**PEREZ-GUERRERO TRUST FUND Project**

**Training, Consultation and Awareness for Small Hydro Power**

**in Developing Countries**

**INT/03/K08/95/99**

# Final Report

Submitted by

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# G77 PGTF Project Final Report

## Introduction

The project “Training, consultation and Awareness for Small Hydro Power in developing Countries”, submitted by IC-SHP and endorsed by Ministry of Foreign Trade and Economic Cooperation (MOFTEC) includes four major elements:

1. Training: One training course in India and one study tour in China.
2. Consultation: Feasibility study for SHP in Himashal Pradesh State and Uttar Pradesh State, India, consultation mission for local grid planning & rehabilitation in Chenzhou, Hunan Province, China.
3. Awareness: Publication of textbook “Small Hydro Power: China’s Practice”, “IN-SHP Newsletter” (monthly in English” and “Global Small Hydro Forum” (semi-monthly in Chinese)

The beneficiaries of the Project are the above mentioned countries and the membership of IN-SHP in general. There are over 120 members in about 60 countries. So the G77 PGTF Project will stimulate SHP development worldwide and improve rural energy and environment conditions.

The outputs generated by this project are described as below.

1. **Publishing the textbook of “Small Hydro Power: China’s Practice” (A1).**

This book comprehensively introduces the whole information on the small Hydro Power in China. With its rapid development of China’s SHP, more and more people want to learn more Chinese experience on SHP.

This textbook includes the survey of SHP development in China, an important

sustainable energy source, SHP based rural electrification, planning and development, cost-effective SHP technology, operations and management, international co-operations for SHP development and the future development of SHP industry. In this book, many ideas/experiences of successful practice could be borrowed by China's on-going electricity industry reformation.

The following categories explains the detailed contents of the book.

8.2.2 Stabilize and Develop Rural Electricity Market

8.2.3 Develop SHP Oriented Economy in Mountainous Areas

The breakdown of the expenditure of the book publishing is listed as in the following table.

| **No.** | **Item** | **Expenditure** |
|---|---|---|
| 1 | Materials collection | US$1,000 |
| 2 | Translation and edition | US$1,000 |
| 3 | Collation | US$400 |
| 4 | Publishing | US$4,000 |
| **Total** | | US$6,400 |

## 2. Publishing “IN-SHP Newsletter” (monthly in English) (A2)

China has the biggest potential and installed capacity in term of SHP on the earth, and it has got great achievement on SHP. In order to introduce its experience and exchange the information between the members, IN-SHP edits the monthly Newsletter and distributes it among IN-SHP members and other interests. The newsletter covers IN-SHP news, China’s SHP information, membership news, and Conference information, etc.

The breakdown of the expenditure of the book publishing is listed as in the following table.

| **No.** | **Item** | **Expenditure** |
|---|---|---|
| 1 | Materials collection | US$5000 |
| 2 | Translation and edition | US$1,000 |
| 3 | Collation | US$500 |
| 4 | Mailing Fee | US$1,000 |
| 5 | Publishing | US$3,000 |
| **Total** | | US$4,000 |

## 3. Publishing “Global Small Hydro Forum” (semi-monthly in Chinese) (A3)

China has the biggest potential and installed capacity in term of SHP on the earth. But apart from this achievement, the outside world knows very few about its SHP industry. Vice versa, China also needs to understand more about the new theory, strategy as well as technologies of world’s latest SHP development, under the new circumstance of the power industry deregulation and market economy system. The semi-monthly “Global Hydro Power Forum” was designed to fill in this vacuum area of information exchange. Its subscribers are mainly the policy makers from the relevant government bodies such as Ministry of Water Resources, Ministry of Foreign Trade and Economic Cooperation, Ministry of Finance, State Planning Committee, etc. This informative magazine was widely welcomed and complimented by the subscribers, including the minister of MWR.

The followings are some of the topics of “Global Small Hydro Forum”

- *The USA’s experiences on electricity market reformation*
- *Competition of electricity supply: the case of Bolivia*
- *The return rate of energy investment*
- *The energy crisis in west America*
- *SHP is the high-quality energy source with the highest return rate*
- *The deregulation of power market in Britain*
- *The management of the electricity market of USA*

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The following is the front page of an example copy of **“Global Small Hydro Forum”.**

# 国际小水电论坛

International Small Hydro Power Forum中文版 2003 年第 10 期

国际小水电论坛

主办:

国际小水电网

邮政信箱：202

## 重视送电到乡项目的勘测设计工作

目前，我国还有 16000 多个无电乡村、约 2800 多万人口没有用上电，无电人口主要分布在川、青、新、藏等省区。这些乡村具有地处边远、交通不便、远离电网、用电负荷小而分散的特点，通过常规方法难以解决当地的用电问题。解放 50 多年来，与其它地区经济发展的差距日益拉大，带来了严重的社会和环境问题。因此，发挥小水电的优势，实现送电到乡，改变无电地区贫困落后状况，使广大边远乡村逐步形成可持续发展的机制，既是当地百姓的强烈愿望，也是各级水利部门的工作重点，具有重大的政治和经济意义。

根据中国政府的决策，由国家财政中拨出一部分款项在一些无电地区实施送电到乡计划，在短期内集中建设一批乡村小电站，强度之大在我国小水电的发展史上是从来没有过的，其意义确实非同一般。一些地方的水利部门也很珍惜这一历史机遇，尽管遇到

The expenditures of publishing “Global Small Hydro Forum” is shown as the followings.

| **No.** | **Item** | **Cost** |
|---|---|---|
| 1 | Information collection | US$1,500 |
| 2 | Translation, collation, editing | US$1,500 |
| 3 | Publishing | US$2,500 |
| 4 | Distribution | US$1,500 |
| Total | | US$7,000 |

## 4 . Feasibility Study for SHP in Himashal Pradesh State and Uttar Pradesh State, North India (C1)

India has vast untapped potentials of hydro power, which could not be harnessed in speedy manner to attain the desirable hydo thermal mix of 40:60. This is due to various reasons like investment constraints, long gestation, apprehension of environmental degradation & rehabilitation burdens etc. The slow pace of big hydro has paved the way for development of small hydro projects with the reliable and mature technology and vast experience back up of hydro power. Emanating from the environmental consciousness, there is an increased thrust on small hydro development in India, which has a potential of over 10,000 MW. With its enormous untapped SHP resources and China's successful SHP development in contrast, India sees the good future of cooperation between two countries. In July 2003, two experts assigned by IC-SHP were sent to Himashal Pradesh and Uttar Pradesh State to undertake the mission of consultation, or more specifically, site evaluation of Duhangal Nalla small hydro power project of Himachal Pradesh. The mission was carried out by four experts, one geologist, one hydrologist and two civil engineers.

The feasibility study of this project had been finished which proved the site economically viable. Some technical solutions were recommended by Chinese experts for saving cost in developing the project in the future. The site owner is now securing the investment to put this site under construction soon.

The expenditures occurred in this project are:

| No. | Item | Cost |
|---|---|---|

| | | |
|---|---|---|
| 1 | International travel of four experts | US$12,000 |
| 2 | Accommodation | US$2,000 |
| 3 | Profession time | US$10,000 |
| Total | | US$24,000 |

## 5. Consultation Mission for Local Grid Planning & Rehabilitation in Chenzhou Municipality, Hunan Province of P. R. China. (C2)

1. Background Summary—Chenzhou City

Chenzhou City is situated in the southeast of Hunan Province. It is the gateway linking the central western part of China and the costal areas of Guangdong Province. The city covers a total land of 19,388km2, including 11 counties with a population of 4.48 million.

In 1999, GDP totals RMB23.16billion, among which RMB9.95 billion was attributed to agriculture, RMB7.62 billion came from industry especially the non-ferrous metal industries. In addition, the industry of construction materials including cement and rock material is on the steady growth for the past few years.

Chenzhou is acclaimed as the Global Non-ferrous Metal Museum. There are a variety of 96 metal mines across the city. The reserve of tungsten, bismuth and molybdenum top the whole China, especially the tungsten accounts for 1/4 of the total reserve worldwide.

Chenzhou is rich in water resources. Annual rainfall of approximates to 1400 – 2000 mm. Water flow covers about 100 m2 miles. There are more than 60 rivers. The hydropower potential amounts to 1511.3MW, among which 700MW is best for SHP. Till the end of year 2000, 990MW are developed, of which 400MW is SHP, accounting for 41.1%. 385.8MW untapped SHP is to be developed. Up to now, 635 SHP stations have been built with a total installed capacity of 400 MW. Annual output amounts to 1.6 billion Kwh. The total assets reach RMB 2 billion, while the income from power generation amounts to RMB1 billion annually. Chenzhou has developed an integrated local grid including 650m 110kv transmission line and 8 substations of 110kv.

SHP has brought substantial returns for Chenzhou. The tax levied from SHP totals 150million RMB; accounting 15% of all the tax income of Chenzou.200 thousand of rural population are isolated from poverty. 9 counties have been electrified till the end of 2000. SHP greatly spurs the development of local economy. 90% of the total 130,000 rural industrial enterprises are fed by SHP. Meantime, SHP has created 15,600 job opportunities directly, 40% of which are available for women.

Besides, the role of SHP playing in environmental protection is vital. Substitute

firewood with electricity though SHP has changed the conventional rural energy consumption pattern. Each year 500thousand tons of firewood are saved and the forest coverage increased from 53% ten years ago to 67.8% last year.

2. Project Introduction

Though remarkable progresses have been achieved in SHP development in Chenzhou, there are many issues which if not successfully planned and settled will hamper the sustainable growth of power sector in Chenzhou. The key issue concerns to the local grid planning and rehabilitation.

The consultation sub-project untaken by IN-SHP under the subjected G-77 Project Proposal submitted by IN-SHP in September April 2003 is composed of the following 5 sub-tasks:

- Consultation on Local Grid Planning & Rehabilitation in Chenzhou

Chenzhou local grid covers an area of round 60 square mile. According to the planning, two substations with capacity of 3 x 31,500KVA, two transmission lines of 110 KV total length of 45km, 16.5 Km 35KV transmission line and one 42 Km 10KV transmission line are expected to be newly built; while one 110KV substation with capacity of 1 x 31500 KVA, two 35KV substation with capacity of 1 X12500 +1X16000KVA and 22 Km 10 KV transmission line are expected to be rehabilitated. The total budget is RMB 136.54 million Yuan.

- Consultation on Jiujiedai SHP Station in Rucheng County of Chenzhou

Jiujiedai SHP Station is located in Wenming Village, Rucheng County of Chenzhou. The main constructions includes dam, diversion tunnel, powerhouse and substation. Maximum water head is 154.12 m with minimum head at 136.77 m. Total installed capacity is 2 x 6300KW with firm output of 3450 KW(90%). Annual average output goes at 6.048 Mwh and annual utilization hours at 4800 hrs. The static investment totals RMB 50.73 million Yuan with per KW investment at RMB 4026 Yuan/KW.

- Consultation on Wannianqiao SHP Station in Rucheng County of Chenzhou

Wannianqiao SHP Station is situated at Nuanshui Village, Rucheng County of Chenzhou. The main construction comprises of dam, diversion tunnel (culvert), powerhouse and substation. Maximum head is 34.92 m with lowest at 30.9 m. Design head is 32 m. A flow of 15.3 m3/s is consumed per unit. Installed capacity is at 3 x 4,000KW and annual average output at 6.604 Mwh. Firm output is 3650KW (90%) with 5503 hrs of annual utilization. The static investment is budgeted at RMB 58.38 million Yuan.

- Consultation on Yongxing II SHP Station in Yongxing County of Chenzhou

Yongxing II SHP Station is located in the lower reaches of Yongxing I SHP Station, Mayangpin Village, Yongxing County of Chenzhou. The main constructions are dam, lock and substation. The design water head is 5.16 m with total installed capacity of 2 x 10,000KW and firm output of 3461KW. Annual utilization hours is around 4236 and average output will be 90Mwh annually. The total budget is RMB 149 million Yuan with per KW investment at RMB 7450 Yuan.

- Consultation on Daxishan Cascade SHP Station in Linwu County of Chenzhou

Daxishan Cascade SHP Station is located at west of Linwu County of Chenzhou. Sangshui I SHP Station is 8km away from the county and 207 m design water head with installed capacity at 3 x 3200KW. Shunfengzhai II Station is 3 km away from the county and 74m design head with 3 x 1250 KW installed capacity. Bahou III Station, 35km from the county is designed at 42 m water head with installed capacity of 3 x 500Kw and an aggregate installed capacity of 14,850 Kw and 4620 KW firm output. Annual average output is expected at 5686 Kwh. Total investment is RMB 102.03 million Yuan with per KW investment of RMB 7,580 Yuan.

3. List of technical parameters
- Local Grid Planning & Rehabilitation in Chenzhou
- Jiujiedai SHP Station in Rucheng County of Chenzhou
- Wannianqiao SHP Station in Rucheng County of Chenzhou
- Yongxing II SHP Station in Yongxing County of Chenzhou

4. Appendix
(1). Drawing on Chenzhou local Grid and proposed projects
(2). Drawing on geographical connection for Wannianqiao Station
(3). Geological drawing for Wannianqiao Station
(4). Layout drawing for Wannianqiao Station
(5). Layout drawing for Yongxing II Station
(6). Geographical Drawing on Yongxing II Station

## Local Grid Planning & Rehabilitation in Chenzhou

| **No** | **Item** | **Scale** | **Year of Construction** | **Type** | **Budget Unit:10,000Yuan** |
|---|---|---|---|---|---|
| 1 | Chengjiao 110KV Substation | 2x31.5MVA | 2003 | Newly built | 1700 |
| 2 | Tizilin 110KV Substation | 1X31.5MVA | 2005 | Newly built | 1250 |
| 3 | Shigaitang 110KV | 1X31.5MVA | 2004 | Rehabilitatio | 600 |

| | | | | | |
|---|---|---|---|---|---|
| | Substation | | | n | |
| 4 | Chengqianlin 35KV Substation | 1X12.5MVA | 2004 | Expansion | 300 |
| 5 | Gaoshanbei 35KV Substation | 1X16MVA | 2003 | Expansion | 400 |
| 6 | Cheng-Deng II Transmission Line (LGJ-150) | 2X6km | 2003 | Newly built | 384 |
| 7 | Deng-Ti 110KV Transmission line (LGJ-240) | 35km | 2005 | Newly built | 1400 |
| 8 | Ti-Qiao 110KV Transmission line (LGJ-240) | 10km | 2005 | Newly built | 400 |
| 9 | Shi-Deng I Transmission line (LGJ-240) | 2x1.2km | 2005 | Newly built | 120 |
| 10 | Deng-Cheng 35KV (LGJ-185) | 1.5km | 2003 | Newly built | 37.5 |
| 11 | Jiao-Gao 35KV (LGJ-185) | 2km | 2003 | Newly built | 50 |
| 12 | Jiao-Cheng 35KV (LGJ-185) | 1.5km | 2003 | Newly built | 37.5 |
| 13 | Ti-Jiao 35KV (LGJ-185) | 10km | 2005 | Newly built | 250 |
| 14 | 10KV line | 18km | 2003-2007 | Newly built | 378 |
| 15 | 10KV line | 22km | 2003-2007 | Newly built | 232 |
| 16 | 10 KV line | 24km | 2003-2007 | Rehabilitatio n | 2400 |
| 17 | | 48 | 2003-2007 | Newly built | 1920 |
| 18 | Switches | 82 | 2003-2007 | Newly built | 820 |
| 19 | Transformer | 11.4MVA | 2003-2007 | Newly built | 228 |
| 20 | Auxiliary equipment | 8.5MVAR | 2003-2007 | Newly built | 85 |
| 21 | Automation and communication | | 2003-2007 | Newly built | 661.7 |
| 22 | Total | | | | 13653.7 |

## Jiujiedai SHP Station

## in Rucheng County of Chenzhou , Hunan Province

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## The main technical parameters of the project

| No. | Items | Unit | Quantity | Remark |
|---|---|---|---|---|
| **I.** | **Catchment Parameters** | | | |
| 1 | Catchment area over the dam site | $km^2$ | 202 | |
| 2 | Average yearly flow | $m^3/s$ | 5.43 | |
| 3 | Average yearly run-off | 100 million $m^3$ | 1.0812 | |
| 4 | Design flood flow | $m^3/s$ | 352 | P=3.33% |
| 5 | Flood flow for checking | $m^3/s$ | 553 | P=3.33% |
| 6 | Average yearly sand flow | 10,000tons | 3.99 | |
| **II.** | **Reservoir Parameters** | | | |
| 1 | Normal water level | m | 432.50 | |
| 2 | Design flood level | m | 432.50 | |
| 3 | Dead water level | m | 427.50 | |
| 4 | Regulating capacity | 10,000 $m^3$ | 65.5 | |
| 5 | Dead storage capacity | 10,000 $m^3$ | 48.5 | |
| **III.** | **Hydraulic Parameters** | | | |
| 1 | Maximum head | m | 154.12 | |
| 2 | Minimum head | m | 136.77 | |
| 3 | Average head | m | 143.40 | Design head |
| 4 | Installed capacity per Unit | KW | 6300 | |
| 5 | Unit | Set | 2 | |
| 6 | Firm Output | KW | 3450 | |
| 7 | Average yearly output | 10,000kWh | 6048 | |
| 8 | Average utilization hours | Hours | 4800 | |
| **IV** | **Inundation** | | | |
| 1 | Resettlement | Family/ Habitant | 2/7 | |
| 2 | Inundated farm land | Acre | 18.12 | |
| **V** | **Main Buildings** | | | |
| 1 | Dam type | | Concrete masonry arch dam | |

| | | | | |
|---|---|---|---|---|
| | Maximum dam height | m | 26.0 | |
| | Length of dam axial | m | 67 | |
| 2 | Inlet gate | | Arched steel gate | |
| | Number of gate | | 2 | |
| | Size of Gate | | 5 x8 | H x W |
| 3 | Powerhouse | | | |
| | Dimensions | m | 3.08x13.6x 23 | Lx WxH |
| | Length of Tunnel | m | 3663.0 | Penstock |
| | Diameter | m | 3.00 | |
| **VI.** | **Main quantities** | | | |
| 1 | Open-excavated earth &rock | $m^3$ | 59,051 | |
| 2 | Earth & rock excavation in tunnel | $m^3$ | 30,760 | |
| 3 | Concrete masonry | $m^3$ | 5,731 | |
| 4 | Cement masonry | $m^3$ | 2,202 | |
| 5 | Concrete & reinforced concrete | $m^3$ | 10,241 | |
| 6 | Metal works | ton | 501.7 | |
| 7 | Refilling grouting | $m^2$ | 1,885 | |
| 8 | Curtain grouting | m | 420 | |
| **VII** | **Main construction materials** | | | |
| (1) | Steel bar | ton | 963.70 | |
| (3) | Cement | ton | 4400.00 | |
| (4) | Timber | $m^3$ | 515.00 | |
| **VIII.** | **Economic indexes** | | | |
| 1 | Total Investment (Static) | 10,000Yuan | 5073.35 | |
| 2 | Investment per KW | Yuan/KW | 4026 | |
| 3 | Investment per kWh | Yuan/kWh | 0.84 | |
| 4 | Cost per kWh | Yuan/kWh | 0.042 | |
| **VIII** | **Labor** | 10,000 Person day | 28.00 | |
| **IX** | **Total Construction Period** | Year | 2.00 | |

## Wannianqiao SHP Station

## in Rucheng County of Chenzhou , Hunan Province

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## The main technical parameters of the project

| No. | Items | Unit | Quantity | Remark |
|---|---|---|---|---|
| **I.** | **Catchment Parameters** | | | |
| 1 | Catchment area over the dam site | $km^2$ | 1111 | |
| 2 | Average yearly flow | $m^3/s$ | 37.2 | |
| 3 | Average yearly run-off | 100 million $m^3$ | 11.73 | |
| 4 | Design flood flow | $m^3/s$ | 1420 | Dam site |
| | (P=5%) | $m^3/s$ | 2069 | Powerhouse |
| 5 | Flood flow for checking | $m^3/s$ | 553 | P=3.33% |
| | (P=1%) | $m^3/s$ | 2855 | Powerhouse |
| 6 | Average yearly sand flow | 10,000 tons | 56.3 | |
| **II.** | **Reservoir Parameters** | | | |
| 1 | Normal water level | m | 323.5 | |
| 2 | Normal Storage capacity | 10,000$m^3$ | 77 | |
| 3 | Applicable regulating storage | 10,000$m^3$ | 28.5 | |
| 4 | Water utilization factor | % | 77.68 | |
| **III.** | **Hydraulic Parameters** | | | |
| 1 | Maximum head | m | 34.93 | |
| 2 | Minimum head | m | 30.9 | |
| 3 | Design head | m | 32 | |
| 4 | Average head | m | 33.44 | |
| 5 | Installed capacity | MW | 12 | |
| 6 | Unit | Set | 3 | |
| 7 | Firm Output | KW | 3650 | |
| 8 | Average yearly output | 10,000 kWh | 6604 | |
| 9 | Average utilization hours | Hours | 5503 | |
| **IV** | **Inundation** | | | |
| 1 | Resettlement | Family | 33 | |

| | | | | |
|---|---|---|---|---|
| 2 | Inundated farm land | acre | 48.84 | |
| 3 | Permanent occupied land | acre | 103 | |
| **V** | **Main Works** | | | |
| 1 | Dam type | | Gravity dam | |
| | Maximum dam height | m | 229 | |
| | Length of dam axial | m | 67 | |
| | Crest altitude for spilling part | m | 314.5 | |
| | Crest altitude for non-spilling part | m | 326 | |
| | Strobe type | | | Arch steel |
| | Number of strobes | | 6 | |
| | Strobe dimensions | m | 8 x 9 | |
| 2 | Inlet system | m | 4723.5 | |
| (1) | Inlet gate | | | Tower |
| | Bottom floor | m | 320 | |
| | Number of gates | | 2 | |
| | Dimensions | m | 3.8 x4 | B x h |
| (2) | Diversion tunnel | m | 4288.5 | |
| | Section dimensions | m | 4.8x5.77 | B x h |
| (3) | Culvert | m | 150 | |
| | Section dimensions | m | 4.8x4.1 | B x h |
| (4) | Aqueduct | m | 110 | |
| | Section dimensions | m | 4.8 x 4.75 | B x h |
| (5) | Channel | m | 175 | |
| 3 | Surge tank | | | |
| | Dimensions | m | 40x20x9.4 | Lxbxh |
| | Bottom floor | m | 309 | |
| | Total capacity | M3 | 6486 | |
| 4 | Penstock | | | Steel, outdoor |
| | Inner diameter | m | 2.6 | |
| 5 | Powerhouse | | | Open |
| | Main powerhouse | m | 41.9x15.1x24.69 | Lxbxh |
| | Auxiliary powerhouse | m | 37.15x10x11.5 | Lxbxh |
| 6 | Step-up substation | | | open |
| | Dimensions | M | 35x35 | Lxb |
| | Bottom floor | m | 305 | |
| **VI.** | **Main quantities** | | | |
| 1 | Open-excavated earth &rock | 10,000$m^3$ | 18.24 | |
| 2 | Earth & rock excavation | 10,000$m^3$ | 17.18 | |

| | | | | |
|---|---|---|---|---|
| 3 | Concrete masonry | 10,000$m^3$ | 4.52 | |
| 4 | Cement masonry | 10,000$m^3$ | 3.96 | |
| 5 | Concrete & reinforced concrete | 10,000$m^3$ | 2.44 | |
| 6 | Metal works | ton | 347 | |
| 7 | Concrete grouting | m | 1050 | |
| **VII** | **Main construction materials** | | | |
| (1) | Steel bar | ton | 1380 | |
| (3) | Cement | ton | 17776 | |
| (4) | Timber | $m^3$ | 2167 | |
| **VIII.** | **Economic indexes** | | | |
| 1 | Total Investment (Static) | 10,000 Yuan | 5838 | |
| 2 | Dynamic investment | 10,000 Yuan | 7309 | |
| 2 | Investment per KW | Yuan/KW | 6091 | |
| 3 | Investment of unit energy | Yuan | 1.11 | |
| **IX** | **Labor** | Person day | 72.54 | |
| **X** | **Total Construction Period** | Year | 3.00 | |

## Yongxing SHP Station

## in Yongxing County of Chenzhou , Hunan Province

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## The main technical parameters of the project

| No. | Items | Unit | Quantity | Remark |
|---|---|---|---|---|
| **I.** | **Catchment Parameters** | | | |
| 1 | Catchment area over the dam site | $km^2$ | 8922 | |
| 2 | Average yearly flow | $m^3/s$ | 234.1 | |
| 3 | Average yearly run-off | 100 million $m^3$ | 73.8 | |
| 4 | Maximum flow measured | $m^3/s$ | 6460 | Aug, 1961 |
| 5 | Guaranteed flow | $m^3/s$ | 145 | P=90% |
| 6 | Design flood flow | $m^3/s$ | 5750 | P=3.33% |
| 7 | Flood flow for checking | $m^3/s$ | 9040 | P=0.33% |
| **II.** | **Reservoir Parameters** | | | |
| 1 | Normal water level | m | 97.5 | |
| 2 | Dead water level | m | 96.4 | |
| 3 | Design flood level | m | 101.3 | |
| 4 | Tail water level | m | 99.95 | |
| 5 | Flood level for checking | m | 103.64 | |
| 6 | Tail water level | m | 102.13 | |
| 7 | Check flood Storage capacity | 10,000 $m^3$ | 3302 | |
| 8 | Normal storage capacity | 10,000 $m^3$ | 1254.9 | |
| 9 | Water utilization factor | % | 96.70 | |
| **III.** | **Benefits** | | | |
| 1 | Installed capacity | MW | 20 | |
| 2 | Firm Output | MW | 3461 | |
| 3 | Average yearly output | GWh | 0.8473 | |
| 4 | Average utilization hours | Hours | 4236 | |
| **IV** | **Inundation** | | | |
| 1 | Resettlement | person | 200 | |
| 2 | Inundated farm land | acre | 70 | |
| **V** | **Dam** | | | |
| 1 | Dam type | | Strobe dam | |
| | Maximum dam height | m | 21 | |

| | | | | |
|---|---|---|---|---|
| | Length of dam crest | m | 262.5 | |
| | Hole size of weir dam | m | 6-10x3.0<br>8-10x7.5 | No of holes -w x h |
| | Design flood flow | $m^3/s$ | 5750 | |
| | Check flood flow | $m^3/s$ | 9040 | |
| **VI** | **Powerhouse** | | | Riverbed |
| | Main powerhouse dimensions | m | 27.1x19.0x 42.2 | |
| | Space between units | m | 13.05 | |
| | Units installation height | m | 86.5 | |
| | Turbine | | | Tubular |
| | Number of units | | 2 | |
| | Unit capacity | kw | 10000 | |
| | Design water head | m | 5.16 | |
| | Maximum head | m | 5.20 | |
| | Minimum head | M | 3.18 | |
| | Average head | m | 5.16 | |
| | Flow consumed in generation | $m^3/s$ | 450 | |
| | Flow consumed per unit | $m^3/s$ | 225 | |
| **VII.** | **Main quantities** | | | |
| 1 | Construction duration | Years | 2.25 | |
| 2 | Earth & rock excavation | 10,000$m^3$ | 39 | |
| 3 | Earth& rock refilling | 10,000$m^3$ | 30 | |
| 4 | Cement masonry | 10,000 $m^3$ | 12.08 | |
| 5 | Concrete & reinforced concrete | 10,000$m^3$ | 1.42 | |
| **VIII** | **Main construction materials** | | | |
| 1 | Steel bar | ton | 1749.8 | |
| 2 | Steel | ton | 791 | |
| 3 | Cement | ton | 24330 | |
| 4 | Timber | $m^3$ | 1233 | |
| 5 | Explosive | ton | 50.3 | |
| 6 | Labor | 10,000person day | 82 | |
| 7 | Total Investment (Dynamic) | 10,000Yuan | 15496 | |
| 8 | Total construction cost (Dynamic) | 10,000Yuan | 15180 | |
| 9 | Investment per KW (Dynamic) | Yuan/KW | 7748 | |
| 10 | Construction cost per KW (Dynamic) | Yuan/kW | 7590 | |

**The expenses of activity are summarized in the following table.**

| No. | Item | Unit Rate USD | No. of Persons | Total man days | Total cost USD |
|---|---|---|---|---|---|
| 1. | Flight Tickets | $225(Two-way) Hangzhou-Guangzhou | 6 person x 2 times | / | 2700 |
| 2 | Train Tickets | $25(Two-way) Guangzhou-Chenzhou | 6 person x 2 times | / | 300 |
| | Travel | Sub-total | | | 3000 |
| 3 | Accommodation | $40 per/night | 6 person x 2 times | 12x 10 days | 4800 |
| 4 | Salary for Experts | $50 per/day | 6 person x 2 times | 12x 10 days | 6000 |
| 5 | Report & Drawing | Lump sum | / | / | 500 |
| 6 | Communication & Miscellaneous | Lump sum | / | / | 700 |
| | | Sub-total | | | 12,000 |
| | Total | | | | 15,000 |

## 6. SHP Training Course in Trivandrum, India (T1)

This training course was designed for the participants from South Asia countries. The event took place in Kovalam, Kerala State, India from 30 June, 2003 to 5 July, 2003. Thirty-one participants from Sri Lanka, Bangladesh and India were present in the training course. The two-week course covered all aspects of small hydro development. Three experts were sent to Kerala on this mission. The name list of the participants and the program are attached.

The expenditure of this activity is explained in the following table:

| No. | Item | Cost |
|---|---|---|
| 1 | International travel | US$6,000 |
| 2 | Accommodation | US$3,000 |
| 3 | Course preparation & logistics | US$9,000 |
| 4 | Training materials | US$1,000 |
| Total | | US$19,000 |

**Participants of The International training workshop On Small Hydro Power Project Implementation.**

**30 June- 5 July 2003, Kerala, India**

| No | Name | Official Address |
|---|---|---|
| 1 | Mr.Abudul Latheef Kurudan Chalil | Asst.Executive Engineer, Civil Circle,KSEB<br>Kakkayam<br>Kozhikode 673 615 |
| 2 | Mr.G.Anil | Energy Technologist-E-I, Energy Management Centre, Karamana P.O, Thiruvananthapuram |
| 3 | Mr.Anji N Kollemparamp | Joint General Manager, KITCO Ltd,PB No.1820<br>Ravipuram, MG Road, Cochin 682 016 |
| 4 | Mr.Arun Sharma | Asst.Technical Officer, IREDA, Core-4'A',East Court, Lodhi Road, New Delhi –110 003 |
| 5 | Smt Beena K P | Asst.Exe.Engineer,KSEB, O/o the CE(C)(I&DS)<br>Vydyuthi Bhavanam,Pattom,<br>Thiruvananthapuram |
| 6 | Mr.Christy G Varghese | Steel Industries Kerala Ltd<br>Steel Fabrication Unit, Cherthala post |
| 7 | Mr.VP.Cletus | Asst.Execuative Engineer<br>Vydyuthi Bhavanam, KSEB<br>Pattom, Thiruvananthapuram |
| 8 | Mr.A.N.Dinesh Kumar | Energy Technologist-B, Energy Management Centre, Karamana P.O, Thiruvananthapuram |

| | | |
|---|---|---|
| 9 | Mr.Esther P. Chempakasseeril | Asst.Executive Engineer<br>O/o The Chief Engineet (C)<br>Vydhyuthi Bhavanam<br>Pattom,Thiruvananthapuram |
| 10 | Mr.Gajanana K Hegde | Manager, IT Power India Pvt. Ltd, #6 Romain Rolland Street, pondicherry-605 001 |
| 11 | Mr.V.Harinarayana Reddy | Director, Manihamsa Power Projects Ltd<br>6-1-133/4/2/A,<br>1st Floor,Walker Town,St.No 10<br>Padmaraonagar<br>SECUNDERABAD 500 025 |
| 12 | Sri. Jayachandran.K.A | IRTC, Mundur, Palakkad 678 592 |
| 13 | Sri.M.Krishna, Saha | Council of Scientific &industrial<br>Research, Dhaka, Bangladesh |
| 14 | Sri.M.Krishna Prasad | Vice-President, NCL Energy Limited<br>Raghaba Ratna Towers, 7thFloor,Chirag Ali Lane, Hyderabad 500 001 |
| 15 | Mr.Krishnan Mappidicheri | Asst.Enggineer, Civil Circle, KSEB<br>Kakkayam, Kozhikode |
| 16 | Ms.K.V.S Madhavi kudaligama | Electrical Engineer<br>Generation Planning Branch,Sir C.A.Gardinar MW, Colombo 02, Sri Lanka |
| 17 | Mr.S.Manoj | Asst.Engineer, Generation Circle, KSEB<br>Moolamattom |
| 18 | Mr.Pradeep.M | Asst.Executive Engineer, IP&BD Cell<br>KSEB, Pattom, Thiruvananthapuam |

| | | |
|---|---|---|
| 19 | Mr.P.R.Reddy | Engineer, SILK, Thrissur |
| 20 | Mr.Reju.R | Assr,Manager, IREDA<br>Core-4'A',East Court<br>1st Floor,India Habirat Centre<br>lodhi Road,New Delhi-110 003 |
| 21 | Mr.Reju.R | Executive Engineet<br>Civil Division , KSEB, Kannur |
| 22 | Mr. Satheesan M M | Agricultural Engineer<br>Peermade Development society<br>Post Box No.11,Peermade<br>Idukki-685 5310 |
| 23 | Mr. Sidhartha Gupta | Director, Him Urja, Delhi |
| 24 | Mr. Sijumon Jose | Asst. Manager(Projects)<br>Solar Technologies &Services<br>India (p) Ltd<br>V Floor, Vallamattom Estate<br>MG Road , Ravipuram<br>Kochi -15 |
| 25 | Mr.P.V. Sivaprasad | Asst. Executive. Engineer<br>Water Resource Management Cell<br>Vydyuthi Bhavanam<br>KSEB, Pattom, Thiruvananthapuram |
| 26 | Smt.V.Sovha | Asst. Engineer, RE Cell<br>O/o Chief engineer, Corporate Planning,<br>Vydhurhi Bhavan<br>KSEB, Pattom, Thiruvananthapuram |
| 27 | Mr.C.K.Srikumar | Asst.Manager –Finance<br>Kerala Power Finance Corp. Ltd<br>T.C 15/508,U.S.Road<br>Sasthamanalam P.O, Thiruvananthapuram-695 010 |

| | | |
|---|---|---|
| 28 | Mr.B.Sukumar | Scientist E-II<br>Centre of Earth Science Studies<br>Addulam, Thiruvananthapuram. |
| 29 | Mr.N.K. Sukumarana Nair | Consultant<br>Distict Panhayat, Maramon |
| 30 | Mr.Suresh Kumar D S | Mr. Suresh Kumar D S<br>RA, STED<br>Shatra Bhavan, Pattom,Trivandrum 695004 |
| 31 | Mr.B.P.Taraiya | Add,C.E.(Civil)<br>Gujarat Electricity Board, vadddara |

**The Programme for The SHP Project Implementation**
**Training Workshop in Kerala, India**

| | | | |
|---|---|---|---|
| 30.06.03 | 0930-1300 | **Technical Session - IX** | Lecturers |
| | | Sustainable Development implications of SHP<br>People's Participation in SHP<br>Cost evaluation and Power Purchase Agreements | Mr. |
| | 1400-1700 | TECHNICAL Session-X | |
| | | SHP Flood Analysis<br>Sand Prevention in Hydraulic Structure | Mr. |
| 1.07.03 | 0930-1300 | **Technical Session - XI** | |
| | | Power Evacuation ,Grid Interfacing and Hybrid RE Systems<br>Operation and Maintenance of SHP Electromechanical equipment | Mr. J. Sudhakaran Nair (Former CE, KSEB & Consultant KINFRA) |
| | 1400-1700 | TECHNICAL Session-XII | |
| | | SHP Water Energy Calculation<br>Design of Hydraulic Structures | |
| 2.07.03 | 0930-1300 | Workshop | Chair: |
| | 0930-1030<br>1045-1230 | Feedback from Participants<br>SHP Co-operation workshop | |
| | 1400-1700 | **Technical Session - XIII** | |
| | | Cluster approach & Cascade stations<br>Preparation of regional Master Plans | |
| 3.07.03 | 0930-1300 | **Technical Session - XIV** | |
| | | SHP Long range Planning<br>Hydrology Calculations<br>SHP Practice: Lessons from China | Mr.M.K.Parameswaran Nair<br>Consultant, formerly Member-Civil, KSEB |
| | 1230-1300 | Distribution of Certificates &Valediction | |
| | 1400 onwards | Visit to Peppara 3 MW SHP Station | |

| | | | |
|---|---|---|---|
| 4.07.03 | | Visit to Maniyar 12 MW SHP Station | |
| 5.07.03 | | Independent local visits by participants | |

## 7.Study tour/ Training Course in China (I)

The Training Course in Hangzhou, China, April 2004, had 15 registered participants from 13 countries. The name list of the participants is attached.

The objectives of the training course as:

1)To enable efficient and trustworthy cooperation between IC-SHP and developing countries in Small Hydropower field,
2)To share China's unique experience in the field of SHP and to help in promoting the Technology Transfer of Small Hydropower Equipment and Know-how among developing countries,
3)To explore the possibility of establishing a development framework with focal points at regional and country level in the developing countries for further development of IC-SHP activities,
4)To facilitate the holding of the First meeting of the Advisory Committee of IC-SHP;

The participants were invited to make their presentations in the subsequent sessions with special emphasis on the planning and resource mobilization strategies for SHP in their home countries.

The Training Course Program.is also attached.

**The followings are the outputs of the training course.**

### 1.General Presentations

In the first presentation entitled 'Introduction to SHP in Rural Areas and The Establishment of Preliminary Rural Electrification Counties in China', Prof. Tong Jiandong, DG of the Centre, shared with the participants, the widespread practice and cumulative experience of China in tackling poverty alleviation, environmental protection and rural development, together with energy production for 300 million people through SHP.

The development of strategies for Technical Cooperation in Developing Countries (TCDC) over the years and the current situation and prospects of South-South cooperation were presented by Prof.Li Zhiming, focusing on Public Private Partnership (PPP). Stakeholders from various circles and at different levels in this process are encouraged by China and all were invited to participate in the development of SHP with joint cooperation from IC-SHP.

Prof V. K. Damodaran, MD of IN-SHP, made a keynote presentation on the Prospects for Cooperation, INSHP and Developing Countries, in which he highlighted region-wise, the huge quantum of small hydro potential yet to be tapped globally, especially in Africa and Asia, and outlined 13 areas in which cooperation could be considered and the modalities of linkages were underlined. He also pointed out seven major technical reasons, which make the Chinese experience a very valuable input for planning cooperation exercises.

**1) Country Presentations on the Demand for Cooperation in Developing Countries**

On the second day, the technical sessions opened with the presentations on Demand for Cooperation. Prof.Tong Jiandong chaired the two sessions, which covered these presentations. The participants made highly informative presentations on total hydro and SHP potentials, current status of development and the demand for cooperation in their countries as well as the policy environment prevailing in each administrative region that they represent. The presentations were followed by discussions. During the discussions, the specific needs of the countries were further identified.

Mr. Shamil Birkadze from Hydro Power Ltd., Georgia, informed the participants of the abundant hydropower resources in Georgia, with a total SHP potential of 3000 MW in 1200 sites, among which only 400 MW has been developed. The availability of the high hydro resources potential, shortage of energy in the country, good prospects for energy export to neighboring countries and the existence of high voltage lines and grids, made Georgia fully prepared to develop SHP. Its immediate plan includes rehabilitation of older SHP stations and construction of new efficient SHP projects. Assistance from IC-SHP is required in:
-Training on special computer design programs for SHP project development, manufacturing and assembling of equipment.
-Advice on evolving legislation, for giving further encouragement to the development of SHP.

Mr. G. D. Boateng, from Ghana, made a summary description of potential SHP sties in Ghana and the regulatory policy environment in the country and highlighted the needs. The government has prepared the ground through a regulatory framework that sets the stage for IPPs to invest in power sector. But, the country needs training to carry out detailed feasibility studies and preparation of detailed project reports, as well as in-country and in- ICSHP, training for their professionals on SHP including hands-on experience for project implementation.

Mr. K. R. Abdulla of TANESCO, Tanzania, in his presentation, gave a full account of the rural electrification status of the country:
-Joint effort for technology transfer to developing countries to harness the abundant SHP potential.
-Developing cost-effective designs of small hydro stations through standardization of electro-mechanical equipment and thro' new concepts for layout design (flexibility aspects).
-Developing capacity to manufacture equipment close to the market centers in a cost-effective manner (Co-operation in technological development).

In a presentation from Energy Management Centre, Kerala, India, Mr. K. M. Dharesan Unnithan, gave in absentia, an account of the successful cooperation between the Centre and Kerala in the implementation of four cooperation shp projects as well as India's and the region's shp potential and achievements in implementation, highlighting further cooperation needs as follows:

Mr. Mazharul Islam from Bangladesh Power Development Board, later in his presentation, submitted an attractive proposal to develop a 10 kW micro hydropower plant at Teesta Canal. The proposed demonstration micro hydropower plant, though of very low head, will be a pioneering initiative for harnessing power from existing civil structures and unutilized water current in Bangladesh. Successful implementation of the project will enable the model to be replicated to other existing or future irrigational canal systems for harnessing hydropower in developing countries.

**2.Other Technical Presentations**

The training course workshop felt that as a mature technology with untapped market potential, with the lowest investment cost of all renewable electricity sources in this output range and commercialization resulting in sustainability and self-replication, IC-SHP is urgently required to introduce and disseminate the pico hydel technology to developing countries and help to promote the application and popularization by establishing demonstration projects in selected countries.

Mr. Tan Xiangqing from IN-SHP Chenzhou Base shared the Chenzhou's model of developing SHP for rural income generation, energy supply and environment protection as an independent power developer.

**2)Group Discussion**

The participants were later divided into three groups, representing Asia, Africa and China respectively, for separate discussions with focus on regional SHP development and cooperation. The group discussions were chaired by Dr. Nishantha Nanayakkara (Asia), Mr. K. R. Abdulla (Africa) and Mr. He Zicheng (China). Ms. Hu Xiaobo, Ms. Huang Yan and Mr. Wang Yansong assisted the groups as Rapporteurs.

**2) Field Visit**

Following the 3-day training course, a field visit was organized by IC-SHP from 22 to 23 June. The Fuchunjiang River Hydroelectricity Equipment Works, the 2 x 1.6 MW Long Men SHP Station, the 2 x 1.6 MW Fengshu SHP station and the 2 x 3.2 Tonshan – I and 2 x 2 MW Tonshan – II stations making up a cascade on the Xinganjiang river within the One thousand Islets Lake (Qiandaohu) and a number of other islands of cultural interest were visited by the team. The participants had thus, an opportunity to see these plants in operation and discuss a variety of issues related to design and practical implementation of SHP schemes in China.

**3) Conclusions**

The training course:

a) Reached common understanding of further SHP cooperation approaches and strategies;
b) Established a framework of Advisory Body of IC-SHP;
c) Allowed to enhance exchange of information/technical know-how/expertise among developing countries,
d) Explored the opportunities for SHP technology transfer in various forms through PPP; and
e) Approved the Recommendations on SHP Cooperation Among Developing Countries.

| | | |
|---|---|---|
| **April 15** | Participants Arrive | |
| **April 16** | | |
| **Morning** | 08:30~09:00 | Registration |
| | 09:00~10:00 | Opening Ceremony |
| | 10:00~10:15 | Coffee Break |
| | 10:15~12:00 | ***Session I***<br>The Role of International Community in Facilitating SHP Cooperation among Developing Countries |
| | 12:00~14:00 | Lunch Break |
| **Afternoon** | 14:00~15:45 | ***Session II***<br>SHP Development in India |

| | | |
|---|---|---|
| | 15:45~16:00 | Coffee Break |
| | 16:00~17:30 | ***Session III***<br>SHP Development in Other Developing Countries in Asia |
| | 18:00~19:30 | Banquet |
| **April 17** | | |
| **Morning** | 08:30~10:00 | ***Session IV***<br>New SHP Technologies<br>Hydrogen energy from small hydro power<br>Small Tidal Power |
| | 10:15~11:45 | Touring West Lake |
| | 11:45~12:30 | Lunch Break |
| **Afternoon** | 13:00 | Leave for Chenzhou by Train |
| **April 18** | | |
| **Morning** | 06:59 | Arrival at Chenzhou |
| | 08:30~09:30 | Breakfast |
| | 09:30~10:30 | Welcome Ceremony at<br>IC-SHP Chenzhou Base |
| | 10:30~10:45 | Coffee Break |
| | 10:45~12:00 | ***Session V***<br>Case Study--Experiences of<br>IC-SHP Chenzhou Base |
| | 12:00~14:00 | Lunch Break |
| **Afternoon** | 14:00~15:45 | Session VI<br>New Developments in SHP Equipment Technologies |
| | 15:45~16:00 | Coffee Break |
| | 16:00~17:30 | ***Session VII***<br>Financing SHP |
| | 18:00~19:30 | Banquet |
| **April 19~April 20** | | ***Session VIII***<br>Site Visit |
| **April 21** | | |
| **Morning** | 08:30~12:00 | ***Session IX***<br>Group Discussion-Formulation of Region-wise Action Plans |
| **Afternoon** | 14:00~15:45 | ***Session X***<br>Video Presentation on SHP Construction<br>Q & A |
| | 15:45~16:00 | Coffee Break |
| | 16:00~17:30 | ***Session XI***<br>Seminar Conclusion and Closing Ceremony |
| | 18:00~19:30 | Banquet |

4) The Expenditure of the workshop is listed in the following table.

| **No.** | **Item** | **Expenditure** |
|---|---|---|
| 1 | International Travel for some of the participants | USD 10,000 |
| 2 | Train tickets from Hangzhou to Chenzhou for the participants: | USD 1,000 |
| 3 | Accommodation and Meals in Hangzhou<br>30/Person•Day × 2 days×15 persons | USD 900 |
| 4 | Accommodation and Meals supplied for some of the participants in Chenzhou<br>25/Person•Day × 5 days×15 persons | USD 1875 |
| 5 | Teaching Material & Other textbooks | USD 1,000 |
| 7 | Prof. Time of Trainers | USD 2,500 |
| 6 | Equipment Rent and materials preparation | USD 1,500 |
| 8 | Local Service & Transportation in Hangzhou | USD 2,000 |
| 9 | Local Service & Transportation in Chenzhou | USD 2,500 |