO**

Against the background of depleting forest resources of Himalayas, the UNDP-GEF India Hilly Hydel Project was initiated in the year 1994 as the first Indian Project from GEF portfolio in order to develop a national strategy and master plan for optimum utilization of Small Hydro resources of Himalayan and sub-Himalayan regions with an outlay of US $15 million. The scheme also envisages implementation of 20 demonstration schemes, upgradation of 100 water mills for electricity generation. A revolving fund has been created at IREDA to finance commercial schemes under the project.

**PORTABLE MICRO HYDEL PROGRAMME OF MNES**

Another innovative concept that has been developed and is under implementation, is the installation of light weight Portable Micro Hydel Sets in the hilly areas of the country, particularly the Himalayan region. The main objective of this novel scheme is to provide power to non-grid connected remote areas by using 'stand alone systems' ranging from 5 to 15 kW, which would be easily installed and maintained by the local communities. MNES in the first instance has supplied 50 such sets free of cost and IREDA is the implementing agency for the same. The beneficiary will have to carry out all peripheral works essential for completion of the projects, including civil works, local distribution network etc. In the subsequent phases, based on the success of implementation and demonstration of the benefits of the first phase, the programme may be further expanded with phased reduction of subsidy. As of now, 35 projects have been commissioned and are generating power.

**IREDA'S LENDING ACTIVITIES**

IREDA's Mission is to be a pioneering, participant friendly and competitive institution for financing and promoting self-sustaining investment in energy generation from renewable sources and energy efficiency for sustainable development.

IREDA's main objectives are:

* To promote renewable sources of energy
* To provide financial support to manufacturers and users
* Act as a financial intermediary

* Assist in rapid commercialization
* To promote energy efficiency & conservation, and
* To provide consultancy

IREDA's mandate covers a wide spectrum of financing activities including those that are connected to energy conservation and energy efficiency. At present, IREDA's lending is mainly in the following areas:

* Hydro Energy
* Wind Energy
* Bio- Energy
* Solar Energy
* Developmental Activities New Initiatives
* New & Emerging Technologies
* Energy Efficiency & Conservation

The maximum extent of assistance extended by IREDA is determined by IREDA's exposure limit which is set according to the client's credit worthiness and the security/ guarantees offered for the term loan.

To qualify for IREDA financing the projects are required to satisfy the following criteria:

* The project must be technically feasible;
* It must represent the least cost option;
* The borrowers capability to undertake the project in terms of their performance track record, soundness of financial operations and adequacy of organizational and technical capabilities must be satisfactory;
* The project must be financially viable with an internal rate of return of not less than 12%;
* The project must be economically justified with satisfactory social cost benefits in terms of generation and/or conservation of energy, employment generation and contribute to balanced economic growth in the region; and
* All statutory clearances from State & Central Government agencies need to be furnished.

**Table 3 HIGHLIGHTS OF FINANCING NORMS**

| | |
|---|---|
| Debt instruments | Project financing |
| | Equipment financing |
| | Loans for Manufacturing |
| | Market Development (including Export Promotion) |
| | Energy Centres |
| | Financial Intermediaries |
| | Business Development Associates |
| | Renewable Energy Umbrella Financing |
| | Non -Conventional Energy Technology Commercialization Fund Scheme |
| Quantum of Assistance | Upto 75% of the project cost |
| | Upto 80% of the equipment cost |
| Rate of Interest | 3.0 %- 14.50 % per annum (Varies from sector to sector) |
| Moratorium | Upto 3 years (Varies from sector to sector) |
| Repayment Period | Upto 10 years (Varies from sector to sector) |

## IREDA'S FINANCING SCHEMES FOR SHP SECTOR

IREDA started financing small Hydro Projects from middle of Vllth Five Year Plan [1985-1990] and the projects sanctioned were for Government sector along with subsidy from MNES. In line with Govt. of India policy of privatisation of power sector, from 1992-1993 IREDA started financing Private Sector small hydro projects from its own resources and a modest beginning was made through financing one private sector project of 12MW and another renovation project of 1 MW. By the end of the financial year 2000-2001 IREDA has financed a total of 91 Small Hydro projects with loan assistance amounting to Rs. 6887.68 million for installation of aggregate capacity of nearly 265.03 MW, which include 81 private sector projects.

## PROMOTIONAL ACTIVITIES

Apart from the role of a financial institution, IREDA also conducts various promotional initiatives through the business meets, seminars and workshops etc. IREDA also does entrepreneurial development through it's various Entrepreneurship Development Programmes (EDPs), a number of them exclusively devoted to women. It also encourages more and more women participation. IREDA also takes critical care to ensure environment friendliness and better eco-balance. The agency also encourages, rural development, self employment and self reliance through decentralized NRSE programmes.

## INTERNATIONAL ASSISTANCE

IREDA's track records of achievements have also attracted global attention. Renowned multilateral and bilateral agencies have come forward to join this global movement for sustainable development.

**CORPORATE PLAN AND VISION**

IREDA's activities form an integral part of the National. Five year plans and annual plans are particularly dovetailed to the five year plans of the MNES. During the 9th plan period which coincides with the Corporate Plan, IREDA's proposal envisages ambitious targets for sanction & disbursement of loan for setting up renewable energy projects. The thrust during this period is to harness renewable energy sources for productive purposes. The highlights of the plan are as under:**IREDA 9TH PLAN TARGETS (1997-2002)**

**Capacity Addition**

* Installation of power generation capacity of 1150MW
* Setting up projects to generate energy equivalent to 0.392 Million MT of coal through renewable resources.

**Sanction of term loan**

* Rs. 3779 Crores

**Disbursement of lcon**

* Rs. 2703 Crores

**IREDA VISION TARGETS (1997 - 2010 )**

**Capacity addition**

* Installation of power generation capacity of 2993 MW
* Setting up projects to generate energy equivalent to 0.976 Million MT of Coal through renewable resources

**Sanction of term loan**

* Rs. 16100 Crores

**Disbursement of loan**

* Rs. 13880 Crores

**EMERGING SCENARIO & STRATEGIES FOR FUTURE**

From the foregoing discussions, it is apparent that in India, it is an opportune time that Small Hydro should get a strategic thrust, as environment driven awareness has rediscovered 'Small Hydro' as a principal renewable energy source for sustainable development.

For a multi-dimensional strategic thrust, identification of weak areas and threat perceptions need to be visualised carefully and appropriate steps need to be taken. In this connection, following need to be addressed:

* Non- availability of hydrological data and pre-investment study reports of newly identified sites.
* Single window clearance facility not functional in all the States.
* Non- uniformity of Wheeling & Banking facility.
* Non- uniformity of buy-back and third party sale.
* Water royalty charged from Private Entrepreneurs.
* Economics depends on Government Policies which need to be consistent.

A country-wide scientific resource assessment needs to be done making full use of metered data of atleast 2 to 3 years as well as corroborative data from the existing irrigation and power projects. On the policy front, uniformity of facilities from State Electricity Boards may be a desirable step besides withdrawing water royalty from Small Hydro Projects. State clearance mechanisms need to be further streamlined and fine-tuned to make single window clearance really effective. The various fiscal and financial incentives extended by the Government should continue in the forthcoming plans to ensure economic viability and attractive returns from the projects.

Target segment based approach would be desirable in a diverse country like India with complex, socio economic objectives. Following segments appear imminent for evolving strategies to achieve a balanced growth of Small Hydro:

1. Hilly Hydels
2. Existing irrigation canal falls
3. Run-of-the-river schemes
4. Socially relevant micro hydel schemes
5. Hybrid systems with other renewable sources as well as conventional sources of energy
6. Stand alone systems for off-gird applications
7. R&M of existing Small Hydro Schemes
8. Mini Hydel Schemes in return canals of Power Plant cooling water system.

In the overall scenario of Small Hydro, few trade-offs are necessary to be carefully perceived for a right kind of decision on strategic development of Small Hydro. These ore:

a) Detailed Vs. Adequate Investigation,
b) Conventional Vs. Innovative designs,
c) Standardisation Vs. Optimisation,
d) Efficiency Vs. Effectiveness,
e) Commercialisation desirability Vs. Socio-economic Objectives.

**CONCLUDING REMARKS**

With the dawn of liberalisation policy in India, power sector is attracting private participation in a big way. The World Bank line of credit with its emphasis on private sector participation is boosting the current trend in SHP development and is expected to contribute to the rural and semi-urban energy scenario of the country in a significant way. A technically sound programme like this operated in an entrepreneur friendly fiscal environment is likely to spin off an entirely new techno commercial scenario paving the way for attractive business opportunities in Small Hydro. ■

## U.K. regulators exempt hydros from climate levy

The United Kingdom's Office for Gas and Electricity Markets (Ofgem) has accredited 123 small hydro generators as qualifying renewables sources for exemption under the Climate Change Levy. Those plants are among 396 generators, totaling 1,232MW, accredited for exemption under the levy, according to the office that regulates gas and electricity industries.

Previously, industrial and commercial electricity customers, also called non-domestic customers, paid a Climate Change Levy of 0.43 pence per kWh (0.61cent U.S.) to suppliers, who sent the payment to the government's tax office. Residential customers, also called domestic customers, are not affected by the Climate Change Levy and therefore are not entitled to the exemption.

Under the exemption program, accredited generators have been issued Levy Exemption Certificates for their monthly production, retroactive to April 2001.Electricity suppliers who buy that output for resale to industrial and commercial customers do not pay the Climate Change Levy on that electricity and may pass the savings along to customers who have signed renewables contracts.

The hydro plants, which range from 80 kW to 10MW and total about 158.2 MW, represent 31 percnet of the generating stations exempted from the levy. Other accredited generating stations are powered by landfill gas, wind, sewage gas, and waste.

Ofgem posted a list of exempted generators on the internet: www. ofgem. gov. uk/industry/ccl. htm. That list is not final, as generators still are being encouraged to apply for the exemption. ●

## Croesor power station restored

The historic 500-kW Croesor Power Station in Snowdonia National Park is one of five hydroelectric projects in the North Wales area of the United Kingdom operated by Innogy.

Pioneering engineer Moses Kellow built the station nearly 100 years ago to supply power to slate quarries. The quarries closed in the 1930s. The plant fell into disrepair in the 1950s.

National Power, now known as Innogy, redeveloped the power plant at Blaenwm, Gwynedd, returning it to service in November 1999 at a cost of more than £1 million (US$ 1.6 million).

Dulas Ltd. Worked on the project, on a turnkey design-to-commissioning basis. Extreme terrain conditions required special equipment, including a "walking excavator" tethered to rock face. A helicopter transported pipes and intake materials.

The project features a 1,000-rpm Gilkes single-jet Pelton turbine that is operated under 260 meters head. The project contains a runner mounted to the extended alternator shaft, a hydraulically actuated wafer butterfly valve that isolates the machine, and Dulas' "Minscon" solid state controller. All equipment was manufactured in the United Kingdom, with the exception of the alternator, which was manufactured in Spain. The plant is operated remotely via a SCADA system. ●

**India's NHPC develops two small hydros**

India's National Hydroelectric Power Corp. (NHPC) is in the process of developing two small hydro plants, the 4-MW Sippi project on Sippi River and 6-MW Kambang project on Siru River, both in Arunachal Pradesh State.

Sippi is to feature two 2-MW turbine-generator units and Kambang is to contain three 2-MW units. NHPC was recruiting contractors to design, manufacture, supply, erect, test, and commission generating plant and hydromechanical works. Contractors also will handle various civil works. ●

**India utility commissions Andaman Island project**

India's National Hydroelectric Power Corp. reports it has commissioned the 5.25-MW Kalpong hydroelectric project on Andaman Island in the Bay of Bengal. The first 1.75 MW unit was connected to the local grid on July 1,2001, 16 months ahead of schedule.

Developed on the left and right forks of Kalpong River for the Andaman and Nicobar Islands Administration, the Kalpong project includes a 34-meter-tall, 138-meter-long concrete dam, a 27-mter-tall, 146-meter-long rockfill dam, a 300-meter-long canal, a 133-meter-long tunnel, three penstocks, a powerhouse containing three 1.75-MW units, and a switchyard.

The project is to generate 14.83 million kWh annually, replacing some diesel generation for which fuel must transported. ●

***Source:HRW***

# New bank to finance projects in Nepal

A new bank formed by a group of financial institutions and other corporate groups is to finance hydro and other "clean energy and infrastructure" ventures in Nepal. The Clean Energy and Infrastructure Development Bank(CEIDB) will lend money to entrepreneurs to develop hydropower; other generation projects, including solar, wind, biomass, biogas, and municipal solid waste; and clean energy-driven infrastructure projects such as electric-powered trolley buses, cable cars, and trains.

Winrock International in Nepal has identified 28 small scale hydropower projects, exceeding 75MW in total installed capacity, for CEIDB investment. Opportunities also have been identified in other renewable energy projects to meet energy needs of hotels, residences, and small industries in rural areas.

Winrock, which is serving as technical secretariat to CEIDB, provided incubation services to the new bank. Those services included financing/commissioning a feasibility study; structuring the bank; garnering support from prospective promoters (banks, finance companies, insurance companies, other contract saving institutions, and other corporate groups). The company also arranged for preparation of charter documents, contacted foreign investors to measure their interest in investing in the the bank(10 percent of the total equity is earmarked for investment by foreign investors), and arranged to tap the World Bank's Global Environment Facility fund to support incorporation and financing of the bank.

Initially, the bank will have a paid-up capital equivalent to about US$6.7 million(Rs500 million). Sixty percent of the amount(about US$4 million) has been committed for subscription by promoters including provident funds, insurance companies, banks and finance companies, and other corporate groups. By the sixth year, the bank's borrowings and deposits are projected to reach US$36 million and US$60 million, with a lending and investment portfolio expected to exceed US$100 million.

For information about CEIDB, contact Ratna Sansar Shrestha, FCA, Senior Adviser, Clean Energy Group, Nepal, Winrock International, P.O.Box 1312, Kathmandu Nepal;(977)1-472839;Fax:(977)1-476109;
E-mail:rsansar@winrock.org.np. ●

## *Uganda plans assessment of energy resources*

The government of Uganda plans to assess alternative energy resources, including small hydropower, and how to meet demand of energy deficient areas of Uganda.

The Ministry of Energy and Mineral Development wants to establish a technically, economically, and socially feasible program of least cost alternative energy resources to serve rural areas and small towns. The entire study is to require 13 months.

The first phase of the study is to formulate an alternative energy development program, with assessment of resources including mini-and micro-hydro, biomass, solar, wind, and geothermal power. Also included is forecasting of energy demand, preparation of pre-feasibility studies, and formulation of a development strategy.

Phase 2 includes preparation of feasibility studies of priority projects for five of the most energy deficient areas. Phase 3 includes detailed design of selected projects. ●

## India state moves to build six small hydros

India's Bihar State Hydroelectric Power Corp.Ltd. is conducting a small hydro program that will include construction of six 1-MW hydroelectric projects on Sone Canal in Bihar State. BSHPC is raising funds to develop a total of 22 such projects, including four tendered previously.

The group of six projects, each featuring two 500-kW turbine generator units, are to be located at Dehra and Sipatia in Aurangabad District, Belsar in Jehanabad District, and Sebari, Shirkhinda, and Paharma, all in Rohtas District. ●

## China's 54 MW Fushi hydro in full operation

The third and final unit of the 54 MW Fushi hydropower plant began commercial operation June 28 on the Rongjiang River, 153 kilometers from Liuzhou in China's Guangxi Zhuang Autonomous Region.

Meiya Power Co. Ltd., which owns 70 percent of the project, said the first and second 18-MW units began operation in April and October 2000. MPC's joint venture partner is Liuzhou Rongjiang Hydropower Development Co. Ltd. The plant is connected to the Guanxi regional grid and, in addition to supplying power, will improve area irrigation and navigation. ●

## Cambodia rural power plan to include small hydro

The government of Cambodia expects to recruit contractors and consulants to carry out a rural electrification program that includes development of mini-and micro-hydropower plants.

The government said it intends to seek a US $ 30 million credit from the World Bank's International Development Association for the project. It previously received a loan from the Asian Development Bank for the program. ●

***Source: HRW***