PEREZ-GUERRERO TRUST FUND Project INT/98/k06/A/95/99

Training, Consultation, Awareness and Capacity Building for Small Hydro Power in Developing countries

FINAL REPORT

Submitted by

International Network on Small Hydro Power

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G77 PGTF Project INT/98/K06/A/95/99

FINAL REPORT

Introduction

The project proposal of "Training, Consultation, Awareness Building for Small Hydro Power in Developing Countries", submitted by HIC and endorsed by Ministry of Foreign Trade and Economic Cooperation (MOFTEC), was approved at the twenty-second Annual Ministerial Meeting of the Group of 77 in New York for an amount of US$150,000 in September of 1998.

The project includes four major elements:

1. Training: One seminar (India), two courses (Jamaica and China) and one on-the-job training workshop (Cuba), one workshop (Cuba);
2. Consultation: Missions to help with feasibility studies and planning of SHP projects in Africa, Jamaica, Guatemala, Zambia, Venezuela, Georgia and Kirghiztan;
3. Awareness: Publication of two training texts, and research and compilation of three surveys and a standards study;
4. Capacity Building: Recruitment of international staff and establishment of a SHP trust fund.

The beneficiaries of the Project are the above mentioned countries and the membership of IN-SHP in general. There are over 120 members, but members of particular interest to PGTF include the following organizations and, indirectly, their memberships:

- African Energy Policy Research Network (AFREPREN)
- International Center for Integrated Mountainous Development (ICIMOD)
- Latin America Energy Organization (OLADE)
- South Pacific Applied Geoscience Commission (SOPAC)

On February 12, 1999, it was signed by the Director of the Special Unit for TCDC, UNDP and was also countersigned by the Permanent Delegation of China to UN. The disbursement began from August 1999 after IN-SHP signed a Standard Contract for Service with the National Executing Agency China International Center for Economic and Technical Exchanges (CICETE).

With the support of Chinese government, IN-SHP's memberships and involved parties, up to now, the project Int/98/K06, which was started implementation from April 1999, has been finished. The outputs generated by this project are described respectively as below and the detailed reports are attached in the appendixes.

Output 1. SHP Seminar in Hangzhou (T1)

The Seminar was organized by IN-SHP with support from UNIDO. Nine participants from 8 countries (the list of participants is attached in the annex) attended the seminar. The attending international experts made presentations on planning and resource mobilization strategies for SHP in their countries.

At the Seminar, extensive information/technical know-how/expertise among developing countries, Hangzhou Center and UNIDO on SHP development practices and strategies were exchanged; TCDC/ECDC possibilities explored and a number of activities to be followed up identified; also the opportunities for utilizing expertise and technology access of Hangzhou Center sponsored by UNIDO for promoting SHP applications in developing countries were explored.

During discussions, participants of the Workshop strongly supported the idea of establishing the International Center on SHP under UNIDO auspices with the prime objective to promote SHP applications world-wide, sharing technologies and experience for developing countries.

The representative from UNIDO outlined the structure of UNIDO, modalities for cooperation and briefly presented the 16 service modules, which form the core competence area of UNIDO. With due regard to the subject of the seminar, more detailed information was given on "Rural Energy Development" and "Energy Efficiency" modules. The participants were encouraged to approach UNIDO and with reference to the seminar submit formal requests to UNIDO so that preparatory work for SHP project development could be initiated without delay.

During the seminar, a site visit was organized by the Hangzhou Center with support from the Hydro and Electric Power Bureau, Lin'an County, Zhejiang Province. Three small hydropower plants were visited where participants had an opportunity to see the plants in operation and discuss a variety of issues related to design and practical implementation of SHP schemes in China.

For detailed report, please refer to appendix 1.

Output 2. SHP Training Course for Jamaica & Neighboring Caribbean Countries (T2)

The training course was originally planned in July 1999, however, due to unexpected problem of visa procedure in China, it was postponed to March 19-23, 2001.

A team of two senior experts will be dispatched to Kingston, Jamaica as lecturers for the workshop. The local partner is Petroleum Corporation of Jamaica. 25 participants from

Jamaica and neighboring Caribbean countries have been enrolled for the course.

A work program and the teaching materials that will be used in the training course are attached in appendix 2.

Output 3. On-the-Job training course for Cuba in Hangzhou (T3)

Five Cuban engineers took part in this activity from November 3, 1999 to January 19, 2000. Among them, there is one hydropower engineer, one mechanical engineer and three electrical engineers. The program for the five engineers comprised lecturing, site visiting to SHP stations, factories and colleges, working with HIC staff, participating the design work and other tasks which HIC will undertake. This program has widened and deepened their understanding of SHP development in China and worldwide.

For detailed report, please refer to appendix 3.

Output 4. SHP Training Course for Cuba in Cuba (T4)

Four Chinese experts visited Cuba from November 29 to December 12, 1999 to organize the proposed SHP workshop. The workshop was held in Maxim Gomez Baez Profession Training Center, a profession basis 5 kilometers far from Bayamo, the capital of the Province Granma.

INRH, Cuba enrolled 24 trainees for the training course. Most of them were at work on station maintenance, some on SHP programming. Two teachers of SHP participated this training course. During the workshop, they were introduced to China's SHP and Policy, Capital Construction Procedure and Design Course of SHP: Plan of River Basin and Selection of Site, Project Proposal, Feasibility Study, Preliminary design, Preparation Stage, Ejection Stage, Production Preparation Stage, Final Acceptance, and Evaluation after 1or 2 years of operation; Civil Works: forebay, diversion works; Electronic equipment & Water Turbine: Selection of SHP Equipment and design; During the training course, the trainers also introduced the operation management, the economical evaluation.

During the training course the Cuba partner organized the class to visit some power stations. And in the class, the trainers helped the participants to analyze these stations, and answer the questions.

The participants were interested in this training course and new technology. And they suggest that HIC should organize another training course in Cuba in order to introduce China's experience and technology.

For detailed report, please refer to appendix 4.

Output 5. Mission to Promote SHP in Africa (C1)

The African energy sector is a critical input to development on the continent, yet to date the sector has been plagued by problems which reflect the economic and environmental problems of many African countries: frequent power and fuel cut-offs, low access to "modern" fuels and electricity, financially precarious energy sector institutions, and a chronic lack of infrastructure investment.

The lack of access to sufficient, affordable, and environmentally sustainable commercial energy is reflected by key energy indicators. Biomass continues to be the larges energy source, providing half of Sub-Saharan African energy.

Per capita *commercial* energy use, among the lowest in the world, has actually been falling in recent years. Despite the low commercial energy use, energy intensity(e/unit GDP) is triple that of Europe.

INSHP undertook a Consultation mission to the two African countries with large potential of small hydro resources, Ethiopia and Zimbabwe, between 13-25 June 2000.

Following the invitation of the Regional States of Oromia, (the region with the highest resources base in the country) Department of Water, Mineral & Energy Resources, Several institutions would be involved in an interdisciplinary project to develop the existing and proposed SHP potential sites.

As a concrete result of the intensive negotiations a Memorandum of Understanding (MOU) was signed.

Following the invitation of the ZESA and ZPC, INSHP undertook a consultation mission between 17-25 June 2000 in Zimbabwe, visiting the SHP sites in the Eastern Highlands. Several institutions would be involved in an interdisciplinary project to develop the existing and proposed SHP potential sites.

As a concrete result of the intensive negotiations a Memorandum of Understanding (MOU) was signed.

For detailed report, please refer to appendix 5.

Output 6. Technical consultation mission for the Laughlands Great River hydro project of Jamaica (C2)

The proposed Laughlands Great River Hydroelectric Project is located on the north side of the island. There has been irrigation canal on Laughlands Great River. The proposed project with installed capacity of 5.1 MW is just to utilize the water head between Laughlands Little River and the weir formed by building a dam on the downstream of the irrigation canal on the Laughlands Great River.

The project comprises a 15 feet high and 36 feet long weir, 5435 feet long trapezoidal cross section canal, a circular forebay with 35 feet diameter, 2140 feet long penstock with 55~63 inches diameter and 2083 feet long tailrace canal.

The main powerhouse: design water head 382 feet, division flow 175 cfs, two horizontal Francis turbines with 2500 capacity for each.
The powerhouse with additional function for irrigation: water head 167 feet, flow 17.5 cfs, one 310 kW crossflow turbine.

Annual Output: 22.057 GWh, the investment was estimated to be 10.40 million US dollars.

The above information was drawn from existing feasibility study report. According to the agreement between HIC and the project developer, the former role is to make re-evaluation based on this feasibility study. For the detailed evaluation report, please refer to appendix 6.

Output 7. Consultation for Clavellinas project in Guatemala (C3)

Guatemala is rich in natural resources. Its topography creates a lot of falls, rivers which are the basic elements for developing small hydro power. One of main restraints the nation has been facing in rural economic development is electricity shortage, while exploiting mini/small hydro power could help a lot in this regard. Under this background, Ministerio de Energia Y Minas de Guatemala worked out a national SHP improvement program. Clavellinas project is one item of this program.

Three optional schemes have been made in exploiting this project, as briefly described hereinafter.

i) Rehabilitation and updating of Nebaj SHP plant.
The installed capacity of Nebaj SHP plant will reach 500 kW after rehabilitation ($Q=2m^3/s$, H=30m). The cost was estimated to be US$1,200,000.

ii) Clavellinas A Option
This option will built a 40m long dam which will create 180m water head for the station with installed capacity of 1.5 MW. The total cost was estimated to be US$2,850,000.

iii) Clavellinas B Option
In this option, a 20-m long dam will be built. The installed capacity of this station will be 3.45 MW.

With the assistance of OLADE, HIC experts have investigated the site. Some more detailed information has been given to HIC by the cooperation partner in Guatemala recently and is under study currently. Based on the information in hand, HIC will compare these three optional schemes and make the choice or, if necessary and available, design a new, optimal one. The report on the project had been finished in December 1999.

For detailed report, please refer to appendix 7.

Output 8. Feasibility Study of Luckela and Chakata Falls project sites in Zambia (C4)

IN-SHP initiated this project with Centre for Energy, Environment and Engineering (Zambia) Ltd (hereinafter CEEEZ). IN-SHP and CEEEZ jointly drafted a proposal for undertaking a pre-feasibility study in potential sites for development on small hydropower stations for electricity generation and thereafter a workshop of various stakeholders involving Ministry of Energy and Water Development, Ministry of Finance and Economic Development, Financial institutions, members of Parliament and District Councils of the identified sites, Zambia Electricity supply Corporation (ZESCO), and private business people and other interested investors.

Four potential sites are to be considered in the pre-feasibility study, namely Luckela and Chakata falls project, Kabompo/Manyinga in North Western Province. The original arrangement was that the pre-feasibility study of these projects would be finished under IN-SHP experts' technical guidance. However, when IN-SHP contact CEEEZ in 1999, CEEEZ asked IN-SHP to cover all the cost that may incur, which was out of IN-SHP's financial capacity. Therefore the IN-SHP gave some consultation and comments to our partner. A copy of the proposal was attached in appendix 8.

Output 9. Consultation for two SHP projects in Venezuela (C5)

In July-August of 1998, at the invitation of Ministerio de Energia y Minas of Venezuela, IN-SHP sent two experts to Venezuela to provide consultation service for SHP projects.

The team investigated SHP sites at Portugues waterfall, Playa Blance waterfall and Cuyuni river, Pauji waterfall, Icabaru river, Carpupa in the State of Bolivar, and Puerto Viejo, Isabel River in the State of Surce. The best two sites are Pauji waterfall and Playa Blance waterfall, which the team suggested start follow-up cooperation.

For detailed report, please refer to appendix 9.

Output 10. Consultation for Chelti river's small hydro power in Georgia (C6)

According to IN-SHP 1999 work plan, HIC sent a consultation team of two engineers who were partly sponsored by G77 PGTF, to Georgia to consult for the local sites of small hydro power on Chelti river from November 17 to 24, 1999. Arranged by the Ministry of Fuel and Energy of Georgia, the team investigated the Chelti river's fall and provided technical consultation. A detailed technical report was finished and submitted to the Georgian partner the Ministry of Fuel and Energy for review and a copy was also attached in appendix 10.

Output 11. Consultation Mission for SHP Stations and Local Grid Planning and Development in Kirghizstan (C7)

There are abundant hydro resources in mid Europe, especially republics of former Soviet Union like Kirghizstan and Georgia, which the technical force is strong and has good development conditions, while the manufacturing level is low and fund is short. According to the general target of our center as well as China's manufacturing situation for small hydro equipment, it is workable to make equipment supply for small hydro project in mid European countries. And both governments have shown positive attitudes and the responses from China's Ministry of Water Resources as well as Kirghizstan's Ministry of Agriculture and Water Resources are also positive and supportive.

Ministry of Agriculture and Water Resources in Kirghizstan provide us with the main technical parameters of 6 small hydro sites and send us formal invitation for our expert team to make on-site investigation. Meanwhile our center also invites the first Vice Minister of Agriculture and Water Resources in Kirghizstan, Chancellor of Scientific & Technological Research Institute and Chief Expert in Rural Hydro to visit China.

Our center organizes engineers to make research on the technical data of 6 hydro stations and make initial comments. And we also study the possible ways and schemes regarding the cooperation with Kirghizstan.

The 6 projects in Kirghizstan are technically feasible and the both government also shown a positive response to the coming cooperation. The technical evaluation and consultation has put a solid base for the future cooperation between two parties. If we can succeed in finding possible funds from international organizations or export credit from Chines banks, we can continue the development of these projects in Kirghizstan.

For detailed report, please refer to appendix 11.

Output 12. Textbook serial on SHP Design (A1)

One SHP design textbook serial has been published on schedule by the China Planning Publishing House in Beijing in October 1999, including 9 different books with contents covering low-voltage equipment, turbine, regulator, automation technology, electrical section, equipment management, operation and maintenance. This series publicizes the new technology and innovations in this field, taking the station operators as potential readers. The nine books are respectively titled as,

- Operation and Maintenance
- Accessory Equipment
- Governor
- High Voltage Equipment
- Electrical equipment
- Control System
- Equipment Management
- Monitor & Repair
- Mini Hydroelectric Equipment

The copies of the covers of the 9 textbooks are attached for reference as appendix 12.

Output 13. Textbook on "Small Hydraulic Turbine" (A2)

As a clean and affordable renewable energy source, small hydropower (hereinafter as SHP) has been proven an effective way to rural electrification, poverty alleviation and overall social sustainable development in many countries. However, in many developing countries, due to lack of practical technical know-how and appropriate equipment, the SHP development was hampered, a large population in those countries still do not have access to electricity for basic needs.

International Network on Small Hydro Power (IN-SHP), as the key player in this field to promote SHP development worldwide, decided in the 1995 IN-SHP Coordinating Committee meeting in Milan to publish a set of standards for SHP equipment and a training textbook on the basis of some parts of my book *Small Hydraulic Turbine* to disseminate the advanced and practical technologies and experiences to where they are most needed.

The book was published in February 2001, co-write by Prof. Petr Fleischner of Brno Technical University of Czech and Prof. Tong Jiandong, Director of IN-SHP.

The book consists of four chapters: Chapter I is about basic theory of turbine; Chapter II focuses on the design of turbomachines, Chapter III explains the methods of calculation for turbomachines, and the last chapter is on the indigenous manufacture of small turbine. Chapter II and III were finished by Prof. Fleischner.

A copy of the cover of *Small Hydraulic Turbine* is attached as appendix 13.

Output 14. Research paper *Standards of Rural Electrification: Country Studies* (A3)

In 1999, IN-SHP participated in the survey and discussions for the formulation of Standards of Rural Electrification of China organized by the Ministry of Water Resources, China. By the end of 1999, the standards was drawn up and adopted by the State Council of China. In early 2000, the standards came into effect.

A copy of the standards of Rural Electrification in China is attached as appendix 14.

Output 15. Research papers *An Overview of SHP Worldwide* (A4)

The SHP information from 132 countries in Europe, South Pacific region, Latin America, Africa and Asia has been collected.

The papers are attached as appendix 15.

Output 16. The Second Survey of Medium/Small Hydropower Equipment in China (A5)

In 1999, China Association of Medium/ Small Hydropower Equipment Manufacturers, which is affiliated with IN-SHP, co-organized with the Association of Water Resources and Power Enterprises of Ministry of Water Resources of China the second survey of medium/small hydropower equipment in China on the following points:

1. Price of water turbine, generator, governor and excitation system since last survey in 1993
2. Quality of the equipment
3. Procedures and management of equipment supply contracts

Conclusion: in China, the cost per kW for medium and small equipment production in China is continually going up since 1993, almost amounting to the average cost in industrialized countries. The price of the medium/small hydro equipment of China is no longer a winning point in competition with those from industrialized countries, while the quality of the product cannot reach the same level as those of industrialized countries. If the situation is not improved and technology upgraded, China's hydro equipment producers will soon lose their market share even in China.

For detailed report, please refer to appendix 16.

Output 17. Research and Survey of the Structural Reform in Medium/Small Hydropower Sector in China (A6)

At the initiative of the Bureau of Hydro Power and Rural Electrification, Ministry of Water Resources, IN-SHP undertook a research and survey of the structural reform in medium/small hydropower sector in the provinces China where hydropower is the main energy sources.

The research analyzed all sorts of monopolies of power industry in China; introduced the latest information of deregulation of power market in industrialized countries; and suggested the changes as appropriate.

For detailed report, please refer to appendix 17.

Output 18. Recruitment of 8 International Staff (B1)

In accordance with the HIC/IN-SHP work plan, which is also the project INT/98/K06 approved and funded by Perez-Guerrero Trust Fund, up to February, 2000) IN-SHP has successfully recruited 11 international staffs, over-fulfilling the target in the project. Please refer to the table "Recruited International Staffs".

For detailed report, please refer to appendix 18.

Output 19. Establishment of a SHP Trust Fund to Promote SHP in Developing Countries (B2)

Since its inception, IN-SHP has been seeking support for the establishment of a SHP Trust Fund to promote SHP in developing countries. At its annual meeting in Toronto 1996, the decision-making body of IN-SHP Coordinating Committee calls for the establishment of a SHP Trust Fund. IN-SHP explored a number of options in order to realize this goal. With the assistance of international experts, IN-SHP pursues the route of a Trust Fund under the auspices of UNIDO for UNIDO is a key player in promoting industry in the world and IN-SHP has close cooperation ties with UNIDO since its own establishment.

With the support of Chinese government through MOFTEC and UNIDO, a Trust Fund Agreement was signed on December 3rd of 2000 and came into effect upon signature. The Trust Fund was therefore established, which will greatly promote the development of small hydro power in developing countries.

A copy of the Trust Fund Agreement is attached herewith for reference in appendix 19.

Appendixes:

1. Report on SHP Seminar in Hangzhou
2. Report on SHP Training Course for Jamaica & Neighboring Caribbean Countries
3. Summary reports for "On-the-Job" training course
4. Report on SHP Training Course for Cuba
5. Report on Mission to Promote SHP in Africa
6. The evaluation report for the Laughlands Great River hydro project of Jamaica
7. The evaluation report on Clavellinas project in Guatemala
8. Proposal on Feasibility Study of Luckela and Chakata Falls project sites in Zambia
9. Report on Consultation for two SHP projects in Venezuela
10. Consultation report of Georgia Chelti river's small hydro power
11. Report on Consultation Mission for SHP Stations and Local Grid Planning and Development in Kirghizstan
12. Copy of covers of the textbook serial on SHP Design
13. Copy of cover of the Textbook on "Small Hydraulic Turbine"
14. Research Paper *Standards of Rural Electrification: Country Studies*
15. Research paper *An Overview of SHP Worldwide*
16. Research paper on the Second Survey of Medium/Small Hydropower Equipment in China
17. Research paper of the Structural Reform in Medium/Small Hydropower Sector in China
18. Report on Recruitment of 8 International Staff
19. Report on Establishment of a SHP Trust Fund to Promote SHP in Developing Countries

Annex 1

Annex 1

PEREZ-GUERRERO TRUST FUND Project INT/98/k06/A/95/99

SHP Seminar in Hangzhou, China

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Submitted by

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Report

UNIDO/Hangzhou Center/MNES Workshop on Small Hydro Power (SHP)

Hangzhou, China, 26-29 October 1998

1. Participants

The Workshop was attended by 9 participants from 8 countries (the list of participants is attached in the annex).

2. Opening of the Workshop, election of officers and adoption of the agenda

The representative from UNIDO welcomed the participants to the meeting and made a presentation on the background of the UNIDO project "Institutional Capacity Building, Assistance to Hangzhou Center in Promotion of International Network on SHP", which provided the framework for this meeting.

Prof. Tong Jiandong, Director of Hangzhou Center for SHP, was elected Chairman of the meeting, Dr. P. Saxena, Ministry of Non-conventional Energy Sources, from India was elected Vice-Chairman, Mr. M. R. Haroon, Bangladesh Power Development Board, was elected Rapporteur of the meeting.

The Workshop adopted the provisional agenda and time-table as given in the annex.

In their welcoming speeches, Prof. Tong and the representative from UNIDO informed participants of the past activities and current cooperation between Hangzhou Center, UNIDO and other UN organizations. Special attention was given to the recent request from the Government of China for the establishment of the International Center on SHP under UNIDO auspices.

The international experts were encouraged to make presentations on planning and resource mobilization strategies for SHP in their countries in light of the following objectives of the Workshop:

1) to enhance information exchange among developing countries on SHP development practices and strategies;
2) to explore possibilities for strengthening TCDC/ECDC cooperation;
3) to analyse the opportunities for utilization of Hangzhou Center as a technology and information resource for the promotion of SHP in rural areas in their countries;

4) to exchange views on establishment of International Center within the framework of UNIDO as a mechanism for promotion of international collaboration in the area of SHP;

3. Presentation on the situation and experience of SHP development in China

A detailed report on the situation and experience of SHP development in China was presented by Prof. Tong (see annex). Main features allowing China to become the leading country in the exploitation of SHP resources are:

- decentralized approach for SHP development;
- special incentive policies and strategies adopted at regional government level;
- close relation of SHP development with electrification of rural areas;
- cost-effective SHP technologies;
- decentralized/local grid development.

The variety of issues raised by the participants reflected the diversity of the countries interest in particular aspects of SHP development, but it was clear that the Hangzhou Center was regarded as an information & technology resource on SHP and its internationalization within the framework of UNIDO can be a valuable tool for sharing experience among developing countries.

4. Presentation on SHP programme in India

An in-depth analysis on SHP development in India was presented by Dr. P. Saxena (see annex). The participants especially welcomed a number of issues raised in the report, such as:

- national and regional capacities for mobilizing initial investment in SHP development;
- clarifications regarding environmental impact expertise required for implementation of SHP projects;
- correlation between the existing inter-state electricity transmission lines and local grid development in rural areas, etc.

In addition, a document "Policy on Hydropower Development" prepared by the Government of India was introduced to the participants of the Workshop. In the paper, the strategies of the Government towards the implementation of the 9-th five-year plan (1997-2002) are clearly outlined. The meeting was also informed that an international training programme on SHP is being organized at AHEC (Alternate Hydro Energy Center), University of Roorkee, India next year. It was suggested by the participants that special focus of the training programme may be on GIS (Geological Information System) models for identification of SHP sites. In this connection, UNIDO was requested to consider sponsoring a few candidates from developing countries to this training programme.

Among the areas for assistance from UNIDO and Hangzhou Center, Dr. Saxena identified the following:

- strengthening of national capacities in India in designing SHP projects/equipment industry for rural electrification and development of small-scale industries;
- quality and standardization in SHP;
- development of decentralized power supply in remote areas;
- methodology for optimizing load in decentralized SHP projects;
- models for community's participation in developing SHP projects.

5. Presentations on SHP development in Bangladesh, Bhutan, Cambodia, Lao PDR and Pakistan

The participants made highly informative presentations on SHP development in their countries (see annex), which were followed by the question/answer sessions. During the discussions, the specific needs of the countries were identified.

In **Bangladesh**, assistance from UNIDO and Hangzhou Center is required in:
- local capacity building for project design and management;
- training of specialists in SHP technologies;
- identification of investors for SHP projects and fund mobilization.

Hangzhou Center was also requested and agreed to coordinate the follow-up activities in regard to the visit of Chinese SHP experts in 1984 when 12 potential sites for SHP schemes were identified.

It was also agreed that within the framework of TCDC/ECDC activities, India would be able to provide Bangladesh Power Development Board on their request with GIS/hydrological models for identification of new SHP sites.

In **Bhutan**, assistance from UNIDO and Hangzhou Center was required in national capacity building in SHP project design and management including training for SHP specialists. Another area where UNIDO involvement is needed is identification of international donors and fund mobilization for implementation of non-commercial SHP projects which have, however, high social and environmental impact.

Within TCDC/ECDC, India could also provide Bhutan with technical expertise for reliable methods of investigation and hydrological data collection for SHP development. Hangzhou Center offered its assistance in exploring possibilities of reducing the energy costs through introduction of appropriate SHP technologies and optimization of equipment.

Cambodia requested UNIDO and Hangzhou Center's assistance in carrying out a capacity building programme at the national level including SHP project design and implementation, collection and analysis of data for assessment of SHP potential and identification of sites, training in SHP technologies, international expertise for project development and feasibility analysis.

In **Lao PDR**, UNIDO and Hangzhou Center's involvement is desired in planning and implementation of a programme in the northern part of the country on development of SHP for rural electrification and replacement of existing diesel power plants which cannot be considered as providing long-term solution for sustainable energy supply in the region. As a first step, a proper examination of SHP potential for rural areas should be undertaken. The participant from Lao PDR also requested assistance in carrying out a wide spectrum of activities focused mainly on local capacity building and training of specialists in SHP technologies.

Mr. Mahli from **Pakistan** in his presentation informed the meeting that more than 720 micro-, mini- and small hydro power schemes are identified in the country with a total potential of up to 1664 MW and requested technical assistance in implementation of specific SHP projects with emphasis on funds mobilization and identification of investors, models of community's involvement in SHP project development.

Training at Hangzhou Center may be extended under the sponsorship of UNIDO to avail the experience of SHP development in general.

During discussions, participants of the Workshop strongly supported the idea of establishing the International Center on SHP under UNIDO auspices with the prime objective to promote SHP applications world-wide, sharing technologies and experience for developing countries. The information regarding the intention of the Government of China to enter into discussions with UNIDO on this issue was welcomed by the participants.

6. UNIDO presentation

The representative from UNIDO outlined the structure of the Organization, modalities for cooperation and briefly presented the 16 service modules, which form the core competence area of UNIDO. With due regard to the subject of the Workshop, more detailed information was given on "Rural Energy Development" and "Energy Efficiency" modules.

The participants were encouraged to approach UNIDO and with reference to the Workshop submit formal requests to the Organization so that preparatory work for SHP project development could be initiated without delay.

7. Site Visit

During the Workshop, a site visit was organized by the Hangzhou Center with support from the Hydro and Electric Power Bureau, Lin'an County, Zhejiang Province. Three small hydropower plants were visited where participants had an opportunity to see the plants in operation and discuss a variety of issues related to design and practical implementation of SHP schemes in China.

8. Conclusions

The Workshop:

1) allowed to enhance exchange of information/technical know-how/expertise among developing countries, Hangzhou Center and UNIDO on SHP development practices and strategies;
2) explored TCDC/ECDC possibilities and identified a number of activities to be followed up;
3) explored the opportunities for utilizing expertise and technology access of Hangzhou Center sponsored by UNIDO for promoting SHP applications in developing countries.

In this context, the meeting:

- commended the initiative of the Government of China for supporting Hangzhou Center;
- supported the initiative of the Government of China to establish the International Center on SHP within the framework of UNIDO, as well as the intention of the Government of China to enter into discussion with UNIDO with the purpose of concluding the necessary agreements as soon as possible;
- requested participants to bring the report of the Workshop and the issue of establishment of International Center on SHP within the framework of UNIDO to the attention of the experts concerned as well as relevant government officials;
- requested UNIDO and Hangzhou Center to bring the report of the meeting to the attention of the Government of China and Director-General of UNIDO.

In addition, the participants:

- greatly appreciated the efforts of Prof. Tong Jiandong, Director of Hangzhou Center, in promoting SHP applications in developing countries;
- thanked Hangzhou Center and the Government of China for excellent arrangements and facilities for the Workshop and general hospitality.

List of the Participants
of the UNIDO/ HIC/MNES Workshop on Small Hydro Power
26-29 October 1998 Hangzhou, China

Country	Name of participant	Title and organization	Contact address
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Schedule of the UNIDO/HIC/MNES Workshop on SHP
26-29 October 1998
Hangzhou, China

Sunday 25 October 1998

Arrival & Registration

Monday 26 October 1998

09:30-10:30	Opening Ceremony - Election of Chairman, Vice Chairman and Rapporteur - Review and adoption of the agenda - Welcome speeches from UNIDO and HIC/IN-SHP
10:30-11:30	Presentation on the situation and experience of SHP development in China ● *International Network on Small Hydro Power*
11:30-11:45	Tea Break
11:45-12:45	Presentation on the situation and experience of SHP development in China, followed by the Question & Answer session ● *International Network on Small Hydro Power*
12:45-14:00	Lunch
14:00-17:45	Introduction to SHP in India and presentation on Rural Energy Programme, followed by the Question & Answer session ● *Ministry of Non-Conventional Energy Sources, India*

Tuesday 27 October 1998

09:30-11:00	Presentations on the planning and resource mobilization strategies for SHP in the participating countries, followed by the Question & Answer session ● *Bangladesh: Bangladesh Power Development Board* ● *Bhutan: Division of Power, Royal Government of Bhutan*
11:00-11:15	Tea Break
11:15-12:45	Presentations on the planning and resource mobilization strategies for SHP in the participating countries, followed by the Question & Answer session ● *Cambodia: Ministry of Industry, Mines and Energy* ● *Lao PDR: Ministry of Industry and Handicraft*
12:45-14:00	Lunch
14:00-14:45	Presentations on the planning and resource mobilization strategies for SHP in the participating countries, followed by the Question & Answer session ● *Pakistan: Pakistan Water and Power Development Authority*
14:45-15:45	Discussion on TCDC/ECDC possibilities in SHP sector
15:45-16:00	Tea break
16:00-17:45	Discussion on TCDC/ECDC possibilities in SHP sector

Wednesday 28 October 1998

Site Visit

Thursday 29 October 1998

09:30-10:30 Closing Ceremony
- Adoption of the Report of the Meeting

Annex 2

Annex 2

PEREZ-GUERRERO TRUST FUND Project INT/98/k06/A/95/99

SHP Training Course for Jamaica & Neighboring Caribbean Countries

FINAL REPORT

Submitted by

International Network on Small Hydro Power

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A WORKSHOP ON SMALL SCALE HYDROPOWER
IN-SHP, China, Petroleum Corporation of Jamaica
March 19-23, 2001

MONDAY – March 19

Morning: (a) Opening Ceremony
(b) Overview of Small Hydropower (SHP) in China
(c) Jamaica's SHP and the needs
(d) IN-SHP and its Activities
(e) Review study of SHP equipment and Practice
(f) Hydrology and Energy
(g) Civil Works
(h) Selection of SHP Equipment
-Electrical and Mechanical Equipment and Automation
-Indigenous manufacturing of SHP equipment

Afternoon: Complementary Information on Laughlands Great River Project

TUESDAY – March 20

Site Visit: To Laughlands Great River in St. Ann and either the Roaring River (3.8MW) or Lower White River (4.9MW) hydropower stations

WEDNESDAY – March 21

Morning: Laughlands Great River Project – Presentation of Information and Development of a Case Study

Afternoon: Continuation of Case Study

THURSDAY – March 22

Morning: Continuation of Case Study

Afternoon: Economic analysis of a potential project at Laughlands Great River

FRIDAY – March 23

Morning: Presentation of results of case study

Afternoon: Closing of the Workshop

Power Channels of the Hydro Stations

According to the types of water head collection, hydro stations can be divided into two major schemes, namely the dame scheme and diversion scheme. As far as stations with diversion scheme are concerned, it mainly depends on the diversion channel to collect the head. Since there is no necessity to construct large dames, the damage caused by the inundation is comparatively small. Most of the medium and small hydropower stations belong to the diversion scheme.

Under such a scheme, the diversion structures play a role to collect water head and transmit the discharge. The diversion scheme is most popular especially in mountainous rivers with steep slope. Here I would like to focus on the free-flow diversion scheme. The most common type under such a scheme is to utilize the channel which is popularly used in most mountainous rivers in China. Related statistics showed that small hydropower stations with diversion scheme account for about 63.8% of the total SHP stations. And it is witnessed to be a simple and economical way of development.

Major elements of the channel design

1. Route selecting of the channel

In specific projects, due to the difference in topographical conditions, geological conditions and public facilities to be resettled along the channel, the direction of channel varies. The overflow schemes of each channel section also have different types like open channel, tunnel, culvert, aqueduct and inverted siphon. Generally speaking, the channel route is worked out according to the contour line and channel longitudinal slope designated on the contour map. Special research will be conducted towards to the difficulties encountered along the channel route so as to choose a possible scheme. Finally different schemes have to be compared to find a best one.

(1) Main Conditions in Choosing Power Channel of Hydro Stations

The topographical conditions and surface features. In selecting the channel route, considering the different design stages, the topographical features along the channel route, sectional topographical drawings in special sections and vertical and transversal drawings profiles will be collected so as to meet to demand for laying out the power channel and channel system.

Hydrological and meteorological conditions. To collect data of the hydrological features like water level, runoff and flood etc, silting and water quality in diversion rivers and other rivers, streams and valleys. It is also necessary to collect meteorological data of precipitation (rainstorm included), air temperatures, wind force, wind direction, frost period, depth of frozen ground.

Engineering geological and hydrological geological conditions. In accordance with "the basic technical specifications for geological survey of hydro projects", geological survey shall be carried out. Normal geological features at the channel region shall be clarified and geological conditions at locations of both channel route and channel systems will be studied in details. The type of underground water, depth of burying, depth of water-bearing bed, dynamic current direction, feeding and discharging conditions as well as water quality shall be explored.

Conditions for facilities along the channel route. All structures at the channel region shall be indicated in the topographical drawing.

2. Principles in Selecting the Channel Route

Before selecting the channel route, locations of the headworks and powerhouse have been settled. Therefore as far as the route selecting is concerned, the channel shall try to be short as well as straight so as to reduce the energy loss of the power channel. In case that the channel comes across the valley and/or mountains, alternative of detouring and running through will be compared. If conditions allow, aqueducts and tunnels could be uses to shorten the channel length.

In selecting the channel route, in order to adapt the topographical changes, when the channel comes across the bend, the bend diameters of unlining channel shall be no less than 5 times that of the width of water surface and the bend diameter of lining channel shall be no less than 2.5 times that of the width of water surface.

Dangerous land section shall be prevented along the channel route and deep excavation & high dam shall be prevented. In place where the channel route runs through the railroad, public road as well as the rivers and ditches, it is better to keep crosscut.

Example for Selecting the Channel Route

Saopo Station in Wenshuan County of Sichuan Province is a station with diversion scheme. The station has a high head and a reservoir with daily regulation capacity. Design head is 391 m, design discharge is 9.6m^3/s, and installed capacity is 2*15MW and the yearly average power dame, sluice gate, inlet gate, sand basin, diversion system like tunnel and aqueduct, forebay, penstock, main and auxiliary powerhouse, tailrace and substation. The construction of the project was started in March, 1985. In February, 1988 the first unit came into commissioning and in April of that year the second unit was put into operation.

The altitude of the project is between 1500m and 2500m. The project is characterized with steep topographical features and complicated geological features. The selection of the channel route experienced four stages of planning and siting, geological survey, preliminary design and engineering design.

During the stage of planning and siting, comparison of topographical and geological conditions has been conducted. Since the topographical and geological features at the right bank are more complicated than that at the life bank, the channel route is finally settled at the left bank. By utilizing the Malingshan Tunnel of 1040m, the whole channel has been shortened and an additional head of 166m is earned. The additionally earned accounted for about 40% of the total design head. Nevertheless in this stage, it is unable to have a clear idea regarding the complexity of both topographical and geological feature. Except the Malingshan Tunnel, all the rest part of the channel is designed as open channel.

Geological Survey Stage. Before the preliminary design stage, geological survey has been conducted during which the channel route selected in planning and siting stage will be adjusted according to the geological condition and two tunnels of Kechong Tunnel No.1 and Lamayan Tunnel No. 1.

Preliminary Design Stage. According to the data collected in the geological survey and topographical conditions, readjustment has been done to ensure a safe and stable water flow, economical and suitable channel cross-section and convenient construction, management and maintenance. 4 tunnels have been added with a total length of 2469.18 M. Considering that the land altitude at the outlet of sand basin is comparatively low and the inside is more steep, therefore the open channel in this section was substituted by aqueducts. In areas of detritus stream, inverted siphon which is deeply buried under the channel bottom. Seven places of open channels have been replaced with culverts with a total length of 3000.8 m. All the culverts are arranged together with the tunnels and a totally enclosed 5585.78 m long diversion system has thus been formed.

Engineering Design Stage. According to the related reports made in preliminary design stage as well as geological reasons, another adjustment was made to the channel route. The length of aqueduct has increased from 115.8 m to 240 m. The Kechong Tunnel No. 2 and 3 have been merged into one. Another new Lamayan Tunnel No. 3 has been added. After the comparison, the scheme of inverted siphon has been canceled, in stead the scheme of discharge through weir crest has been adopted. Finally, the whole channel is 5432.44 m and around 153.34 m has been reduced.

2. Several Issues that Might Rise in the Design of Power Channel

(1)The Design Discharge of Power Channel

As far as the design discharge of power channel was concerned, except the power generation is a concerned, possible problems like leakage loss and discharge required for sand sluicing have to be taken into consideration. Therefore generally speaking the design discharge is equal to and larger than that of unit inflow.

Leakage problems are normal in the channel design, especially those earth channel with long route, the water lost due to the leakage is considerable which might account for 30-40% of the total effective discharge. Furthermore, since the leakage makes the local soil become saturated., it might cause side slope to be unstable. Theoretical method could be used to calculate the leakage loss. Nevertheless, in practice, the local geological conditions are quite complex and the simple assumption made from the theoretical calculation can not meet the practical conditions. In this case, experience formula has been adopted to estimate the leakage. I is symbolized as the percentage of discharge loss per kilometer.

For Soil with high leakage status $I = 3.4/Q^{0.5}$

For Soil with medium leakage status $I = 1.7/Q^{0.4}$

For Soil with low leakage status $I = 0.7/Q^{0.5}$

In case that the leakage value surpasses the allowed one, anti-leakage measures will be carried out to the channel.

As far as the sluicing discharge is concerned, the solutions vary in accordance with the different local silt conditions. Take Xinjiang Minority Autonomous Region for example, due to the large sediment, the designed sluicing discharge at the forebay accounts for 10%-30% of of the total design discharge for generation. The value in Sichuang Province is about 6%. The sluicing capacity designed in Gansu Province accounts for 20-60% of the design discharge for generation. . Since the sluicing can be conducted between the generation period, it is not necessary to enlarge the design discharge of the channel. Generally speaking, for the sake of structural arranement, the dimension of the sand outlet can not be too small. The sluicing normally controlled by certain gate with suitable dimension.

(2)The Base Slope of the Power Channel

Related statistics show that most base slope of the power channel in China is 1/1000 – 1/2000, and there is hardly an exception because the power channel in China normally use lining to prevent the sediment. For projects with large discharge and medium and low head, the base slope of diversion channel, self-regulated channel, clean water channel and earth channel is normally gentle and ranges between 1/2000 to 1/12000; and for projects with high water head, the base slope of division channel and channel with large sediment etc. is comparatively steep ranging from 1/500 to 1/2000.

(3)Design of Transversal Section of Power channel

The shapes for transversal section of power channel are rectangular and trapezoid which is more popularly used. What have to be considered here are the problems of hydraulic economic cross section and practical economic cross section. Since the selection of over section involves issues like topography, geology, high slope, construction conditions, utilization conditions, silt characteristics and dynamic economy etc. Therefore the hydraulic economic cross section sometimes is different from the practical economic cross section. According to related survey, in practical projects, hydraulic economic cross section is hardly used. Sometimes the ractical use of approximate hydraulic economic cross section dose exist, and in most cases, narrow and deep channels are adopted.

(4)Design of Average Velocity of Power Channel

The selection of average velocity of power channel is closed connected with the characteristic of the cross section, gradient ratio and other related aspects. And it will be finalized after the technical economic comparison. Generally the channel shall be kept from deposit without flushing. Please note here that, in view of hydraulic engineering, the value of kinetic flow factor has to be considered . if the Fr is larger than 0.6, the deflation and inflation might easily occurred in the channel which will lead to the head loss. Experiences see that the suitable range of design velocity for diversion channel of small hydro projects are: 1m/s – 2m/s for lining channel and 0.6m/s – 0.9 m/s for earth channel.

(5)Lining of Power Channel

According to related survey, in China most of the diversion channels are lined and those without lining have no good operation effects. There are mainly three advantages for lined channel namely flushing prevention, leakage prevention and reduction of roughness. Since two advantages of Prevention of flushing and reduction of roughness are apparent, here we mainly focus on problem of leakage prevention.

a. Leakage prevention for unlined earth channel

- Tamping: By tamping the earth, it is possible to reduce the leakage loss of earth channel to 10%.
- Choking Up: Clay grains are mixed with Water and poured into the channel, those grains are carried into earth by leaking water and fill the interstice. The way is

popularly used in channel make of sand loam and sandy soil.

- Salt Feeding: Every 3-5 kilos salt will be fed on the channel surface and rolled so as to reduce the leakage. Two disadvantages are that on the one hand, it has a weak capacity to stand, on the other hand it undermines the stability of the channel side slope.
- Humus: The rice straw, weeds and other organic matter are mixed with raked soil, then tamped together. After water enters into the channel, under the condition of oxygen shortage, the organic matter is decomposed by those anaerobic bacteria which enhances the dispersiveness and plasticity of the soil, and thus reduces the water leakage. One the the main disadvantage is that the it is easy for weeds to grow in the channel bed.
- Cementing: Add the cement inside the soil and surface it onto the channel bed after mixed with water.

b. Lining of Channel

The lining with masonry may prevent flushing and reduce the roughness, while is unable to prevent leakage. The paving of clay and polymeric material can prevent the leakage but can not orevent flushing and reduce the roughness. Only by utilizing the asphalt concrete, concrete reinforced concrete can not only prevent flushing, reduce the roughness but also prevent the leakage.

- Asphalt concrete: general thickness is 5-8 cm, before paving, the broken stones and gravel will be bedded. Since the asphalt concrete is likely to breach in cold weather and melt in hot weather, it is not suitable to be used in these areas.
- Concrete and reinforced concrete: it is mostly common used in lining power channel, since the water flow in power channel is unstable and surge is likely to occur, therefore flushing prevent is required. In this case the lining shall be made on stable side slope. Normally it is poured at the site to ensure its integrity. Since the use of precasted concrete slab may cause problems like too many joints, leakage and disadvantageous to roughness reduction, it is normally not used in practice.
- In case that the concrete and reinforced concrete are casted at site, if the channel bed is made of clay, frost upheaval is more likely to occur in winter. Therefore drainage cushion under the lining shall be thickened to 0.3-0.5m. If the underground water level outside the lining is comparatively high, when the channel water level lowers, the external leakage pressure will force the lining to heave. In this case, gravel cushion shall be used to serve as a cushion and drainage pipes might be considered to be furnished in the cushion.
- The expansion joints of lining normally are horizontal ones, and the distance interval depends on the temperature range as well as the friction coefficient between lining and cushion, normally it goes between 10-12m. In cold areas and on rock bed, it ciould be reduced to 4 - 5m. Asphalt is used for sealing of the joints.

3. Structures of Power Channel

(1) Arrangement of intake gate

In order to guarantee the safe operation of the station, gates are furnished at the intake for most of the power channels so as to control and regulate the water flow and provide convenience for channel repair and maintenance.

(2) Side weir

Side weir is of a open air structure which is arranged in the forebay or one side of the power channel. It utilizes natural topographical features to discharge water. the crest height of side weir normally is 0.1 m higher than normal working water level.

(3) Flood control facility

Since the projects with diversion schemes are normally located in mountainous areas, therefore the flood control has to be considered for those channels. In fact damages made by heavy rain and flood occur frequently and suitable structures for overflow shall be considered.

(4) Free flow tunnel

The dimension of the free flow tunnel is confirmed through hydraulic calculation, the clearance dimension shall be no less than 2 m in wide and 2.5 m in height so as to falicitate the construction. For the convenience of aeration, the distance from the highest water level between crest is normally 0.07 times water height, but shall not be less than 0.4 m.

(5) Free flow pipe

The reasons as well as conditions for adopting free flow pipe are: the excavation of open channel is too large, the side slope is not stable or there are large amount of rainfall and silt running through the diversion channel. Since when the pipes is positioned, the design velocity id larger than that of the channel, transition section shall be furnished between these two sections.

(6) Aqueduct

Aqueduct is adopted when the channel has to span valleys or public roads. It has to to noted here that aqueduct shall be positioned in places with good geological and topographical conditions. The podium shall be strong and there shall be little depression.

(7) Dive Culvert

The utilization condition is same as that of aqueduct, which would be used as the alternative for aqueduct. Generally speaking, using of dive culvert has high cost and large head loss. Therefore it is seldom used.

4. Desilting of Power Channel

In water diversion of rivers with large amount of silt, desilting is furnished at the channel inlet, furthermore, the second treatment has to be considered in the channel. The normal measure is to construct desilting gate on the channel side near to the main river route. When the gate is open, water and silt coming from the upstream will be diverted here, since the desilting gate is located at one side of the channel, it belongs to lateral diversion. The desilting ratio is larger than diversion ratio, in this case, it remove most part of the silt. Nevertheless, since desilting through desilting gate will lose a large amount of water and have a small effective scope, most stations seldom use the gate although it is available to them. In recent years, two ways are adopted for channel desilting i.e. silt trench and helical flow.

(1) Silt trench

The transported sediment entered in the channel normally move in forms of rooling, sliding and bounding. Therefore a silt trench might be positioned in suitable channel bed behind the intake. The axis of the trench cross obliquely with the channel. The cross section of the trench normally is rectangular or trapezoid. The outlet of the silt trench is controlled by a gate. The gate is closed most of time, and silt is accumulated in the trench. The bed slope of silt trench is comparativelt large which normally ranges from 1/10 to 1/20. When the gate is open, the longitudinal water flow has a large velocity and the silt will be removed quickly, after which the gate will reclosed. According to operation experiences, it is better to fixed the angel between trench and channel between $30^{o} - 45^{o}$.

(2) Helical flow

The silt trench is proven to be a simple and practical way to remove the silt. Nevertheless, the water consumed in desilting is comparatively large. Recently the desilting technology of using helical flow has been studied and used in channel desilting in small hydropower projects.

The difference between these two technologies lies in: since the cross section of the trench normally is rectangular or trapezoid, the edge can not well catch with the water flowing into the trench which will disturb the flow around the trench and cause the energy waste. Moreover, the silt trench mainly depend on the longitudinal flow velocity and the transversal velocity is rather weak. In this case the helical flow might not be well developed which ahs a negative effect to the desilting. The cross section of vortex tube is circular. Water will move in the direction of its tangent and thus reduce the energy loss. Besides due to the large transversal velocity, the water flow rotates around the tube axis so the helical flow would be well developed. As a result the desliting effect using helical flow is better than that using silt trench and it also has less water consumption.

Experiments as well as practical use prove that the angel between vortex tube and channel shall be appropriate so as to achieve a nice desilting effect. And it is better to set the angel between $45^{o} - 60^{o}$.

Working range for vortex tube

(1) Vortex tuber can be used in channel with both gentle slope and steep slope. The best flow condition to form helical flow is when the Fr is 0.70-0.95. The desilting effect will be dwindled if the value is out of this range.
(2) It is desirous for the tube to be installed in straight and flat channel section with a gradient of 1/250 to 1/1000. In case the gradient of the channel is comparatively small and also flow velocity, a section of bending deflection sill might be furnished.
(3) Open sand and gravel with diameter of 0.5mm would be easily removed by using vortex tube, while silt with smaller dimension might float by.
(4) In case there are large amount of silt, several tubes would be positioned in different section.

Practical example

Qinglingdong Hydropower Station of Ziyang County, Shannxi Province has an installed capacity of 160kW. The length of its power channel is totaled 1.6 km, and the cross section of channel is rectangular. The channel is 1.2m wide and 1.6m deep. The channel gradient is 1/1000. Every flood season, there is a large amount of silt entering into the channel and result in deposit and serious friction damage the turbines. In 7 years since the operation, the main parts have be replace three times and each year the station has to be shut down for half a minth to remove the silt in the channel. In August, 1988, vortex tubes were positioned in its channel. The diameter of tube is 250mm, the aperture is 177mm wide and 1.52 m long. The angel between tube and the water flow direction is 52°. The desilting effect of these tubes is apparent. When the water height in power channel reaches 0.3m, helical flow forms and when the height reaches 0.6 – 0.8m , the helical flow is rather strong. The diameter of major axis of the pebble removed reaches 140mm. Since then the turbine never encountered friction problem and the power revenue also doubled.

5. Desilting Basin of the Power Channel

The above mentioned desilting measure can only prevent bed sediment from entering into the channel, while most of the close-grained hydraulic suspension will enter into the channel together with the water flow. Since the channel velocity is smaller than that of the river velocity, some of the suspension settle down and cause channel silting and some just enter into the turbine basin and cause friction. According to the station's requirement towards water quality, desilting basin has to be furnished in certain place. When the silting inside the basin accumulates to certain degree, the silt in water can not settle down because of the reduced cross section and increased flow velocity. In this case, silting has to be removed by way of hydraulic and mechanical measures.

According to the station's requirements towards the transparency of water flow, the length of the desilting basin is normally set as 100m.

The basin is composed of intake sill, by-pass, separating chamber, silting chamber and sluiceway etc. According to the specific sluicing condition and requirements, the desilting basin has various types like single chamber basin, multi chamber basin, regular sluicing and continuous sluicing. The main design requirement gose as follows,

1. the intake flow shall be smooth and gentle and the velocity distribution shall be even. The backflow and concentrated bottom flow will be avoided. The expansion angle at the transsition section shall be no more than 20°, in case the said angle is too large, water flow might be separated from the side wall and thus back flow might formed which will cause the turbulence inside the basin.
2. The numbers of chamber inside the basin will be determined by the water volume. Single chamber might be used in case the water volume is small.
3. The sluicing discharge of the basin shall be no less than 35%-40% of the channel discharge.
4. The working water height of the desilting basin shall remain as low as possible, generally it is set in 4-5
5. The bottom slope ranges from 0.02 to 0.005. When there is a large amount of coarse silt, it is likely that silt will soon accumulated in the front section of the basin. In this case adverse slope might be used to increase the silting volume.

Curved desilting basin

This secondary desilting measure is popularly used for power channel with high flow speed.

1. the radio of the basin axis shall be four times that of the bottom width, and relative water depth (ratio of water depth to the bottom width) is 1/8 to 1/15.
2. The gradient of transversal slope facing convex bank is 1/8 to 1/10
3. Sluicing way with 5-12 holes will be furnished at the slope foot of the convex bank, and there shall be a large longitudinal slope.
4. The sluicing discharge is normally 15% - 20% of the intake discharge.

Desilting Basin using strong helical flow

The technology is recently developed and the basin size is much smaller than the normal ones. The water consumption is also saved.

1. the diameter of the basin is five times bottom width.
2. The sluicing discharge is normally 30% - 100% of the intake discharge.
3. The bottom plate is inclining with gradient of 1:10
4. The depth of water around is larger than 0.26 times the basin diameter

Overflowing desilting basin using side channel

It is a strip-like basin furnished at the side of the channel which is near to the river route. The basin bottom has a steep slope with gradient of 1/40 – 1/50. Desilting bottom holes are position at the end f the basin. Regular desilting is conducted. This type of design is of simple structure but a smmoth water flow shall be guaranteed. The internal structure of the overflow channel has to be determined after the model test.

Forebay

I. Components and Functions of Forebay

Forebay is the hydraulic structure connecting the diversion channels and penstock. Generally, forebay is formed with diffuser, storage pond, inlet, overflow weir, desilting pipe and outlet works.

Diffuser is the transition section connecting the channel and the pond. Why should there be a transition section? Because the pond is usually wider and deeper than the channel, a diffuser connecting the two will let the flow keep smooth, reduce the loss of head, and avoid eddy. According to the survey of the operation of actual projects, the most suitable transition form is to expand symmetrically from the channel to the pond, and the expansion angle shall not exceed 12°; while the bottom slope in longitude is better less than 1:5.

Inlet consists of a number of inlet chamber and equipment for flow control.

Overflow and sluice structures: when the load of power plant decreases or fault shut-down happens or the penstock and units needs service, the excessive water or all the water can be discharged through overflow weir.

Structures for sewage drain, desilting, de-icing: in order to prevent sewage and sand from entering the penstock, trash rack and desilting device must be built in the forebay (if it is in very cold places, there must also be de-icing structure).

The main functions of forebay:

1. to get smooth flow and water balance. The change of power plant water intake will cause depression and inflation of the water level of the channel, the forebay, with relative larger volume, can alleviate the amplitude of water depression and inflation, hence a steadier water pressure.
2. Ensure ample water quantity. When the load increases and needs more water, forebay can replenish water supply.
3. Discharge excessive water. When the load reduces or units shut down, the excessive water can be discharged through forebay.
4. Uniform distribution of water. Through forebay, water can be distributed uniformly to the penstock of each unit. There are gates at the inlet of penstocks, so that each unit will run or be serviced according to needs of water supply.
5. Drainage and prevention of trash. Trash rack at the inlet of penstock will prevent the trash, which has passed through the channel intake or come from along the bank of channel, from entering the channel. Besides, as the flow comes from channel to forebay, the mud and sand carried by the flow will settle down as the flow slows down, so silt orifice or gate should be set to blow-off the mud and sand.

II. Layout of Forebay

The layout of forebay should be considered jointly with the selection of channel line, arrangement of penstocks, layout of powerhouse and overflow, desilting structure arrangement to ensure a reasonable and compact arrangement, smooth and steady flow, flexible and coordinated operation and safe and economic structures. There are many factors influencing the layout of forebay, and each power plant has its own specific design that can not possibly be the same. According to the suvery to 78 proejcts, the forebay of each project is different with others. But generally, we can still conclude the types of forebay as follows:

1. From plane layout point of view, there are :

1) intake and desilting structure at frontage, and overflow structure at side face;
2) intake at side face, and overflow structure at either side face or frontage.

In our experience, it is better to set up intake at the frontage, because in this way it is easier to prevent sendimentation, the flow is smoother, and head loss smaller than the other way. As to the forebay with intake at side face, usually the flow is not uniform, therefore it is easier to cause eddy; the head loss is more, and it is easier to cause sendimentation since there are more stagnant water areas in this layout.

2. It is also very common to build forebay at a turning point. In such cases, however, attention must be paid to avoid the circulation of flow. Some forebays, after experiments, were built in such a way that regulation ponds were set at the turning point so that the flow can turns the corner and transit to forebay smoothly.

3. Another important factor in plane layout is the relationship between the desilting structures arrangement and the direction of inlet flow, for it concerns the question whether the desilting structure can function effectively. According to project experience, I conclude herewith the four methods of arrangement:

   1) both intake and desilting structure at the frontage;
   2) intake at the frontage, while desilting structure at the side face;
   3) intake at side face, and desilting structure at the frontage;
   4) both intake and desilting structure at side face

   a. the arrangement of both intake and desilting structure at the frontage proves to be most effective method in desilting, especially, at the intake, because the flushing way is located under the bottom sill of inlet chamber, in the same direction in axial with the inlet flow. So the silt seldom comes into the penstock and turbine.
   b. As to the arrangement of intake at the frontage while desilting structure at the side face, because the flow slows down when it comes to the forebay, and the flushing way, being far from the inlet chamber, cannot effectively flush away the sand at the intake; moreover, as the flow speed varies with places of forebay, some places will have serious backflow silting, it is difficult to desilt. Nevertheless, this method can still have good effect on desilting if the forebay is large enough and the silt orifice has enough discharge capacity.

c. The arrangement of intake at the side face and desilting structure at the frontage usually will be adopted when there is several units and one penstock for each turbine, so the forebay usually is narrow and long. As the flushing way must pass under the bottom sill of inlet chamber, and the flow at the inlet is fast, the silt carried into forebay cannot sediment very quickly, gathering in the flushing way. The desilting effect is not very good.

d. About the method of put intake and desilting structure at side face, experience shows little effect on desilting. So it is not recommended to arrange this way.

III. Determination of the Dimension of Various Parts of Forebay

1. Inlet chamber: if there is only one penstock, the net width of the inlet chamber will be 1.5-1.8 times of the diameter of penstock. For more than two penstocks, the width of inlet chamber should be the width of the dividing peirs plus 1.5-1.8 times the diameter times the number of penstock. As to the length of inlet chamber, it is decided by the design of the trash rack, main gate, service gate and headstock gear. For small hydropower plant, the length is generally 2-5m.

2. Front chamber: the front chamber shall be 1-3 times wider and 2.5-3 times longer than inlet chamber. The bottom elevation of front chamber should be at least 1m lower than the bottom of inlet chamber in order to sediment the mud, sand and sewage.

3. The side wall of forebay should be the highest water level of forebay plus 0.3-0.8 m safety freeboard.

4. The overflow weir in the forebay: For small hydropower plants, the overflow capacity shall be equal to the largest weir head, generally it is 0.2-0.5m.

IV. Depth of Forebay

The depth of forebay concerns several characteristics water values:

1. Normal water level: the water level when units get maximum design flow.
2. Maximum water level: for automatic regulation channel, it is the maximum swell level at load rejection. For non-automatic regulation channel, it is the water level when all flow pass through the side weir.
3. Minimum water level: generally, the minimum submerge depth of inlet can be regarded as the minimum water level, but as this is a term of various meanings, special argument should be done for different power plants.

V. Introduction to Siphon Intake

In China, there are only two types of intakes stipulated in the Technical Construction Specification, namely intake controlled by gate and siphon intake that China has mature technology.

The siphon intake has the following advantages:

1. intake stop gate, service gate and relevant operation equipment can be left out;
2. in severe cold areas, it can greatly reduce the difficulty in operation caused by ice, and also alleviate the silt problem at the intake in channels of muddy water;
3. Easy to operate and maintain;
4. Quick to cut off the flow, so alleviate the runaway situation at fault shut-down, improve the safety of service.

Siphon intake works according to the siphon principle. It connects with penstock, and the flow speed is limited, which is one special characteristic different with other siphon structures. But siphon intake can only be used on channel diversion run-of-river power stations and power stations that has relative small diversion flow.

VI. Rehabilitation of Forebay: Case Studies

Diversion SHP plant: the diversion part consists of overflow weir, flushing gate, and inlet gate. The inlet gate and flushing gate are both 2.5 m wide. The bottom of inlet gate is 1.4m higher than that of flushing gate. The design flow of channel is 8m^3/s, longitudinal slope is 1/200. The rectangular wetted cross-section is 2.8m wide and 2.6m high. Water is diverted to the forebay through channel. The layout of forebay is as the diagram shows:

The original design discharge for the flushing gate at diversion intake is too small (only 38m^3/s), and the discharge width is not wide enough (2.5m). In flood season, the flushing gate cannot properly discharge flood, desilt sand or control the main stream, which results in the large amount of bed load sediment entering the channel and the serious abrasion of turbine. The station's design head is 43 m, and the station has two units with 2500kW installed capacity in total. It was put into operation in December 1988, but by Juanuary 1999, the units had already been overhauled three times, and the top cover of turbines had worn out by the sand.

To rehabilitate the whole diversion structure needs a lot of money, so instead, in order to prevent silt, two measures were adopted: one is to install a desilting scroll at the front section of channel, the other is to modify the forebay structure.

The forebay is the type of intake at frontage while desilting structure at the side face. The backflow area has serious sedimentation. To control sedimentation and prevent the mud and sand in the forebay from rushing into the intake of penstock, a curved sand-guide wall was built in the forebay, separating the intakes from the flushing tunnel, as shown in the following diagram:

The sand-guide walll is very effective. Most of the silt coming into the forebay sinks down in the pond, while the clear water in the surface layer overflows the top of sand-guide wall and enters the penstock. When the silt accumulates to a certain level, the flushing gate will be opened to flush the sand. The flushing period is 15-20 days, and the duration of each flushing lasts 3-4 hours, flushing about 80 m^3 of sand each time. After rehabilitation, the economic loss saved per year is 28 times of the cost of this rehabilitation.

VII. Lessons of Forebay Operation

1. Volume of forebay

How to determine the volume of forebay and in what standard is always people's concern in the past years. However, up to now, there is no clear definition in any technical specification of any country, but there is no report of any serious problem in operaion caused by the volume of forebay, either. So the volume of forebay is not a factor that will constitute constraint or hindrance to power plant operation. Once a hydropower station was attacked by water hammer when it rejected all the load, the vibration is strong, even the operators at the power house could feel it. But the forebay remained intact after the swell overflows the weir. Generally SHP stations have 2-3 units, and start-up begins with one unit, then only after the first unit runs properly, will the second one be started. There are seldom simultaneous start-up of all the units. So the swell in the forebay will not be very large.

2. Forebay should be built on solid bed rock or foundation

To demonstrate this point, let's first take one SHP station for example. The station's mean annual flow is 56 m^3/s, and design flow is 42 m^3/s. The diversion channel is 6.45km long, design head is 80.2m, installed capacity id 25.2 MW. It took 38 months to complete the construction of the plant. After the first unit was installed, the plant prepared to divert water into turbine and commissioning on July 15, 1991. However, on that very day, it was discovered that the forebay has serious seepage, and later the tunnel and the forebay were completely crushed down. According to the description of witnesses, the land where used to be the forebay slide slowly to the river just like a ship.

Why did the accident happen? The foundation of forebay was not fully surveyed and researched, and no necessary technical measures had been taken in advance. The huge fissure water pressure caused by water seepage split the mountain, hence the accident. The remedy scheme conducted serious research to the bed rock, and adopted cavern forebay. Anti-seepage requirements were raised for the concrete used for forebay, drainage measures were taken for surface water, and a series of drainage tunnels were used for underground water to improve the hydrological and geological conditions.

We can see from the above case, the design of forebay must have a clear idea of the geological conditions of the foundation, especially attention should be paid to the technical measures of anti-seepage and drainage.

A WORKSHOP ON SMALL SCALE HYDROPOWER
IN-SHP, China, Petroleum Corporation of Jamaica
March 19-23, 2001

MONDAY – March 19

Morning:
(a) Opening Ceremony
(b) Overview of Small Hydropower (SHP) in China
(c) Jamaica's SHP and the needs
(d) IN-SHP and its Activities
(e) Review study of SHP equipment and Practice
(f) Hydrology and Energy
(g) Civil Works
(h) Selection of SHP Equipment
-Electrical and Mechanical Equipment and Automation
-Indigenous manufacturing of SHP equipment

Afternoon: Complementary Information on Laughlands Great River Project

TUESDAY – March 20

Site Visit: To Laughlands Great River in St. Ann and either the Roaring River (3.8MW) or Lower White River (4.9MW) hydropower stations

WEDNESDAY – March 21

Morning: Laughlands Great River Project – Presentation of Information and Development of a Case Study

Afternoon: Continuation of Case Study

THURSDAY – March 22

Morning: Continuation of Case Study

Afternoon: Economic analysis of a potential project at Laughlands Great River

FRIDAY – March 23

Morning: Presentation of results of case study

Afternoon: Closing of the Workshop

DIVERTION WORKS OF SMALL HYDOR POWER

1 FORWARD

Diversion works is a composition of a series of structures that divert water from river into canal, which can be divided into two categories: diverting with a dam and diverting without a dam. It has the characteristics of adaptability, easy construction, low cost. In China, diversion works plays an important role in hydraulic engineering. It is roughly estimated that the number of low_head diversion works is over 90,000.
Most of SHPs are situated on the high_profile and high_head mountainous river. So the diversion works also plays an important role in SHPs. Since this kind of diversion works generally operates with or without small storage capacity, how to divert the clean water into canal and prevent the silt outside is the first problem to be solved.
As far as SHPs concerned, it is impossible to give the same attention on the silt problem during the process of plan and design, as in the great hydro power, because of the capital and technical problem. It makes the silt problem even worse. Fail to solve it causes negative impacts such as mainstream changing, headwork slipping and canal jammed. In the past, it was widely regarded that the silt problem only exists in the overloaded rivers in the Northwest and Southwest. But the practice over twenty years shows that it also exists in the South rivers that can not be ignored. In some South low_head dams, the siltation causes power discharge reduction turbine wear, backwater length extension and negative impacts on the plant growth on riversides.

2 SILTING PROBLEM EXISTING IN SHPs

As the mountainous rivers are steep and of high rate, the big grains and rigid solid load formed by broken rocks are carried by the flow to the intakes even at the early stage when the plants come to generate. This is the cause of many troubles.

2.1 styles of silting problem

2.1.1 Silt wears the turbine severely

The damage to turbine is to wear the turbine into fish scale pits in the runner: the vane edge shape is saw-toothed, butt is alveoled, the gap between runner and diverting mechanism is increased. From statistics, the wear to turbine in overload river is 13~40 times more than in the clean river. It makes the service time short, the maintenance increased, output decreased, generation lost.
In China, 40 percent of medium an large hydro powers are suffered by the silting wear, and SHPs even worse.
The wear mechanism is under study. Generally speaking, it is not only contributed by the wear action to the turbine but by the cavitation, and interact each other. As far as the silt factor concerned, the more the silt is contained, the bigger and harder the grains are, the worse the wear is.

2.1.2 Damage to the hydraulic structure

The damage resulted by solid load is concerned with the water velocity, flow condition, grain, hardness and the smoothness of structure surface. According to the observation of some plants in mountainous area, the affected position include overflow dam, flood way, desilting gate and scour gate and bed plate, sluice and downstream apron. The result is big alveole and bar outcrops.

2.1.3 Siltation in canal and forebay

The siltation in canal and forebay makes canal's passage capacity decreased, forebay's regulation capacity decreased, and so output. There is a SHP in the Southwest, whose deposit is 2m high at the beginning of the canal. The diameter of the biggest pebble reaches 80~100mm. The forebay is filled. The pebbles damage the turbine.

Siltation before dam

2.1.4 The siltation before dam results the unstability of river and chop and change of depth. It affects the water utility and bring the problem of inundation and submerge at the upstream.

2.2 Unwanted grain and percent sand

In fact, it is difficult and unnecessary to make the absolutely clean water without sand through the turbine. The practical way is to determine what percent of unwanted grain and sand is as the parameter for the purpose of mitigating the wear to turbine and improving the design and maintenance.

The damage to turbine is resulted by many factors, such as percent sand, grain, hardness and shape, flow relative velocity, material and quality, operating time, fabric and spatium. At present, the accurate percentage of sand only can be decided by experience since the lack of theory.

Some institute of Water Resource Department of China submitted a report to prove that if the diameter of grains is not over 0.05mm, it affects turbine little; if over 0.05mm, it affects obviously; if over 0.1~0.5mm, more.

So it is can be concluded that:

For high_head station, unwanted grain diameter is 0.05~0.1mm.

For low_head station, 0.1~0.25mm.

Besides, the more the sand is contained and the higher the head is, the more severely the wear is.

The relation between unwanted percent sand and head

Head(m)	20~40	50~60	80~100	>260
Unwanted sand(kg/m^3)	>=0.4~0.5	>=0.3	>=0.2	>=0.1

3 Diversion without a dam

This type of diversion without of a dam is to take advantage of the inconsistency of the surface flow and the bottom flow under the circulating current effect or the natural bend or the man-made bend like the diverting wall. It is good to draw the water frontally and desilt at the side if the intake is located downstream at the acme of bend where the sand is at the minimum.

3.1 the circulating current theory

The circulating current is the annular flow caused by the transverse flow perpendicular to the main flow. The direction of the transverse flow at the surface is contrary to the transverse flow at the bottom, which makes a close rotating flow-circulating current. However since it is combined with the longitudinal main flow, what can be seen in fact is helical flow. In natural the most common circulating flow is caused by the bend.

The transverse flow is resulted by the combination of gravity and centrifugal force when the water flows along the curve. When the water is flowing in the bend, the centrifugal force causes the transverse gradient, which makes the circulating current. Combined with the longitudinal flow, the helical flow emerges. So clean water at the surface flows to the bight causing the scour. The bottom flow carries much sand to the convex side resulting the sedimentation.

3.2 Diverting and desilting at the intake

The factors affecting the sand distribution are as follows:

* The water condition near the intake: discharge, depth, velocity and its distribution, kinetic flow factor, the intensity of circulating current.

* Sand: grain, gradation, deposit ratio ,the percentage of sand, the distribution along the depth, the bed roughness.

* Intake boundary condition: diverting angle, diverting canal width relative to that of main canal, water surface width, preventing sill height and section type.

Due to the variation of above conditions and their combination, it can not be solved from theory. some problems are still under discussion. Here are some explorations in China.

3.2.1 selection of diverting boundary line

The purpose to select diverting boundary line is to find out the scope of surface flow and bottom flow , to estimate the sand quantity when diverting. There are theoretic way and experimental way.

1. theoretic way: to adapt the hydromechanics to select diverting boundary.

Diverting without a dam can be simplified to two-directional flow, it means the velocity only deals with the coordination (x,y) nothing with depth. The diverting scope can be decided by educing the diverting boundary formula on the base of simplification.

From theory what we can do is to educe on the basis of some hypothesis. But the real situation is more complex than ideal fluid. Since the current lines bend when diverting, the transverse circulating flow emerges inside water which makes the surface flow and bottom flow twisted. So the theory analysis only can figure out the flow picture qualitatively. To solve the problem quantitatively, experimental way is adopted.

1. experimental way

Many test results show that when diverting at the straight session, the width of bottom flow is wider than that of surface flow. From the combination of those data, the empiric formula of diverting width to diverted flow is :

Diverted flow ratio: if $k<0.8$ then $Bs=(0.66*k+0.22)b$ $Bd=(1.1*k+0.7)b$

$k<0.8$ then $Bs=(1.07k-1.07)b$ $Bd=2kb$

$k>0.8$ $Bs=(0.66k+0.22)b$ $Bd=(1.1k+0.7)b$

Bh: Width of water depth h

$\varnothing=h/H$

$k>0.8$ $Bn=[\varnothing^2(0.44k+0.48)+(0.66k+0.22)]b$

$k<0.8$ $Bn=[\varnothing^2(0.93k+0.107)+(1.07k-1.07)]b$

if then

2. effect of diverting angle to the entrance of sand

Whether the diverting angle expose effect to sand entrance is under dispute. But we are inclined to think it is deemed to affect the sand entrance because the intensity of circulating current is affected by the diverting angle, and so the surface flow width and bottom flow width near the intake. It can be known that most the sand is gathered in the bottom flow.

Many tests have been done and different conclusion drawn to find out the diverting angle influence. The disagreement is whether the influence reaches so small extent that it can be ignored. The results are different, which show the complexity. But judging from the practice in China, the diverting angle actually affect the sand quantity. The investigations show that when the center line of diverting gate is perpendicular to the stream direction, the phenomena of sand entrance is remarkable; and if the diverting angle is 30° -60° , it is not remarkable.

3.3 Influences of Water Flow Characteristics and Schemes of Diversion Intakes towards Desilting Ratio

(1) Influences of Diverted Flow Ratio towards the Desilting Ratio

Statistics of tests for Diversion without a dam show that when the diverted flow ratio increases, the flow width at the bottom of channel is much larger than that on the surface therefore the increase of silt is a bit faster. Following experence formular is worked out:

K = Diverted Flow Ratio

Kg = Desilting Ratio

In case of $0.06 < k < 0.55$, $1\text{-}Kg = 4(0.55\text{-}K)2$

In case of $K>0.55$, nearly all the silt enters in to the channel

In case of $K<0.06$, $K=Kg$

As far as diversion without a dam is concerned, the general requirement is that the diverted flow ratio is no larger than 20-30% so as to reduce the silting amount.

(2) Influences of Encroached Width of Diversion Intake to the Desilting Ratio

The relative width of diversion intake encroaching the main channel $P=d/B$

According to the data analysis of related tests, the larger the encroached width of the diversion intake, the more similar it is as compared with the right diversion and the less the desilting ratio therefore.

In case of $K=P$, $Kg=P$

In case of $K=0.5\ (1+P)$ $Kg=1$, nearly all the silting enters into the channel

In case of $K=0.5P$, $Kg=0$, the bed silt can be prevented

(3) Functions of Desilting Sill to Bed Silt

The consideration of furnishing desilting sill in front of the diversion intake will effectively prevent the entering of bed silt inside the channel. Experiments prove that desilting sill is not only effective to transported sediment but also the sediment suspension. According to experiences, in pebble bed, the sill height normally ranges from 1-2.5 M while a sill height from 2-3 m is adopted for river bed with fine sand.

The sill height is also connected with the river height.

4. Diversion with Low Dam

Diversion with low dam is clear in arrangement and simple in structure. No special river topographical requirement is needed. Furthermore, it is such a project that diverion could be ensured even without the large scale regulation of the river route. Such a scheme could stablized the water level in front of the diversion intake and ensure that all water is diverted into the channel during the dry season. The sediment in front of the diversion intake can be removed through desilting gate and make the main stream stable at the side of diversion intake. Such a intake scheme is popularly used in small hydropower.

4.1 Location Selection and Requirement

River section with stable river bed, sturdy bank, concentrated water flow and where main stream is close to the river bank and large amount of water volume could be controlled.

River section with good geological condition, shallow rock bed. In case the said requirement can not be met, anti-leakage treatments to the foundation shall be done.
The location shall avoid debris flow areas and river section where branches with large amount of silt and torrent flood trench confluence since all these are not only the main supplier of the sediment but main undermine the safety of diversion intake.
River section with open area so as to facilitate the desilting, diversion, transportation and construction.

4.2 Form of brief structures

1.overflow weir: to dam water and overflow excessive amount of water.

2.retaining dam. Besides overflow weir, retaining dam should be provided to abut and connect riverbanks in wide shallow riverbed.

3.flushing gate: to rush away the silting sand in the flushing trench before the intake gate, and let out part of flood. It is also functional of making the main stream come to the side of intake gate. The flushing trench should be located on one side of overflow weir, separated with a guide wall. Together with the wing wall of intake gate, the desilting and flushing trench is formed. In the working condition of diverting water into intake gate, with flushing gate closed, the flow velocity in the trench is small, the flow is stable, and silt will deposit and stay at the bottom of the trench temporarily. In the condition of flushing gate open. Waterflow will centralized and come out through the flushing gate. Because the bed slab elevation of flushing gate is lower than that of intake gate. Water will form high-speed flow in the flushing trench, rushing away the silt at the bottom, and effecting a certain range of riverbed upstream as well.

4. Intake gate: its function is to diverting and regulating waterflow entering the channel. Intake gate and flushing trench form the integrate facility with the function of diverting and prevent silt. The guide wall plays a role of preventing silt from coming

into channel and diverting. To ensure the desilting and flushing trench working in safe condition.

(3) Several type of low dam diverting method

Low dam diverting, using the arrangement type of "side diverting and flushing in front." its diverting condition has contradicted with the character of sand kinematic. In recent years. After large number of research and practice, a method of providing at the flushing trench a set of facilities including diverting wall, sand guide sill appealed, fundamentally solved the problem of silt coming into the intake gate.

Several style of low dam diverting are as following:

1. Low dam, with desilting and flushing trench

In the early years, the Indian style is adopted, the axises angle between diverting and flushing is 90 degree, which is a contradiction to the nature of water movement. Result in large number of sand and silt coming into the intake gate. Nowadays, amendment have been made, with heightening the sill level of intake, and providing underwater separating wall, sand guide sill in the flushing trench, in order to alternate the distribution of silt and fluid composition, hence to obtain the purpose of diverting and silt prevention.

2.low dam with flushing gallery style

The low dam with flushing gallery style is developed according to the character of silt distribution of various depths. Intake gate is located on the gallery and only intake the surface fraction of the fluid, and the rest carrying large number of silt will be let out through the bottom flushing gallery to the downstream. And this method is suitable for the dam where there is large variety between upstream downstream water head, and also has the constant stream for flushing. According to the relative location of flushing gallery and intake gate, this style can be classified to three subtly.

(1) Side diverting and flushing

Intake gate located vertically to the flow on one side of the river, and flushing gallery located at the point of intake sill or the place upstream of intake. This is for dam the silt and flushing. In order to enlarge the flow into the flushing gallery, a diverting pier can be provided upstream of the gallery inlet.

(2) Side diverting and straight flushing

In order to reduce the silt coming into the intake gate, and enhance the flushing effect, the direction of intake gate can be sharp angle to the stream. And flushing gallery will be linear arranged under the intake gate sill.

(3) Straight diverting and flushing

When the inflow is large, the designed discharge of the intake gate is accordingly large. The intake gate and flushing gallery gate can be arranged on the side near to the main stream. The method of diverting upper fraction water and flushing the lower fraction for desilting. In the case of small stream, several separating walls can be provided in front of the flushing gallery, or only one of the trench using for flushing.

3. Low dam with diverting channel

In the case where the headwork of channel is located in canyon of at the outlet of canyon, the riverbed is narrow, the bank is steep, and there is no sufficient place for flushing and intake gate. An open channel or diverting tunnel can be provided on the hillside, and also provided with control gate at reasonable place, a desilting and flushing trench located at suitable place downstream. Flushing and intake will be arranged according to the principle of straight diverting and side flushing.

(IV) Several questions in designing of the flushing trench.

1.restricting wall

The length and type of restricting wall can be determined by three factors: a. contents the requirement of stabilizing the flow status in front of the intake. b. Meet the transition part of upstream; c. considering the requirement of flushing regularly. Generally speaking, the length of restricting wall (i.e. the length of flushing trench) 2~3times as much as the width of splitting inlet. Normally the upstream part will be arc-shaped, to reduce eddy current and conduct the flow into trench after the transition. The top level of the restricting wall will be the same as the crest of overflow weir or a little higher, to avoid the flow side spilling which cause vortex and bed load sediment coming up.

2. The discharge capacity of flushing trench

The discharge capacity of flushing trench should meet the requirement of diverting discharge and the minimum flushing discharge. To stabilize the main current in front of the intake gate, the selected design discharge should be frequently happened during the monsoon annually. In our experience, the discharge of 75%(frequency) can be used as the designed discharge of flushing gate.

3. The bed level of the flushing gate and the bed slope

The bed level of flushing gate shall be the same as the average level of main stream

Of dry season cross section. In case of silt deposit river, the bed level can be heightened reasonably to 0.5~1.0m. The bed slope of flushing gate (including the flushing trench) shall be the same as the riverbed. Or 1/100~1/200.

(V) Diverting with river retention gate

(1) Location select and requirement

1.the riverbed located should be stable, and the cross section of riverbed should not be changed, with concentrated main stream near either bank. Large amount of the flow can be diverted.

2.better located at the bending part of the river, to make the most of circulating current of natural bend. Intake gate shall be located on the bulge part of the bank. This kind of location is widely used in China.

3. Considering the topography and geological condition

(II) The character and form of brief structures

The method is of replacing the low overflow weir with water retention gate. Using the retention gate to dam water, divert water, spill and flush, hence to avoid the silt deposit in the upstream. Its merit is of remaining the natural status of the river, and characteristic of the fluid and deposit, and also has the flexible working conditions. During operation, retention gate can be partly opened, making the control of the main stream to keep a long-term stable regulating storage and desilt/flushing storage. And also good for diverting from both banks.

The diverting system with retention gate consists of retention gate, flushing and spillway gate, and upstream-downstream regulating system, baffle structure after gate, and intake system. To prevent silt from coming into the channel, silt prevention structure will normally provided in front of the intake gate, such as restricting wall, guide sill and so on, which are of small construction, simple structure, easy to build and effective.

(III) Several questions should be mentioned in designing

1. In the sandy river the flood has its special character. In the case of providing retention gate on a sandy river where the flood and silt are not controlled, planning and arrangement should be made reasonably considering the spillway and flushing structure.

2.

2.making consideration of the alluvial character of the river. During the flood season, the main stream maybe changed, the principle of "wide gate, low sill" arrangement should be adopted. The retention gate sill level can be the average level of the riverbed, to keep the flood flow capacity and silt flushing capacity at previous level.

3. In the working condition of water barrage, sand and silt will be deposit unavoidable. In our experience, in the dry season, we lower the water level to some extend and flushing a certain time, to keep the balance flushing and deposit in the upstream main riverbed.

4.regulation project should be made at downstream of the retention gate, in order to control and divert the flow, and stabilize the main stream of the riverbed.

(IV) Arrangement

Retention gate and flushing gate will be separated by guide wall both upstream and downstream. And also form the flushing trench as well. The intake angle of the intake gate shall be sharp angle; the bed level of intake gate shall be 1.5m higher than that of flushing gate. Separating wall and guide sill can be provided in the trench.

The technical condition of this method is complicate, and the cost will be expensive. Technical and economic evaluation should be when considering the method.

VI diverting with bottom rack

(I) Character of this method

Bottom rack is a facility, which can prevent gravel, scree or big sand from coming into the diverting channel. Its main character is its diverting gallery comes across the riverbed, and provides metal rack on the top of the gallery to prevent gravel. The water and fine sand can come into the gallery through bars. So this method is suitable for the low dam project where the river has mainly gravel and pebble. Its merits are as follow: simple structure, low requirement for upstream downstream regulation. Small quantity of construction and low cost, easy to operate and maintenance, can exclude large size bed load; its shortcoming is: the small gravel or fine sand can come into the channel through the bars, and need additional facility to remove, and the bars are easy to be blocked by grass or other large size waste things.

(II) The range of this method

This method is for the stream in the mountains, which carry large size bed load during flood season. And the total amount of bed is not too high and not too low, i.e. no more than 20~30%

(III) Several questions should be mentioned

1. The consist of structures. Generally speaking, a bottom rack dam, diverting galley and overflow weir will consist the whole system. The elevation of the dam crest will be 0.5m higher than or the same as the level of riverbed. The elevation of the overflow crest will be higher than that of the dam, to ensure that the entire stream comes into the galley during dry season.

2. The selection of the bar type

The selection of the bar type is actually to select the cross section, width, interval, and length of the bar.

a. It is proved by research and practice, that the cross section of the bar should better be in trapezoid shape, which will lead large coefficient (10% higher than rectangle) of discharge. And its merit is that its amount of blocking sand is less, and easy to clean when needed, and easy to maintain and manage.

b. The width of the bars should be that which keep the rigidity and not causing deformation when blocked. Generally speaking, 1.2~1.5cm. The height of bars will be 3~4 times as much as the width, to ensure the flow bypass forms orifice flow which can increase the discharge.

c. The interval of the bars will be determined by the size of sand and silt coming into the gallery. Generally speaking, it should be able to limit the large amount of silt to 80% of the natural river. If the interval is too big. A large amount of sand will come into the gallery, thus increasing the difficulty of silt treatment; on the other hand, it should not be so small, which will cause the decrease of discharge. In our experience, 1~2cm will be suitable.

d. The length of bars will be influenced by the longitudinal rigidity of bars and the construction amount. The bar length will be determined considering the structural stability, fluid fluency and easy management and reliable operation etc. We normally use 1.2~2.0m

e. The slope of the bars. The bar slope to the downstream will be 0.1 or even steeper. The metal component used for fixing the bars should not disturb the flow status and also should avoid being bumped by sand or pebble.

(4) Combining the barrier and regulation dam in sediment-laden rive in China

7. We should take hydraulic design into account in intake project

Hydraulic design is the main base to define the dimension of intake structure. There is a lot of introduction on hydraulic design of the general structure in some references. Here it means that we should specifically taken sand prevention into account during the diversion.

①Manual track curve intake

In the early year, we based on formula from other country. The formula is:

Width of track curve : $B_4=(0.5\sim0.75)A\frac{Q^{0.9}}{J^{0.2}}$

Radius of track curve: convex bank $R=(3.5\sim7)\,B_k$

concave bank $R=(4.5\sim8)B_k$

Length of track curve: $L\geqslant(5\sim6)B_k$

The running experience shows the width is too large according to the design standard for manual track curve intake project. So the experience from the other country is not suitable for some area in China. For instance, in xinjaing autonomous, we come out with some design standard suitable for the local circumstance after made a survey.

Choose bed building discharge

In the past year, the design standard always adopts 3-5% as frequency flood. In fact it is too large. If the frequency flood less than the design discharge in some high-density track curve, the speed is very low and the radius of track curve is big, and it can not form strong circulation flow. Therefore it can cause main flow swing, and silt accumulates in front of water intake sluice.

Using small design discharge and making it larger than the flow of water intake sluice twice can drain unusual flood, so that we can get the good result.

In addition, because the intake condition depends on the circulation flow, we can get suitable judge formula for the local condition after inquiring question about how to decide the strength of circulation flow.

②Flushing trough intake

The flushing trough intake project is compose of the river barrage, flushing sluice, inlet sluice and flushing trough. Among them the normal type of river barrage is low dam. It has the following advantage: simple structure, low cost, convenient construction. But in sediment-laden river, the sediment below crest level is very difficult to be drained to downstream. Because of the sediment upper reach, it can cause the main flow swing. Sometimes it can cause the inlet not work. Under this circumstance, it is suitable to choose the regulation dam. The following introduction is about some question that should take water intake sluice, flushing sluice and flushing trough into account.

1. Water intake sluice

(i) Choosing intersection angle between water intake sluice and river barrage

If the inlet axis and river barrage axis become parallel, it is called facade intake, while the angle is 90°, it is called flank intake. Compare with the flank intake, the facade intake the has the following advantage: less sediment which demonstrated by the following chart.

In general we use bank diversion, therefore in the past year all the setting is flank intake. In order to improve the condition, we can make it in slant intake position. According to the experience, the suitable angle is between 30^{0} and 60^{0}.

(ii)Type of hole and the bottom board level

Most water intake sluice is open, and the bottom board is wide top. Because the water height before gate is varied, we can use the breast wall to reduce the height of trough and the dimension of headstock gear. In order not to affect the water flow, the bottom of breast wall should be 0.1m～0.2m higher than the design water level .

We should pay special attention to the sand prevention requirement in choosing the bottom board. In general, the height should be 1～2meter higher than river bed, and it depends on sand-carrying capacity and particle size. It should be same as or higher than the height of intake canal bottom.

About the height between bottom board and river bed, we can refer to the following two data:(a)one sixth deeper than maximum flood, (b)one third higer than the total intake depth above river bed

(iii)Design water level

It requires 0.1～0.3 meter higher than water level behind trough, using it as the head loss of through flow.

2.Design for gate of flushing sluice

We should mainly solve two problems:define the height of bottom board and choose the design discharge.

(i)Define the height of bottom board

How to define the height will impact the flow condition behind the sluice and drain contamination downstream. The experience shows that the flushing sluice above height of the river bed in a mountain district, lacking of water for flushing and the bottom board is too below, upper reach and downstream can be silted up. It can bury the bottom board, therefore we should raise the height of bottom board. In some pebble riverbed, the height can be 3.5 meter.

(ii)Design discharge of flushing sluice

Design discharge of flushing sluice is refer to the maximun discharge pass by the flushing sluice when spillway dam don't spill the water. At present there is no working standard because of variable factors involved. In order to meet the flushing and main stabilizing the trough requirement, normally we can choose discharge appearing often during the flood season

According to different project experince, some project use 50-80% as frequency flood discharge , while some use discgarge which be equal to 2.5 –3% frequency year annual discharge .

(iii)Size of flushing trough

Its function just like the sediment pool before the intake sluice. The flushing sluice is closed when it functions as water intaking. Current velocity is low, normally is 0.7 1m/s, so that the silt can sing. It requires the current velocity in the trough less than sinking speed of specific grain. When the trough opens, a high current velocity emerge in through, and the value is no less than 1.5~3 m/s but more than the competent velocity of maximum diameter of particle, which will help to flush. The diameter of the minimal particle sing in flushing trough is called design diameter of particle, expressing with d_{min}. The size of the adopted design particle will affect the size of flushing trough. During the diversion in power plant, d_{min} is less than 0.5mm in order to prevent the turbine from abrasive wear.

Defining the size of flushing trough is depend on the following item:

(i)Length and shape of guide wall upper reach and lower reach

The length of guide wall upper reach is same as the length of trough. In general, the value is larger than width of intake. If there exists check dam, it can extend to the check dam upper reach. If there are a few paddle holes and the width is small, the length can be L=A+B.

Lower reach guide wall make the sluice flow put together, so the silt can be carried far away. It can avoid piling nearby the guide wall. The length can extend to the end of the protecting wall.

(ii) Width of flushing trough B

In order to make the current velocity in trough less than current velocity in diversion canal, the cross-section area is 1.25~1.5 times larger than that of canal. When the flushing sluice closes, the discharge flow into the flushing trough should be equal to the diversion discharge Q_k in term of theory. $Q_k=B\cdot H\cdot V$. H is the depth of flushing trough but not including the silt depth. The value we get should larger than the value gets by calculating, and it can kill the back-flow and circulation in trough.

After choosing the width of flushing trough, we should check the current velocity.

After excluding allowable thickness of silt in water depth, we can calculate the working velocity v_2 with selected width of trough and the intake discharge, and let v_2 less than the design average critical sedimentation velocity v_0.

$$V_0=0.645\sqrt{f\cdot R}$$

R: hydraulic radius

f: sand coefficient

Type of sand	Heaven sand	Coarse sand	Medium sand	Fine sand or sludge
Radius (mm)	>2.00	2.00~0.5	0.5~0.25	0.2~0.1
f value	2.00	1.50	1.25	1.00

If the silt in flushing trough pile over the rated height and the current velocity larger than v_0, we should close intake sluice and open the flushing sluice. This moment too much flow pass through the flushing sluice, and the water level of trough reduces, so the current velocity increase. The flow pass through trough is , therefore we can get the depth with the formula, then we can get the corresponding current velocity $v_1$in trough. The velocity should larger than the competent velocity of maximal particle diameter d_{max}.

(iii) Base slope of flushing trough i

The normal type is slight sloe, but it is better to use the steep slope. The slope ratio can be between one tenth and one twentieth.

(iv) Height of diversion dam

Normally, it is same as the height of intake sluice bottom board.

③Multi-level intake

It uses gallery to flushing. A trough should be set in the gallery intake. If the downstream is submerged outflow, a trough also should be set in the outlet. It can prevent the silt back when the it don't flush. Though the structure is very effective to flush, it has complicated structure and cost more.

The main task of hydraulic design if to defines the size of flush gallery and tests the ability of flushing.

(i) Principle of define flushing gallery size and design step

Principle of define flushing gallery size

The cross section size of gallery and current velocity must flush maximum silt grain. If there exist big grave, the current velocity should no less than 4-6m/s.

Gallery flow can flush all the bottom sand before intake sluice.

Though the flow before sluice disorders, bed load sand can not jump to the bottom board of sluice.

Design step

We can use the maximal discharge as design condition when intake (this moment, the river can carry thick and large amount silt), and calculate with cut and try method.

(i)Define size of gallery and vertical arrangement

For the sake of construction and examination and repair, the minimal size of gallery is $0.5^m \times 0.7^m$. In order to avoid forming dead zone that can not be flushed, center line distance should no higher than 3-5m.

(ii)Calculate current velocity of gallery, and the velocity must larger than competent velocity

(iii)Calculate sediment transport competence of gallery, and the competence must larger than the competent velocity.

Each one above has its corresponding computational formula. Because the flow and the sand movement in trough are very complicated, it is under research. So the result we get has corresponding degree of safety.

④Bottom rack intake

(i) Define size of bottom rack

According to experience in China, and taking the grid rigidity into account, the length of bottom rack in the direction of flow is 1.5～2m. If the intake flow is large, we can use double-post-row bottom rack, and the width can be 3.54m. And the length of bottom rack dam has something to do with the rack unit flow.

Bottom rack flow has something to do with the status of gallery under rack. In order to increase the flow, the gallery should be flow in open air. Under this circumstance, the normal computational method is sluice flow in China.

$$Q = \mu PB\sqrt{2qh_{cp}}$$

μ :coefficient of discharge p: grid interval coefficient h_{cp}: average depth above grid

(ii)Hydraulic calculation of intake gallery

When the water flows past the bottom rack and gets into gallery, joining with the vertical flow, it can form strong helicoidal flow. Therefore the flow in gallery is space vector gradually varied flow. At present, most project design use the side-channel spillway hydraulic calculation. In fact, although the two water shape have common ground, there are some differences. Taken the possible error and rack blocking into account, at present, the computational area is enlarged by 20-30% during some project designs in China.

Annex 3

Annex 3

PEREZ-GUERRERO TRUST FUND Project INT/98/k06/A/95/99

On-the-Job Training Workshop for Cuba in Hangzhou, China

FINAL REPORT

Submitted by

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This course was structured in three stages, starting on November 4th, 1999.

- ✓ First Stage: from November 4th until November 28th
- ✓ Second Stage: from November 29th until December 26th
- ✓ Third Stage: from December 27th until January 23rd

During the first stage we mainly got many lectures about technical matters related to hydropower and also visited one manufacturer.

First Lecture's name was *China's Small Hydropower* and was delivered by Mr. Tong Jiandong giving us a background and letting us know the main reasons for China to support hydropower and why they have achieved this high level in hydropower.

Mr. Li Zhiming was in charged of the *General Concept of SHP Technology - Civil Works and Hydropower* developing two outstanding lectures about civil works giving us the sight of this works in China and during the lectured time he developed many practical examples on how to improve all this and on what they were useful also exposing the main data which must be collected for a hydrology study and after having the results what to do with this information and all the factors to have into account before designing.

The *Feasibility Study Methodology* lecture was helped by a very comprehensive text delivered by Mr. Kong Changcai who also developed a very useful and objective lecture skillfully delivered. All the tips required for the financial analysis were related on it.

Mr. Tong Jiandong's book, Small Hydraulic Turbine, was very useful to support *General Concept of SHP Technology – Turbine* lecture developed by Ms. Yan Li who, during these two days lecture, showed all the required skills for turbine selection, the features of chinese equipment, and requirements for auxiliary equipment selection.

An adequate 31 pages paper written by Mr. Wu Weiguo was handed in the lecture named *General Concept of SHP Technology – Electrical Equipment* while discussing and clearing every item on it, including the themes: schemes for the connection of hydropower station and grids, selection of neutral point grounding mode for grids, selection of wire section area for the transmission line, single line diagram, selection of middle voltage electrical equipment, over-voltage protection and grounding, control and protection system for power station, DC power source. The start logic diagram, operation logic diagram and the normal shutdown diagram were also exposed.

Through the *Operation Management on SHP Stations* lecture delivered by Mr. He Zhicheng we knew about the manufacturers in China, managing a SHP Station, the security management for operation, also knew about the average cost and price of energy in China. Mr. He Zhicheng talked about other many features of SHP management and operation in China also spoke in relation to the guarantees of communication in Chinese SHP Stations.

While delivering the lecture *General Concept of Mechanical & Electrical Design of SHP Station*, Mr. Kong Changcai completely fulfilled our expectations for this theme giving information about maintenance, operation, requirements for purchasing, spare parts and auxiliary equipment while delivered an outstanding, practical and very convincing lecture.

One day was assigned for *Visiting Manufacturers – HANGZHOU ELECTRIC EQUIPMENT* arranged by Mrs. Yan Li and Mr. Fu Guodong. Mr. Zhang Jiancheng, general manager of sales department, was in charged with our visit and took us around the factory while answering all our questions. This visit was very interesting, convenient and well coordinated by HIC people in charged.

Related to *SHP's EQUIPMENT IN CHINA*, Mr. Xu Congxiao delivered a very interesting lecture, which called all our attention because we knew about the evolving of Chinese HP Manufacturers in different stages, their achievements, technologies and those who were more remarkable for each equipment.

In the Second Stage of the course each participant was assigned a case study as following:

N°	Case Study	Participant
1	Evaluation on Fuyang SHP project in Zhejiang province.	Angel L. Ricardo
2	Evaluation on Clavellinas project in Guatemala.	Ramón Hidalgo
3	Hydroenergy calculations for Hu Yuan Xi project.	Rigoberto Lamyser
4	Control system and automation design of SHP projects.	Alfredo Correa
5	Turbine selection for Fuyang SHP project.	Juan A. Hernández

Case Study	Description of Activities
Evaluation on Fuyang SHP project in Zhejiang province.	For two alternatives, selection of the wiring modes of generator voltage and high voltage side of transformer, single line diagrams, distribution diagrams of protection and metering as well as the material list.
Evaluation on Clavellinas project in Guatemala.	For two alternatives, turbine selection, selection of the wiring modes of generator voltage and high voltage side of transformer, single line diagrams, distribution diagrams of protection and metering.
Hydroenergy calculations for Hu Yuan Xi project.	Definition of the installed capacity and the energy production. Drawing the Time vs. Flow Curve in PC.
Control system and automation design of SHP projects.	Study of automation projects of two HPS. Logic diagrams of Urumi SHP station in India (start up, normal shutdown, emergency shutdown, failure shutdown and operation).
Turbine selection for Fuyang SHP project	Automation of the turbine selection process and the performance curve drawing by using Excel in PC.

During the Third Stage of the course we went to Linhai and visited some manufacturers and hydropower stations, which are, all listed bellow:

- ✓ Linhai Electric Machinery Works
- ✓ Linhai Machinery Works
- ✓ Chaitan SHP Station
- ✓ Yan Zhufeng SHP Station
- ✓ Gu Xiao SHP Station
- ✓ Ce Kexi N°. 3 SHP Station (Cascade Development)
- ✓ Ce Kexi N°. 2 SHP Station (Cascade Development)
- ✓ Ningbo Xikou Pumped Storage Power Station

Before and after the visit to Linhai City we got lectures about all the required test before putting into commissioning a hydropower station and maintenance delivered by Mr. Kong Changcai.

GENERAL CONCLUSIONS

Many important items related to hydropower have been touched during this course such as: hydrology, civil works, feasibility study, turbine and electrical equipment features, operation management as well as design for a SHP Station.

We also got very remarkable information about all the required tests before putting into commissioning a SHP Station and after that, on how to apply maintenance and the needed spear parts.

During our visit to the equipment factories we learnt a lot about the characteristics of hydropower equipment in China and with our tour through all the SHP Stations we could go also knew how good was their performances and the way they have evolved in time.

We also want to state that all the following textbooks, papers and catalogues were delivered during the course:

1. Feasibility study compiling of SHP, Kong Changcai
2. Small hydraulic turbine, Tong Jiandong
3. Small hydropower: China's practice, Tong Jiandong
4. Mini hydropower, Compiled by HRC
5. 3G Hydro Catalogue
6. Hangzhou Electric Equipment Works Catalogue
7. Electrical design for small hydropower station, Wu Weiguo
8. Calculation and selection of auxiliary equipment, Yan Li
9. Medium Small Hydropower & Equipment, N°.3, 1998
10. Medium Small Hydropower & Equipment, N°.4, 1998
11. Medium Small Hydropower & Equipment, N°.1, 1999
12. Medium Small Hydropower & Equipment, N°.2, 1999

All this information will be highly valuable for hydropower development in Cuba through all the specialists who's been on INSHP for this course.

We also want to thanks all the collaboration of the technical personnel who never hesitate to help us when we needed it.

For all the above-mentioned reasons we state that this course has been very useful for improving our knowledge on the hydropower field and will contribute to impulse hydropower research and development in Cuba.

In our behave, this kind of course should be arranged over again for more Cuban colleagues who could come to INSHP in the years to come.

We also want to thank Prof. Mr. Tong Jiandong, Ms. Zeng Yuehua, Mr. Wang Yansong and all the technical, administrative and service personnel because of their effort while granting us the best stay in HIC and achieving the main purposes of this course.

SUMMARY REPORT
VISITING SHP PROJECTS AND EQUIPMENT MANUFACTURERS LINHAI CITY

During December 27, 28, 29 and 30 we traveled into Linhai City to visit two equipment manufacturers, five SHP stations and one Pumped Storage Power Station according to the schedule on the training in job course.

December 27.

Zhejiang Linhai Electric Machinery Works

Established in 1965 The national second class advanced enterprise. A medium enterprise. Linhai Electrical Machinery Works is classified as manufacturer of medium and small hydraulic turbine generators. The annual production capacity is 300 000 kW.

The director Senior Engineer Jin A Shui made an introduction about the factory and also accompanied us to the tour around the different production areas.

In meeting with the director we had the opportunity of asking many questions about the Linhai's generators, because generators provided by this factory are installed in most of Cuban's SHP stations.

December 28

Linhai Machinery Works

Linhai Machinery Works was set up in 1934, the main products are mixed flow and cross flow turbines with the power below 3 000 kW The annual production capacity is about 80000 kW

We were welcome in the factory by the Director, Senior Engineer Hu Ling and the Senior Engineers Wu Yi Fan and Yang Zhu Jiang.

The director made the introduction about the factory and also accompanied us together with others senior Engineers in the travel throughout the factory.

During the meeting with the director we explored the possibilities of collaboration between the two factories and the National Institute for Hydraulic Resources of Cuba.

Visit to Chaitan hydropower station that has the following characteristics:

Installed capacity	:	2 X 630	kW
Discharge	:	2 X 1,84	m^3/s
Head	:	45,54	m
Turbines type	:	HL 220 – WJ-50A	
Generators	:	SF99 / 6 X 630	
Synchronization type	:	Automatic	
Annual production	:	4	GW.h
Sale price energy	:	0,56 (peak)	¥/kW.h
		0,20 (other hours)	¥/kW.h
Operation hours	:	3 000	h
Workers number	:	13 (7 Women)	
Inversion cost	:	13 000 000	¥

The hydropower station have a tunnel with a length of 1 095 m, the dam capacity is 12,65 millions m^3.

December 29

Visit toYan Zhufeng hydropower station

Installed capacity	:	720	kW
Discharge		2 X (0,087 – 0,11)	m^3/s
Head		450	m
Head		433	m
Turbines type	:	2 X CJ – W- 90/1	
Generators	:	320	kW
		400	kW
Synchronization type	:	Manual	
Annual production	:	2 GW.h	
Operation hours	:	3 000 h	
Workers number	:	12	

Visit to Gu Xiao hydropower station

Installed capacity	:	2 x 630	kW
Discharge	.	2 X (0.0,261 – 0,331)	m^3/s
Head		320	m
Head		433	m
Turbines type	.	2 X CJ22 – W- 70/1x7B	
Generators		SFW 630	kW
Synchronization type		Manual	

Annual production	:	4 GW.h
Operation hours	:	3 000 h
Workers number	:	12

Ce Kexi No. 3 hydropower station:

Installed capacity	:	2 x 800	kW
Discharge	:	2 X (1,86 – 2)	m^3/s
Head	:	43	m
Turbines type	:	HL 702-W-J-50	
Generators	:	800	kW
Synchronization type	:	Manual	
Annual production	:	3	GW.h
Operation hours	:	3 000	h

Visit to Ce Kexi No. 2 hydropower station:

Installed capacity	.	(2 x 400) + (1 x 1000)	kW
Discharge	:	2 X (0,0,261 – 0,331)	m^3/s
Head	.	1 114	m
Head		70	m
Synchronization type		Manual	
Annual production	.	5 GW h	
Operation hours	:	3 000	h
Workers number	:	20	
Average salary per worker	:	15 000	¥/year

Note: Ce Kexi No. 2, Ce Kexi No. 3 together with Ce Kexi No. 1 (10 MW) are in cascade.

December 30

Visit to Ningbo Xikou Pumped Storage Power Station

Installed capacity		2 X 40	MW
Pump head	:	276	m
Turbine head		241	m
Workers number		35 (11 operators)	

Machine Characteristics

	Turbine	Pump	
Head	268	276	m
Qmax	19.6	17,3	m^3/s
Pmax	53.0	44,1	MW

OPINION

In Linhai City we received a special, warm and friendly attention by local Government, the managers of the factories and the SHP stations visited and from the persons who may possible the good accomplishment of the main objectives of our programs.

During our tour Senior Engineer Mr. Kong Changcai and Engineer Mr. Wang Yansong from HIC accompanied us. We want to remark that the whole HIC's crew was always doing their best to allow us getting this tour as successful as possible.

Annex 4

Annex 4

PEREZ-GUERRERO TRUST FUND Project INT/98/k06/A/95/99

SHP Training Course for Cuba in Cuba

FINAL REPORT

Submitted by

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SHP Training Course for Cuba in Cuba

Nov. 29- Dec. 12, 1999

Bayamo, Cuba

Background

Cuba is an Island located in the Caribbean, and this Island is formed of plain and hills. But in the middle of the island there are some mountains where the small hydro resource is to be explored in order to release the lack of electricity.

According to the data, in Cuba the people began to explore the small hydropower long time ago. And the oldest power station was built in 1917. However the hydropower developed slowly. Up to now there are only 175 SHP stations in Cuba and the total installation capacity is only 13MW. Most of power stations were built after the revolution, aided by some socialist countries. Although these stations meet the electricity need, they function inefficiently because of the shortcomings in design, the bad maintain and lack of parts. To solve the said problems, Cuba tries to search the aid from other countries including China.

August, 1997, accompanied by the OLADE (Latin America Energy Organization) officers, Prof. Tong Jiandong, Director of HIC, visited Cuba and interviewed with INRH, Cuba (Ministry of Water Resource, Cuba), about the cooperation between IN-SHP and INRH, signed a MOU. One of the projects is to organize a training course in Cuba.

April,1999, G77 project was ratified and as one of the project funded by G77 PGTF, the SHP training course was organized in Nov. 29- Dec.10, 1999.

I. General Situation of Training Course

According to the suggestion of INRH, the training course was hold in December and it lasted 10 days.

Location of Training Course

According to the programme of INRH, Training Course was hold in Maxim Gomez

Baez Profession Training Center, a profession basis 5 kilometers far from Bayamo, the capital of the Province Granma.

Participants

INRH, Cuba elected 24 trainees to participate the training course. Most of them were at work on station maintenance, some on SHP programming. Two teachers of SHP participated this training course.

II. Program

General introduction of China's small hydro Power: introduction of the China's SHP and Policy.

Capital Construction Procedure and Design Course of SHP: introduction of Plan of River Basin and Selection of Site, Project Proposal, Feasibility Study, Preliminary design, Preparation Stage, Ejection Stage, Production Preparation Stage, Final Acceptance, and Evaluation after 1or 2 years of operation;

Civil Works: introduction of forebay, diversion works;

Electronic equipment & Water Turbine: Selection of SHP Equipment and design;

During the training course, the trainers also introduced the operation management, the economical evaluation.

During the training course the Cuba partner organized the class to visit some power stations. And in the class, the trainers helped the participants to analyze these stations, and answer the questions.

The participants were interested in this training course and new technology. And they suggest that HIC should organize another training course in Cuba in order to introduce China's experience and technology.

Schedule for SHP Training Course in Cuba

Nov. 29– Dec. 12, 1999

DATE	SUBJECT
Nov. 29 Monday	1. Opening
	2. Overview of SHP in China
	3. Cuba's SHP and the Needs
	4. Basic Elements in SHP Design
	5. IN-SHP and It's Activities
Nov. 30, Tuesday	Hydrology and Energy
Dec. 01, Wednesday	Civil Works
Dec. 02, Thursday	Selection of SHP Equipment
Dec. 03, Friday	1.Electrical & Mechanical Equipment and Automation
	2.The Indigenous Manufacturing of SHP equipment
Dec. 04, Saturday	Economic Analysis
Dec. 05, Sunday	Free
Dec. 06, Monday	Case Study
Dec. 07, Tuesday	Clearing Up of Case Study
Dec. 08, Wednesday	Round-table Meeting
Dec. 08~10	Site Visit
Dec. 11	Closing of the Workshop
Dec. 12	Return

Name List of Participants of Training Course in Cuba

NO.	NAME	REMARK
1	María Cristina Braro Rod.	Eng. Mechanic, INRH
2	Manuel Piña Sánchez	Eng. Electricity, DPRH
3	Guillermo Salé Henrera	Eng. Electricity, INRH
4	Miguel Michell P.	Eng. Mechanic, Bayamo, Granma Province
5	José Manuel Verdecio	Eng. Thermal Power, Bayamo, Granma Province
6	Melanio Ramlluz Estuada	Eng. Electricity, Bayamo, Granma Province
7	Luis Reqes Anas	Eng. Mechanic, Bayamo, Granma Province
8	Gafalcino Armés Seéz	Eng. Mechanic, Guantamo Province, Guantamo Province
9	Enrique Muschettramos	Eng. Civil, Guantamo Province
10	Nolbento S[anchez Miralles	Bayamo, Granma
11	Rubn Baga Boza	Electronic Technology
12	Quillermo Roca Alarcon	Eng. Mechanic, D.I.H.
13	Luis García Faure	Eng. Mechanic, D.I.H
14	Mario Sanamé Mlnoz	Eng. Electricity, Guantamo Province
15	Ralmedo Lopez	
16	Amauris Noral Cabrera	Eng. Electricity, Guantamo Province
17	Tomas Garcia Sanchez	Eng. Mechanic, Guantamo Province
18	Luis Almendrez Reiz	Guantamo Province
19	Roger Lapido Batista	D.P.A.A
20	Carlos Rodrigez Castro	Eng. Electricity, Las Tunas Province
21	Edgardo Ramos Jimenz	Eng. Electricity, Santiago de Cuba
22	Tomas Rodriquez Rodriquez	SHP
23	Osmani Pozo Pozo	Eng. Automatic Control
24	Rubin Quesado Ramos	Eng. Electricity, C.P.P.C.

Annex 5

Annex 5

PEREZ-GUERRERO TRUST FUND Project INT/98/k06/A/95/99

Mission to Promote SHP in Africa

REPORT

Submitted by

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African Energy Priorities and Climate Change

The African Energy Sector

The African energy sector is a critical input to development on the continent, yet to date the sector has been plagued by problems which reflect the economic and environmental problems of many African countries: frequent power and fuel cut-offs, low access to "modern" fuels and ***electricity***, financially precarious energy sector institutions, and a chronic lack of infrastructure investment.

The lack of access to sufficient, affordable, and environmentally sustainable commercial energy is reflected by key energy indicators. Biomass continues to be the larges energy source, providing half of Sub-Saharan African energy.

Per capita *commercial* energy use, among the lowest in the world, has actually been falling in recent years. Despite the low commercial energy use, energy intensity(e/unit GDP) is triple that of Europe.

Untapped commercial energy resources-*hydropower,* oil and gas- are significant but concentrated in a few countries,
necessitating a better energy transport infrastructure.

In contrast *renewable energy sources* particularly *solar and hydro* (Sub-Saharan) are abundant and well distributed
but major financial and appropriate technologies as other barriers to their use remain unresolved.

Energy Priorities to Energy Projects

The CMD should bring together development priorities with emissions reductions.

The starting point of thinking about CDM projects should be *regional energy priorities.*

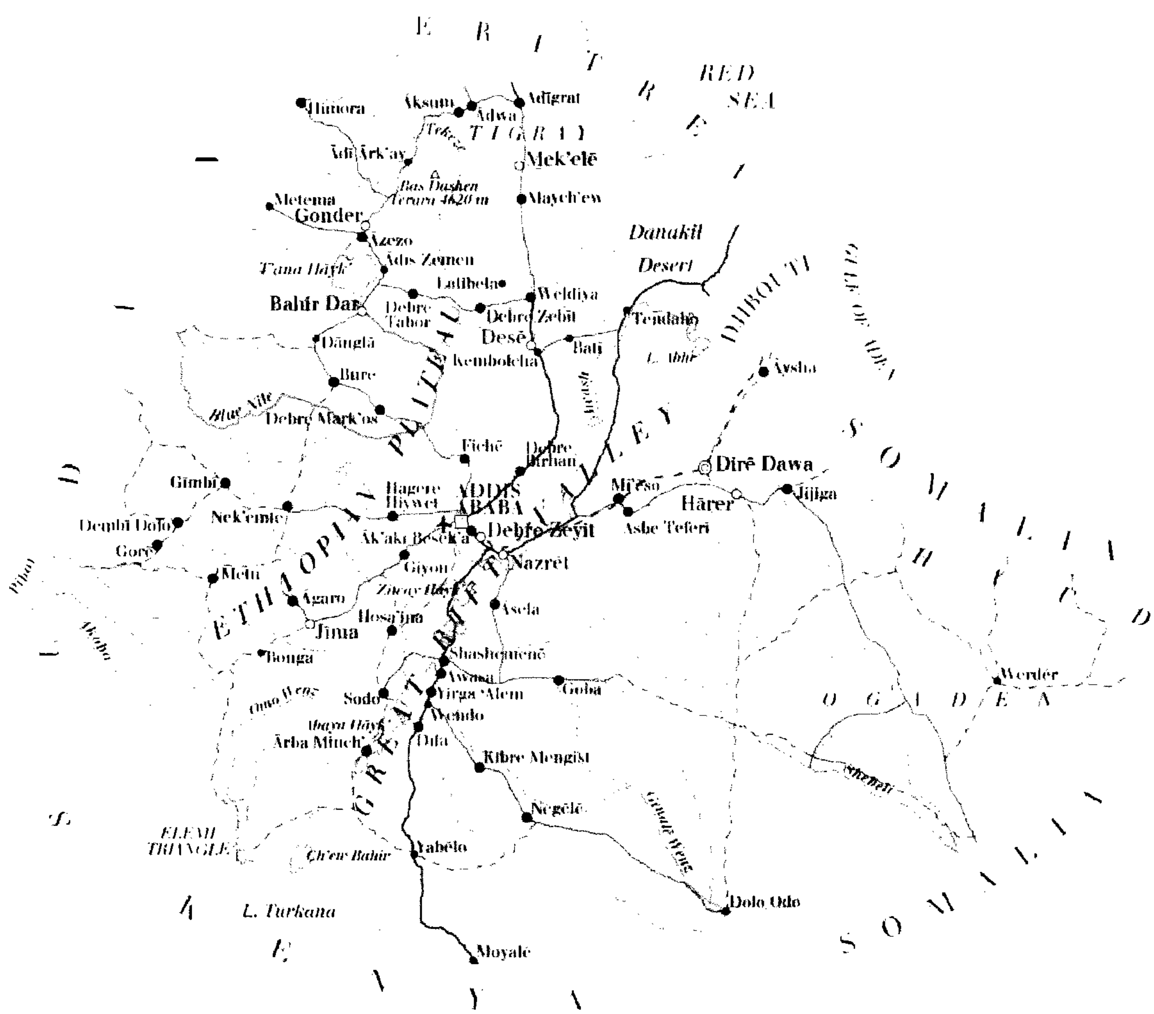
It is INSHP commitment as a global net worker to participate to a range of approaches and strategies including:

- Triangular cooperation on standards, technology development and policy
- Advice local authorities in structural energy reform to enhance performance
- Promote access to renewable technologies(decentralized)
- Regional energy interconnections
- Development of a regional SHP market
- Greater range of technological choice, financing mechanism and technological support for rural
- and decentralized energy systems.
- Sustained capacity building for policy analysis and implementation

According to the INSHP objectives and goal in 2000 was undertaken two consultations mission to African countries. In the following the reports to the Ethiopia and Zimbabwe.

Hydropower provides a developing economy with opportunities to develop appropriate technologies. It has been noted that "one of the first things a country can do is to assess its opportunities for developing alternative energy sources".

ETHIOPIA



The total energy of Ethiopia is largely obtained from traditional biomass fuels. It is estimated that biomass fuels account for 95% of the total energy consumption, with only 5% coming from modern energy sources. Deforestation is so pervasive that today less than 4% of the total land area of the country is covered by natural forests, compared with 40% just a century ago.

Ethiopia's potential for hydroelectric power is considerable. The gross hydro energy potential is estimated at 650 TW/year, which is roughly 8% of Africa's potential. However, the installed capacity of the five major hydroelectric plants is only about 360 MW/year representing only 0.6 % of the country's total energy consumption. Ethiopia's per capita electricity consumption, at about 25 kW/year, is among the lowest in the world.

Large-scale use of imported fuel has been precluded by the ever-growing shortages of foreign exchange. Today, fuel accounts for about one fifth of the value of total import merchandise. Therefore, it is high time to explore the economic potential of small-scale hydropower facilities in rural industrialization

Small-scale hydropower fits nicely into the energy balance of a country. It can contribute to interregional equity by meeting the needs of isolated rural communities. It can be made available in small installations and with relative ease in remote areas of developing countries.

Ethiopia has substantial river resources with eight major river basins: Awash, Baro, Bilgate-Segan-Dawa, Blue Nile, Central Lakes, Ome, Genale and Gestro and Wabi Shebele and Ogaden but its hydro-

Potential has not been fully developed.

The answer to the country's power deficit is *small hydropower* according to Beruk Abreham an Energy Policy Study expert from Ethiopia.

First small hydropower (SHP) could replace thermal plants, thereby reducing the nation's dependence on imported fossil fuels.

Second, it would provide electricity to isolated rural communities and avoid the construction of transmission lines across the country.

It also represents a smaller investment with a guaranteed income.

SHP developments could also control flooding during the rainy season, improve regional water management, and reduce the emission of greenhouse gases through reduced biomass and fossil consumption.

The main national governmental institutions of the newly structured energy sector are:

- Ministry of Mines and Energy
- Ethiopian Electric Agency
- Ethiopian Rural Energy Development and Expansion Center

The Ethiopian Electric Power Corporation tries to work on based on the principle of cost recovery.

Currently, an effort is being made to formulate an overall national energy development strategy, and

to set up medium and long-term energy plans by energy task force.

Following thc invitation of thc Rcgional Statcs of Oromia, (thc rcgion with thc highcst rcsourccs basc in the country) Department of Water, Mineral & Energy Resources, INSHP undertook a

Consultation mission between 13-17 June 2000.

Please find attached the Report in Annex 1.

Several institutions would be involved in an interdisciplinary project to develop the existing and proposed SHP potential sites.

As a concrete result of the intensive negotiations a Memorandum of Understanding (MOU) was signed.

Please find attached the MOU in Annex 2.

Stand by

- The aims of the MOU could not be realize in the mean time. Lack of financing resources, reduced interest of private investors as the lack of attractiveness of the rural power sector for investors are the main factors responsible to be without success in implementation.
- Nevertheless the Regional States of Oromia and INSHP are continuing to undertake efforts to find adequate sources of financing in closer cooperation with donor agencies and UNIDO.
- Together with Mesfin Shenkut Water Management Consultant representing INSHP in Ethiopia we bid for the development and rehabilitation of SHP project in Ethiopia, financed from the Austrian Government.
- Simultaneously it will be developed the cooperation regarding the Volunteer program to INSHP.
- The first Ethiopian participant will arrive at INSHP end of February 2001.

Meeting from June 13, 2000 with **Regional States of Oromia** and **Water Management Consultant** representatives:

Mr. Mesfin Shenkut, General Manager
Mr. Tariku Negera, Deputy Bureau Head
Mr. Mesferu D, Chief Engineer Energy Department

Date/Time: June13,2000 / 15:30

Venue: The Regional States of Oromia Headquarter

The Deputy Bureau Head Mr. Tariku Negera gave a brief introduction of the Regional States of Oromia, the largest States regarding surface and population with the richest water resources in Ethiopia.
Unfortunately just 2% is used to generate electricity.

The Oromia States is interested to develop SHP with the support of IN-SHP Hangzhou.

The Deputy Head Mr.Tariku would like to know the possibilities and the form of cooperation between IN-SHP and the Government. If the support from IN-SHP in developing the feasibility study will be possible the federal Government will also support the SHP development Mr. Tariku Negera stressed.

Regarding the financial support for the project implementation possibilities of financing through IN-SHP was required.

On 16.June 2000 the MOU between Oromia Regional States Represented through Mr.Triku Negera and INSHP represented through Mr.Michael Molnar was signed.

Mr.Tariku Negera sign the Letter of Intention regarding the Training Cooperation on the INSHP Volunteer Program.

Meeting from June 15, 2000 with Mr.Tesfaye Dama, Head of Faculty of Technology, University of Addis Ababa, Ethiopia

- Mr. Tesfaye is very interested to collaborate with IN-SHP and would like to get support in changing technology Know-how.
- The Faculty has a very good background in Hydro end would like tom continue to develop micro hydro equipment. The research group has successfully designed own turbine type.
- In fact, the team exprim their wish to collaborate in developing SHP technology equipment, to manufacture in Ethiopia.
- Mr. Tesfaye exprim his fully support in developing SHP projects in Ethiopia.

The two signing parties have agreed on the development of two SHP projects namely Werabessa and Tegona with the following details.

Werabessa:	Tegona
Gross head 280 m	Gross head 340 m
Discharge 3.88 m^3/s	Discharge 3.37 m^3/s
Expected output = 9 MW	Expected output = 9 MW
Storage structure required	Storage structure required

Depending on circumstances agreeable to both parties and when find to be to the better interest of the Regional State, the location of the projects can be changed.

2 Involved Parties and Responsibilities

The development of this project will be primarily under the leadership of IN-SHP and the Oromia Regional state with substantial involvement of the parties as indicated in chart 1.

2.1 The role and responsibilities of IN-SHP

- Carryout detail technical studies to a feasibility level
- Render advisory services during detail design and implementation phases.
- Assist the role of identification and application in obtaining the necessary fund for the implementation of the project through developing a fund raising strategy.
- Assist in obtaining a 70% equipment export credit.
- Capacity building for engineers by identifying potential IN SHP financing members and donors.
- Workout a strategy of sustainable development in remote rural areas using SHP synergy effect.

2.2 The role and responsibilities of Oromia Regional Government

- Facilitate the execution of the necessary local and national bureaucratic procedures regarding all pertinent matters for the realization of this project.
- Identify and assign appropriate professionals to work as counterparts in all project phases.

- Identify and give available technical data required in the preparation of the technical documentation.
- Organize and motivate potential stakeholders and funding agencies to contribute in the implementation of the project.
- Provide local transportation facilities for the IN SHP expatriates during the feasibility study stage.

3 Project Validity Date

The time frame to complete the feasibility study and availing document should be before end of the year 2000 unless both parties agree on extending this time frame. Following the feasibility study result, the dates for the next activities will be jointly determined and agreed upon.

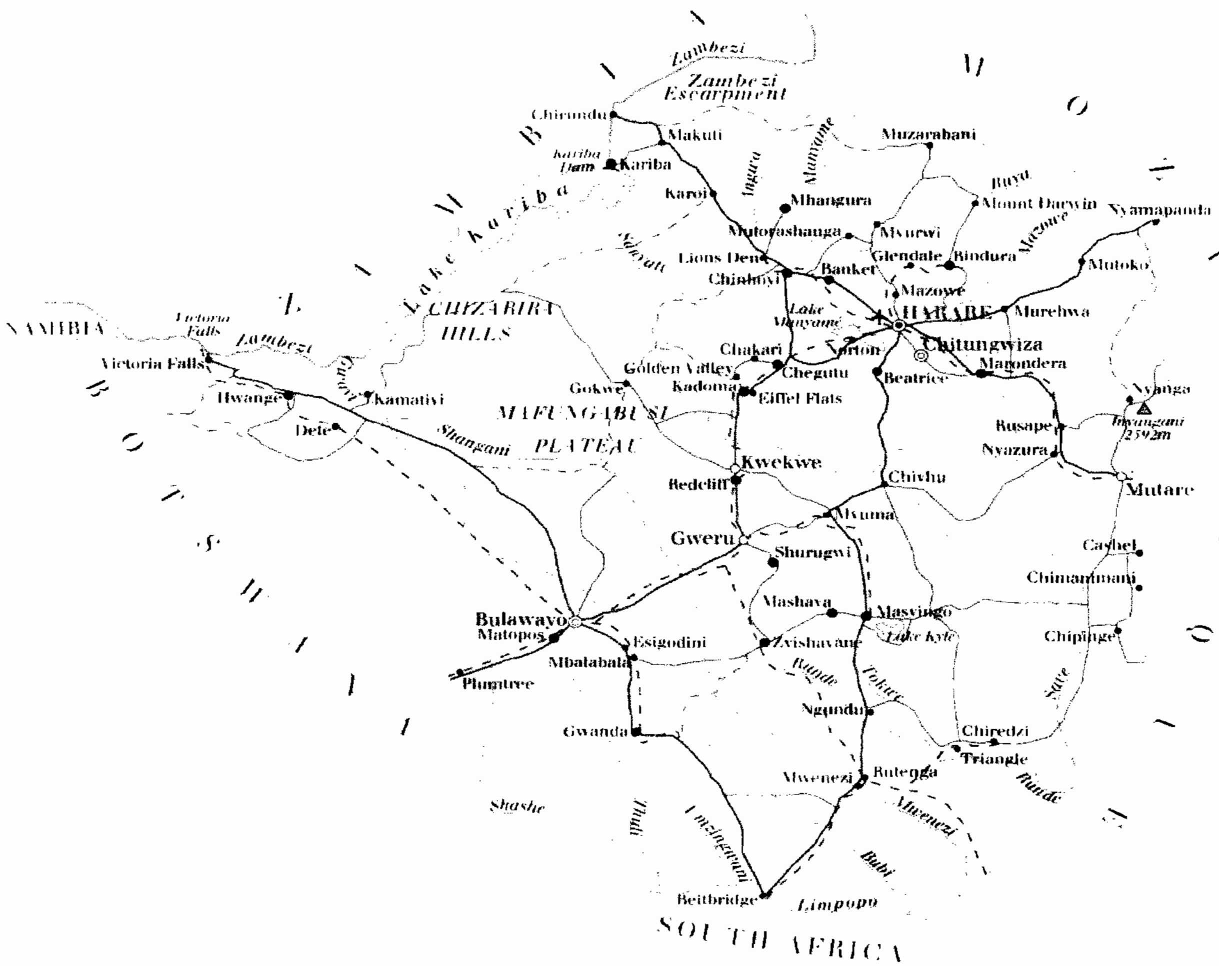
This MoU is signed on this date of 16 June 2000 in Addis Ababa

Tariku Negera Negerti
Deputy Bureau Head
For Oromia WMERDB

Michael Molnar
For IN SHP

Witnesses	1	Mr. Mesfin Shenkut	Water Resources Management Consultant
	2	Mr. Hirpa Duressa	Head Energy Dpt. Oromia WMERDB

ZIMBABWE



Studies carried out by the Department of Water Development found that the mean annual run-off for the whole of Zimbabwe is 19910 million m3, with current shortage at 5831 million m3, indicating that there is scope for storing more water. Current utilisation is only 22% of mean annual run-off.

An extensive network of dams has been constructed throughout the country. These range from small dams on commercial farms and in rural areas, to large dams for the purpose of supplying water to major cities and for irrigation.

Annual rainfall is generally low in Zimbabwe and the rivers are not perennial, it is necessary for water received during the main rainy season to be stored for use during the dry season

Exception may be the Eastern Highlands under the monsoon abundant rein falls with and much small water falls caring water all the year.

Zimbabwe's power requirements are currently met by 60% internal generation and 40% import. The import contracts are due to expire in year 2003 hence the need for new capacity to replace this and to meet the growing demand.

Zimbabwe's peak demand is currently 2 000 MW and is projected to increase to over 2 600 MW by 2004.

It is projected that a total of over 2600 MW of additional capacity is required by 2015.

The main national governmental institutions of the newly structured energy sector are:

- The Ministry of Transport and Energy, Department of Energy
- Zimbabwe Electricity Supply Authority, **ZESA**

Zimbabwe Power Company, **ZPC** as a wholly owned subsidiary of the national utility.

Currently, an effort is being made to substitute the extensions of the National Electric Grid in the remote rural area through decentralised energy generation mainly SHP and Biomass Resources.

There are opportunities to develop renewable energy projects and to market power in Zimbabwe. These are environmentally friendly projects that can be developed to ensure the efficient and sustainable utilisation of resources. ***The major areas are small scale hydro electric schemes***, wood waste based power stations, cane waste based power stations and coal bed methane gas power generation

ZPC has developed a portfolio of power projects. The portfolio of projects has large and ***small hydroelectric schemes*** and renewable energy resource power projects.

ZESA

The authority is responsible for generating, transmitting and distributing electricity. The Authority is working on a number of major rehabilitations and new projects over the next 20 years, mostly in conjunction with neighboring states as it believes that regional power-sharing and co-operation is the best way for equitable distribution of the region's power resources.

ZPC

Zimbabwe Power Company (ZPC) is a private company established in 1996 as a wholly owned subsidiary of the national utility, Zimbabwe Electricity Supply authority (ZESA). Its main purpose is to act as the investment wing in the new power generation projects.

ZPC's strategy for implementing projects involves developing ***joint ventures*** and partnerships with organisations that have technical and management experience and are willing to invest in the development of power projects in the markets that ZPC operates in.

There is also great potential for other large hydroelectric schemes in Mozambique, the Democratic Republic of Congo and in Zambia, which **ZPC** is targeting, to participate in.

Following the invitation of the ZESA and ZPC, INSHP undertook a consultation mission between 17-25 June 2000 in Zimbabwe, visiting the SHP sites in the Eastern Highlands.

Please find attached the Report in Annex 1.

Several institutions would be involved in an interdisciplinary project to develop the existing and proposed SHP potential sites.

Please find attached the two Minutes from 19 and 22 June 2000. Annex 2

As a concrete result of the intensive negotiations a **Memorandum of Understanding** (MoU) was signed.

Please find attached the MoU in Annex 3.

Stand by

ZESA and ZPC express their wish to maintain the dialogue with INSP so that the development of SHP can be realized in Zimbabwe and in the region.

- The establishment of a Regional Center should continue since there is a vast potential for SHP projects in Zimbabwe, Zambia and Mozambique. Some of the SHP potential has been identified and preliminary studies carried out.
- ZPC forwarded application for finance to the Chinese Embassy through the Ministry of Finance in September 2000 but to date no answer was received.
- Supplementary efforts were done by INSP contacting UNIDO Offices but without concrete results.

Consultation Mission in Zimbabwe

Meeting with the officials from:

- Zimbabwe Electricity Supply Authority, Department of Energy, **ZESA**
- Zimbabwe Power Company, **ZPC**
- National Economic Planing Commission
- Local Government and National Housing

The main subject of the meeting was the *comprehensive rural development strategy*.

Mr. Molnar present the SHP Synergy effects as a model of sustainable rural development involving the entire stakeholder.

The presented concept and further possible strategy was appreciated from all the participants.

It was pointed out that basically are 2 types of assessment:

- Financial benefits
- Economically viability

- The Local Government official stressed the demand and the wiliness for approval regarding the development of the sites. They already have been developed a community plan and wish to be involved in to the further development of the program.

- The discussion continued over the grid extension the Project Area, the Master Plan, the Renewable Energy Program and further development of the power sector.

- The ZESA official and the ZPC Manager pointed out the SHP project implementing is according to the Master Plan.

- Further the Ministry of Water Resources, Ministry of Local Authority, the Rural District Counsel needs to give their approval.

- It is to pay attention for all runs of river projects. The user of water and land are the Farmer. Social impact assessment and cultural impact study should be carried out.

To the IPP issue:

- At first needs to develop the frameworks to develop SHP in large scale in Zimbabwe. It does require a large consensus from the entire involved stakeholder.

- Second, find out witch art is proper for what? Decentralized or of grid
  The selection will depend from the communication between the interested participants.

If a new ***Master Plan*** for development on SHP is necessary than is needs to build an:

- Own SHP market
- Small companies who will produce the equipment in Zimbabwe
- Until 1MW is needs of alternators and transformers
- Mechanical/electrical governing
- Co-operation with foreign companies as JV

The Ministry of National Planing will assist for funds after presenting Feasibility study.

Harare 23.06.00

MINUTES OF THE WORKING PARTY ON MINI-HYDRO POWER GENERATION AND A CONSULTANT FROM IN-SHP (CHINA)

DATE	:	19th June, 2000
TIME	:	10:00 Hrs
VENUE	:	ZOC Boardroom (Kurima House)
IN ATTENDANCE	:	
Mr. R. Tirivanhu	:	Department of Energy (Chairman)
Mr. J. Mukuzunga	:	Department of Energy (Secretary)
Mr. T. Neshamba	:	Department of Energy
Mr. T. Chakara	:	Zimbabwe Power Company
Mr. W. Mungwena	:	University of Zimbabwe
Mr. T. D. Nhete	:	I.T.D.G.
Mr. P. Muringayi	:	National Economic Planning Commission
Mrs. E.M. Bhebhe	:	NEPC
Ms S. Thabethe	:	Local Govt. & National Housing
Mr. Michael Molnar	:	IN-SHP Hangzhou, China

1. Introduction

The Chairman gave a brief background on what has been done in Zimbabwe in the field of mini-hydro power generation. Efforts so far involved a number of feasibility studies carried out on the potential for mini hydro power generation (e.g. Sir Alexander Gibbs & Partners, potential on irrigation dams by GTZ and the Manyuchi Mini Hydro scheme to be funded by E7). He pointed out that these studies concentrated on possibilities of connecting the schemes to the grid. The Department of Energy has also made preliminary visits to potential sites on perennial rivers in the Eastern Highlands to identify the physical sites, estimate heads, measure water discharges during high and low flow periods and hold discussions with local authorities and traditional leaders. The Chairman however stressed that more detailed feasibility studies still need to be done before establishing the schemes.

Mr. Michael Molnar of International Network on Small Hydro Power based in Hangzhou, China was given the opportunity to introduce his organisation and the nature of his visit. He indicated that his organization was made up of 120 members from 63 countries and was supported by specialized UN agencies, governments, academics and multilateral financing institutions. He stressed that the major task of his organisation is to support rural areas with the installation of small hydro power to improve general quality of life and create employment. By way of illustration, Mr. Molnar showed different models of what the project could look like to integrate clean water supply, irrigation, environmental protection, small and medium enterprises and rural education. This would only be realised by combining ideas from different stakeholders present at the meeting. It was however emphasised that as an NGO their organisation does not provide with direct financing but rather operate as a bridge to promote private investment.

2. Site selection

Scheduled visits to Nyanga and Mutare were to be carried out the following day, June 20th to assess identified sites and hold meetings with the responsible authorities. It was proposed that there was still room to select more sites (near load centres) in the area as there was a possibility of installing 3 mini hydro sites depending on the given topography and the allocated funds for the project.

Initially a mini hydro of 6MW would be installed in the area through the involvement of foreign expertise. The Authorities dealing with specific aspects of the projects will be contacted, e.g. water rights, land rights, etc. The meeting was informed that preliminary visits showed that the local authorities and traditional leadership were supportive provided the projects benefited the communities. The strengthening of local capacities both in industry as well as human resources was also highly recommended.

3. Regional Centre

Mr. Molnar proposed for a creation of a Regional Centre which will have in its design the capacity to train, promote and support upcoming projects through experienced networking. A representative from ITDG suggested the idea of integrating the proposed Regional Center with the SADC Energy Initiatives.

The meeting concluded on the note that the Ministry of Transport and Energy should take the lead in the organizational process of the said proposal.

The next meeting was set for Thursday, June 23rd at the same venue.

ANNEXURE 3

MINUTES OF THE 2nd MEETING OF THE WORKING PARTY ON MINI-HYDRO POWER GENERATION AND A CONSULTANT FROM IN-SHP (CHINA)

DATE	:	22nd June, 2000
TIME	:	11:00 Hrs
VENUE	:	ZOC Boardroom (Kurima House)
IN ATTENDANCE	:	

Mr. R. Tirivanhu	:	Department of Energy (Chairman)
Mr. J. Mukuzunga	:	Department of Energy (Secretary)
Mr. T. Chakara	:	Zimbabwe Power Corporation
Mr. P. Muringayi	:	NEPC
Ms S. Tabethe:		Local Govt. & National Housing
Mr. Michael Molnar	:	IN-SHP Hangzhou, China

1. MINUTES OF THE MEETING HELD ON 19TH JUNE, 2000

The minutes were read through and there being no changes to make they were adopted as a correct record. The meeting was to report on the findings of the field visit to Manicaland undertaken from 20-21 June 2000.

2. REPORT ON THE FINDINGS MADE IN MANICALAND

2(a) The Chairman gave a brief summary of the site visits and meetings held with Nyanga and Mutasa Rural District Councils and in Mutare. He cited that the meetings held were considerably fruitful as the beneficiaries concerned were very supportive and ready for the implementation of the mini-hydro power projects. Prospective sites on two rivers and Osborne Dam were visited. Discussions on water rights were held at The Department of Water in Mutare. It was indicated that the river systems have Water Catchment Councils composed of all the relevant stakeholders thereby facilitating the resolution of conflicts and addressing concerns of the stakeholders. It is these councils which consider water usage and the issuing of water use permits instead of water rights. The meeting with ZESA officials was centred on the possibility of integrating mini-hydro power with the grid as part of the rural electrification programme. Finally the mission ended with a visit to Osborne Dam.

2(b) Mr. Molnar indicated that Gairezi Falls on Tsanga river, from a topographic point of view would be ranked first as it would be easier to construct. The site on the Gairezi river with up to 25m-26m head also proved to be quite good although a bit more would need to be done in terms of civil works. The two sites were proposed to be included in the project. Duru river in Mutasa District will have to

be considered as a third option while a further possibility is still there to work on the Osborne Dam. The way the dam was design might require a more complicated design for power generation.
Mr. Molnar appreciated the support and commitment to the project from the local authorities following discussions which were held. He pointed out that the detailed feasibility studies will also include the financial and technical aspects of the projects. A comprehensive rural development model will be worked out in consultation with all the stakeholders in order to benefit the rural communities. Mr. Molnar also informed the meting that a common ground had been reached with ZESA and that new sites are expected to be developed in the process. The implementation phase of the project will begin next year after a comprehensive write-up of the feasibility studies.

3. The Way Forward

On the way forward, Mr. Molnar informed the meeting that the requested data for the feasibility studies will be ready by the end of August, 2000. An MOU Agreement will be designed between IN-SHP and ZPC after which feasibility studies will be carried out in September, 2000. Plans for civil works will also be put in place. Local consultants will also participate especially on the hydrological, socioeconomic and cultural aspects of the projects. The actual implementation phase will possibly commence next year, 2001. International funding will be solicited for the projects. The creation of the Regional Centre was reiterated once again as this move would promote the development of more mini-hydro power stations in Zimbabwe and the region. The concept paper for the centre will be developed and sent at a later stage. It is hoped that by May, 2001 the concept paper will have been approved.

Finally, Mr. Molnar requested for detailed addresses from all concerned parties/stakeholders as he would want to update them on progress regarding the project. In turn he proposed for some exchange of ideas and interaction with the stakeholders in coming up with a comprehensive and beneficial programme. DoE will compile the list of addresses of all the members of the Working Party.

The meeting was closed with the Chairman thanking the whole team for the efforts made and appreciating Mr. Molnar's visit. It was called for that the feasibility studies should lead to successful project implementation as this would meaningful development of the targeted rural communities.

SMALL SCALE HYDROELECTRIC POWER PROJECTS

· MEMORANDUM OF UNDERSTANDING

This Memorandum of Understanding is made on the 24th June 2000.

Between

The International Network on Small Hydro Power whose registered office is 310002 Hangzhou, China and;

Zimbabwe Power Company (Pvt) Ltd whose registered office is 12th Floor, Megawatt House, 44 Samora Machel Avenue, Harare.

Each a 'Party' and together the 'Parties'.

Whereas;

Zimbabwe Power Company expressed its interested in developing small scale hydropower sites in Eastern Highlands as there is adequate rainfall in the area which can be fully utilised to generate electricity from renewable energy and create the basis for a sustainable development in the rural area.

The Zimbabwe Power Company is interested in investing in and developing small scale hydroelectric power projects in the Eastern Highlands of Zimbabwe.

The International Network on Small Hydro Power is able to carry out detailed feasibility studies, in conjunction with local consultants, and to deliver and co-ordinate support programmes for the communities in which the hydro project will be developed.

The International Network on Small Hydro Power is willing to provide ZPC with consultancy services to develop small scale hydroelectric power projects for a small fee.

The International Network on Small Hydro Power understands the necessity of developing the untapped resource in the Eastern Highlands for the socio-economic development of the remote rural area which reduces water borne diseases and contributes to the rural electrification plan.

Now The Parties Hereby Agree That:

1. Background and Objectives

Zimbabwe needs to demonstrate and support a sustainable energy program by implementing a significant number of power generating projects based on renewable energy sources such as small-scale hydroelectric power (SHP) projects.

Zimbabwe Power Company (ZPC) is a private company established in 1999 as a wholly owned subsidiary of the national utility, Zimbabwe Electricity Supply Authority (ZESA). Its main purpose is to act as the investment wing in the new power generation projects.

ZPC's strategy for implementing projects involves developing joint ventures and partnerships with organisations that have technical and management experience and are willing to invest in the development of power projects and the power trade business in the markets that ZPC operates in.

Following consultative communications on the subject in the last six months between ZPC and IN-SHP, the representative of IN-SHP, Mr M. Molnar, has conducted over the period 19-25 June 2000 a consultative mission to outline the concept of a joint co-operation with ZPC in the realisation of SHP in the Eastern Highlands. The consultative mission included meetings with other as per the minutes in Annnexues 2 and 3.

In developing the concept to carryout the projects, the parties agreed to sign this MOU as a first step to formalising a contractual agreement.

2. Programme

ZPC and IN-SHP have agreed to work to the programme set out in Annexure 1.

3. Selected Projects

The following projects have been identified for initial development.

3.1. Primary Projects for Initial Development

Perennial River Hydroelectric Schemes

Site	Duru	Girezi Falls ✓
Site Co-ordinates	S18°35' E32°42'	S18°08' E32°54'
Altitude	1403m	1880m
Available head	240m	84.4m
Min. Flow	1.3m^3s^{-1}	1.6m^3s^{-1}
Ave Flow	2.59	3.3
Max Flow	7.82	9.72
Available grid	33kV, 5km away	2Km
Estimated Power Potential	**2X2MW 2X1.5MW**	**1X1MW 3X1.5MW 2X1.5MW**

3.2. Additional Optional Projects

Perennial River Hydroelectric Scheme

Site	Gairezi ✓
Site Coordinates	E18°12' E32°54'
Altitude	1489m
Available head	26m
Min. Flow	8.5m^3s^{-1}
Ave Flow	17.01
Max Flow	52.78
Available grid	6Km
Estimated Power Potential	**2036kW**

Dam Hydroelectric Scheme

Name :	Osborne
District/Province	Makoni / Manicaland
Altitude	1600m
Live Capacity	400.9 x 10^6m^3
Yield at 10% risk	167.0 x 10^6m^3
Mean annual discharge	5.3m^3s^{-1}
Gross head available	60.7m
Available grid	11kV
Estimated Power Potential	**3030kW**

4. Roles and Responsibilities of the Parties

ZPC's primary role is that of developer and owner of the small-scale hydroelectric power projects.

IN-SHIP's primary role is to provide consultancy services to ZPC for the development of the small-scale hydroelectric power projects.

Other roles shall be:

4.1 The role and responsibilities of IN-SHP

- Carry out pre-feasibility and feasibility studies for a small service charge.
- Render advisory services during the detailed design and implementation phase studies for a small service charge.
- Assist in the identification and application for obtaining the necessary funds for the implementation of the small-scale hydroelectric projects by developing a financing strategy and financing plan.
- Assist in obtaining a 70% equipment export credit.
- Carry out a capacity building program and identify potential IN-SHP financing from its members and donors to support the program.
- Work out a strategy of sustainable development in remote rural areas for SHP synergy effect.

4.2 The role and responsibilities of ZPC

- Invest and develop the small-scale hydroelectric power projects.
- Obtain all necessary consents for developing the SHP projects.
- Identify and assign appropriate counterpart personnel in all project phases for local capacity building.
- Identify and provide available technical data required in the technical feasibility studies.
- Facilitate the development of community programs associated with the SHP projects for the synergy effect.
- Cover local living and transportation expenses for the IN-SHP expatriates during site visits.

IN WITNESS WHEREOF the Parties have duly executed this Memorandum the day first above written

For Zimbabwe Power Company

Isaac Mupotsa
Managing Director

For International Network on Small Hydro Power

Micheal Molnar

Annex 6

Annex 6

PEREZ-GUERRERO TRUST FUND Project INT/98/k06/A/95/99

Consultation to the Laughlands Great River Hydro Project of Jamaica

EVALUATION REPORT

Submitted by

International Network on Small Hydro Power

136 Nanshan Road, P.O. Box 202
Hangzhou, Zhejiang Province, China 310002
Tel: 86 571 707 0070   Fax: 86 571 7023 353
Email: hic@mail.hz.zj.cn

CONTENT

PART I GENERAL DESCRIPTION OF THE PROJECT

1. General

The proposed Laughlands Great River Hydroelectric Project is located on the north side of the island on and around the Cran Brook Estate between the Laughlands Great River and Laughlands Little River. There has been irrigation canal on Laughlands Great River. The proposed project with installed capacity of 5.31 MW is just to utilize the water head between Laughlands Little River and the weir formed by constructing a dam on the downstream of the irrigation canal on the Laughlands Great River.

The project will operate run-of-river,using 382 feet of water head, which involves construction of a new diversion weir and intake structure near the headwaters of the Laughlands Great River; a headrace canal; a headpond/surge tank; a steel penstock; a main powerhouse rated at 5MW; an auxiliary powerhouse rated at 0.31MW is proposed to provide the required minimum irrigation releasing to the existing Richmond Canal.

The primary purpose of the project is for power generation and irrigation, which will be fed mainly to the Jamaica Public Service Company. On completion, the power plants will offer 5.31 MW of output and average annual net energy generation of 22,057,000kWh. In addition, more economic benefit will be obtained from the coordinated operation of hydro and other power plants.

2. Necessity of the Project

Jamaica is located in the northwest of the Caribbean Sea. It is an island country with an area of 10999 km^2 and population of 2,366,000. Jamaica island is the third island in the West Indian Archipelago. Its topograghy is mainly composed of highlands. The Blue Mountains in the east are more than 1800m in the elevation whose peak elevation is 2256m. Along the seas are narrow plains. It belongs to tropic rain forest climate. Annual precipitation is about 2000mm.

Bauxite-alumina , sugar cane and tourism are three main stanchions of the national economy of Jamaica. But the whole economy of the country is not developed and the living standard is low. Jamaica is short of natural resource,especially energy resource. Electricity supply is not sufficient. As hydropower is concerned, the total inatalled capacity for the country is less than 30 MW. Due to the shortage of the electricity supply, industrial and agricultural development and civilian electricity consumption in this country have been seriously hindered for years. It is urgent to develop hydro project to get rid of poverty, improve civilian living quality and meet the need for electricity.

Jamaica is short of fossil fuels. If fossil fuel plant is developed, fuels must be imported and operation cost will be increased. When burning fossil fuel, greenhouse gas(carbon dioxide) and poisonous gas such as sulphur dioxide and nitrogen oxide are released into air which have bad effect on environment and the tourist industry.

Because of the tropic rain forest climate, precipitation is sufficient and water resource is abundant, which is suitable to develop hydropower. Hydropower is clean, non-polluted and renewable energy resourse, which also can benefit the tourist industry.

3. Construction Condition

3.1 Meteorology and Hydrology

Great River Basin has a tropic maritime climate. Mean daily temperatures range from a seasonal low of 22 centigrade in February to a high of 25 centigrade in August. The mean annual temperature is 23.8 centigrade. Daily sunshine hours are fairly constant throughout the year, averaging about 8.2 hours.

According to the data observed, the long term mean annual rainfall over the basin is about 1785mm. The basin regularly comes under the influence of tropic storms and hurricanes during the period July to Novermber,characterised by flood producing rainfall of high intensity and magnitude. According to the data from the Underground Water Authority of Jamaica. The mean monthly relative humidity in the Great River Basin is near constant throughout the year, ranging from a low of 71 percent in August to a high of 77 percent in October and averaging 74 percent.

The Underground Water Authority of Jamaica has provided the flow data of the 1981- 1982 and 1985-1994 period. But the data of high flow are not included and there are some gaps in the data. Harza Engineering Company International has developed annual flow duration curves and monthly flow duration curves from the flow data available for the project. The mean flow is found to be 109 cfs(cubic feet per second). But the result is not very reliable because of the quilty and completeness of the data.

To meet the need of irrigation of sugar plannations, an constant demand of 17.5 cfs is released to the Rimond Canal through the auxiliary powerhouse. For hydroenergy generation estimate of the main powerhouse, no deduction from the recorded flows is necessary to account for irrigation release since the flows recorded by the stream gauging station already reflect withdrawals for irrigation.

3.2 Engineering Geology

The survey of the engineering goelogy has conducted by the Lahmeyer International. The weir and intake are founded on rock. The right side of the weir would be directly founded on the rock while the left side would be founded on lean concrete fill on rock. The headrace canal is constucted on the mild slope. At one end of headrace the weir and intake are connected. Portions of the headrace canal are cut completely above exiting ground, some partially cut into sloping ground , and some constructed above exiting ground. The headrace canal cross four main gullies that will need to be filled in and where culverts are required. At the other end of the headrace the headpond surge tank is arranged. A part of headpond/ surge tank is shaped by excavating whose foundation is rock. the depth of the excavation is more 16 feet. After the headpond the penstock is fabricated. The penstock is aligned on the steep slope.

In some places the slope is more than 50° . Some anchorages are provided to

surport the penstock. Much attention must be paid to the foundation condition and stability of the anchorages. At the end of the penstock the powerhouse is constructed. The powerhouse is located on the sand gravel.

3.3 Access Road

The access road is mainly of highway. A highway will be constructed at the downstream of the Laughlands Great River. At the one end of the road is the service yard for the main powerhouse and at the other end a main road is connected.

3.4 Main Structure and Construction Period

The main structure for the Laughlands Great River consists of the weir and intake, headrace canal, tailrace canal, penstock, main powerhouse, and auxiliary powerhouse.

3.4.1 Weir and Intake

The proposed weir is located about 450 feet downstream o fthe headwaters. The weir is constructed of reinforced concrete and rockfill with side slopes near the weir. The weir has a fixed crest elevation of 426 feet. The width of the weir is 36 feet. The headrace canal intake is incorporated into the right abutment of the weir. The intake has two openings and before the openings the trash rack is arranged for protection. Stoplog slot and a roller gate are provided for the intake.

3.4.2 Headrace Canal

The headrace canal is a structure with trapezoidal cross section. The crest width of the headrace canal is 11.0 feet, the base width is 7.6 feet, and the wall height is 6.75 feet. The headrace canal is constructed of natural stone masonry lined with 0.5-1.0 thick lime-cement facing. The base slab is constructed of reinforced concrete. The design discharge for the headrace canal is 205 cfs(175 cfs for the main powerhouse and 30 cfs for the auxiliary powerhouse).

3.4.3 Surge Tank

The surge tank is a structure of reinforced concrete. It is 24 feet high and 36 feet in the diameter. The intake for the penstock is located at one end. In front of the intake the trash rack is arranged. An irrigation outlet with a diameter of 24inch is provided with valves as well. Nomal water level in the tank is about EL.420.0 feet.

3.4.4 Penstock and Bifurcation

The penstock is 5559 feet long and 63 inch in the diameter with a wall thickness of 3/8 inch. Mild steel is proposed for the upper portion of the penstock, and high strength steel is proposed for the lower reaches. The upper portion of the penstock is located above ground on the concrete saddles founded on rock, and the lower portion is buried under the ground. Coal tar epoxy is prospose for the exterior of the penstocks, and cement mortar lining on the inside. At the lower end, the penstock is bifurcated into two 36 inch diameter lines leading to the main powerhouse.

3.4.5 Main Powerhouse

The main powerhouse is a structure of reinforced concrete. It is located on the sand and gravel material. The substructure is constructed of reinforced concrete and the superstructure is constructed of reinforced concrete framework with masonry block wall. Two horizontal francis units rated at 2.5 MW using a net head of 382 feet and a discharge of 87.5 cfs are installed in the main powerhouse. The turbines discharge into an open tailrace canal with a weir to control tailwater levels.

3.4.6 Auxiliary Powerhouse

Irrigation releases of 2.3 to 28.25 cfs are required into the Richmond Canal. The auxiliary powerhouse is constructed to use the releases [illegible] the turbine rated at 0.31 MW with a design discharge of 17.5 cfs and a net head of 167 feet is installed in the powerhouse. A bypass line with manually operated energy dissipating valve is proposed tp maintain releases to the canal when the unit is unavailabe for operation. The tailrace discharges flow to the Richmond Canal.

3.4.7 Tailrace Canal

The tailrace canal that is 2083 feet long has a trapezoidal cross section.The bottom width is 2.8 feet and the wall height is 9.2 feet with a side slope of 2:1. The canal is covered with grass.

The period of construction for the project will last for 21 to 24 months.

PART II ECONOMIC EVALUATION FOR THE PROJECT

4 Cost Estimation

The proposed project belongs to run-of-river plant. Its main function of the power station is to generate powerenergy and irrigate.The installed capacity is 5.31MW, and the annual power generation is about 22,057,000 kWh. The main structure is comprised of the weir and intake, headrace canal, surge tank, penstock, main powerhouse, auxiliary powerhouse.

The cost estimation is based on the engineering quantity which Lahmeyer Internation provided and unit price which Harza Engineering Company Internation.

Total cost estimation

Table 1

No.	Items	Estimation (US Dollars)
1	Civil Work	3,170,000
2	Turbine Generator Equipment	2,750,000
3	Aux. Mechanical Equipment	1,200,000
4	Aux. Electrical Equipment	375,000
5	Contingency	1,125,000
6	Engineering & Administration	1,080,000
7	Construction Management	700,000
Total		10,400,000

The estimated cost results in a rato of $1,962 of capital cost per kilowatt of installed capacity. According to the engineer experience in China, this ratio is a little higher than normal condition.

Construction mangement costs have been estimated and included in the cose estimate. Experience indicates that full time construction management services are well worthwhile in obtaining a qulity project and maintaining costs within budget. For this project we have estimated the costs at 8% of the direct construction costs based on experience in Jamaica and assuming a 21 to 24 month period of construction.

More detailed information for the cost eatimate is contained in the following table.

Table 2 ***Cost estimation for civil works***

Unit: US dollars

No.	Items	Unit	Qty.	Estimation price	
				Unit price	Total price
1	**Weir and intake**				
	Clearing	sq.yds	620	3	1,860
	Soil excavation	cu.yds	645	8	5,160
	Rock excavation	cu.yds	540	25	13,500
	Substructural concrete	cu.yds	162	220	35,640
	Structural concrete	cu.yds	304	350	106,400
	Gabions	cu.yds	190	100	19,000
	Rockfill	cu.yds	86	20	1,720
	Cofferdam and dewatering	lump sum	1	50,000	50,000
2	**Headrace canal**				
	Clearing	sq.yds	12,900	3	38,700
	Soil excavation	cu.yds	14,000	8	112,000
	Rock excavation	cu.yds	6,990	25	174,750
	Slope protection	sq.yds	450	50	22,500
	Concrete base	cu.yds	2,270	220	499,400
	Natural stone masonry	cu.yds	5,420	30	162,600
	Lime-cement plaster	sq.yds	11,445	27	309,015
	Fill	cu.yds	3,700	8	29,600
	Bridges	lump sum	4	5,000	20,000
	Armco culverts	yds	117	150	17,550
	Gabions	cu.yds	500	100	50,000
3	**Headpond**				
	Clearing	sq.yds	422	3	1,266
	Rock excavation	cu.yds	517	25	12,925
	Superstructural cocrete	cu.yds	163	300	48,900
	Structural concrete	cu.yds	100	350	35,000
	Backfill	cu.yds	200	8	1,600
4	**Penstock**				
	Clearing	sq.yds	7,233	3	[illegible]
	Rock excavation-by hand	cu.yds	92	[illegible]	[illegible]
	Rock excavation-ripped	cu.yds	1,500	[illegible]	[illegible]
	Concrete-precast saddles	cu.yds	58	350	20,300
	Concrete,structural fill	cu.yds	140	220	30,800
5	**Main powerhouse**				
	Clearing	sq.yds	4,323	3	13,026
	Soil excavation	cu.yds	5,282	8	42,256
	Substructural concrete	cu.yds	595	220	130,900
	Structural concrete	cu.yds	175	350	61,250
	Superstructural concrete	cu.yds	45	300	13,500

Table 2 *Cost estimation for civil works(continued)*

Unit:US dollars

No.	Items	Unit	Qty.	Estimation price	
				Unit price	Total price
	Backfill and compaction	cu.yds	637	8	5,096
	Hollow block masonry(8inch)	sq.yds	380	27	10,260
	Builder' s work	Cu.yds	2,600	20	52,000
	Doors and windows	lump sum	1	5,000	5,000
7	**Auxiliary powerhouse**				
	Clearing	sq.yds	201	6	1,206
	Soil excavation	cu.yds	50	8	400
	Rock excavation	cu.yds	20	50	1,000
	Structural concrete	cu.yds	25	350	8,750
	Hollow block masonry(8inch)	sq.yds	80	27	2,160
	Builder' s work	cu.yds	120	25	3,000
	Doors and windows	lump sum	1	5,000	5,000
8	**Tailrace canal**				
	Soil excavation	cu.yds	9,920	8	79,360
	Backfill & compaction	cu.yds	9,920	8	79,360
	Sealing/slope protection, etc	lump sum	1	50,000	50,000
	Property road bridge	lump sum	1	5,000	5,000
9	**Access road**				
	Road to weir and surge tank	ft	5,300	20	106,000
	Road to powerhouse	ft	2,750	30	82,500
	Mobilization and demobilization				264,101
	Undeveloped details				264,101
	TOTAL				3,170,000

5 Finance Evaluation

5.1 Funds and Financing for this Project

5.1.1 Funds of Fixed Assets

The total funds of fixed assets for the project will be $11,517,500. The funds comes from the private investor, and the annual interest rate is 7.0%.

5.1.2 Interest during Construction

The interest rate of load is calculated as compound interest and the interest of the loan during construction is $1,117,500.

5.1.3 Floating Capital

The floating capital of these power stations is $6,500, and used as the funds when putting into units operation. The principal sum will be taken back once at the end of the calculating period. Plan of investment and financing are listed in Table3.

Table 3 ***Investment plan and capital raising chart***

Unit: 10^4 US Dollars

No.	Items	Construction period		Operation period	Sum
		1	2	3	
1	Total investment		1151.75	0.65	1152.4
1.1	Fixed assets investment	520	520		1040
1.2	Loan interests of construction period		111.75		111.75
1.3	Floating capital			0.65	0.65
2	Capital raising				
2.3	Loan	1151.75			
	Principal	1040			
	Interest	111.75			

5.2 Basic Data

5.2.1 Energy Output to Grid

The electric power is stepped up to 69kV from 6.9kV. The energy output to grid is counted as 95% of total annual generation power. And the total generation power of these stations for one year is 22,057,000 kWh. The total energy output to grid is 20,954,000 kWh.

5.2.1.1Fixed Assets

The total fixed assets are $10,400,000, and the interest during construction of these power stations is $1,117,500. The total fixed assets that will be made up is $11,517,500.

5.3 Calculation of the Total Cost

5.3.1 Cost for Generating Power

The total cost mainly include the depreciation, overhauling cost, wage of employees and other welfare, cost for construction materials, cost for water resource, cost for loan interest and other costs.

The cost of operation should be taken as the following : the total cost that depreciation cost, interest payment, cost for servicing and examination and amortization payment were derived from it.

Depreciation cost =fixed assets of stations×comprehensive depreciation rate

Reparation cost = fixed assets of stations × Reparation rate

The comprehensive depreciation rate of power station is selected as 4.5%; reparation cost including material cost is selected as 0.5% according to experience date of exist power stations.

The total salary is counted as number of staffs plus average salary of each person. The defined number of staffs of these power stations is 43. The average salary is &1000 for each person (including the allowance).

The welfare fee accounts for 14% of total salary, then the salary and welfare fee are $49,000.

Rate of other cost taken $1.3;

Details of estimation for the total cost can be seen in Table 4.

5.4 Calculation of the Benefit Coming from Generating Power

5.4.1Income of Generating Power

The financing evaluation of these power stations was done to regarding the station as a self-reckoning unit in the grid. And the equation of calculating as follows.

Income for generating power =amount of power output to grid× price of power output to grid. Current price of power output to grid is taken $0.0828 /kWh. The price of power output to grid does not include the value added tax and the same thereinafter.

5.4.2 Tax and Duty

Tax for electrical production includes value added tax and additional tax of electric sell.

Value added tax belong to tax outside the price, and here we only taken it as the basis of calculating additional tax for electric sell. According to concerned regulation, the value added tax is counted as 6% of sale income.

The additional tax includes that for city preservation and construction, and calculated and levied base on value added tax. Tax rate of the two items is 5% and 3%.

5.4.3Profit

Generation profit =generation income - total cost – additional sale tax

Profit after tax = profit for power sell – income tax

The rate of income tax is 33%。

The profit after income tax will be apportioned followed such a sequence:

a、 Accumulation fund of surplus will be taken first according to the law

b、 Then public welfare fund will be taken.

Accumulation fund of surplus is taken according to the national regulation from profits after tax and used for the development of the company ,making up deficit or as reservation fund to transfer and add capital. Accumulation fund is taken according to 10% of profit after tax.

Commonweal fund , which is used as staff welfare, is taken according to 5% of profit after tax.

Undistributed profits equals to profit after tax subtracted from Accumulation fund and commonweal fund.

Generation income, tax and profit calculation is shown in table 5.

5.5 Analysis of Loan Payback

5.5.1Payback Capital

Payback capital consists of payback profit and payback depreciation. The profit which is not distributed is all used to payback the loan, and 90% of depreciation fee is also used to payback loan.

5.5.2Payback of the Principal and Interests of Loan

The calculation of payback the principal and interest is shown in table 6

5.5.3 Capital Source and Utilization

Capital source and utilization is shown in table 7. It is shown from calculation that there will be surplus capital in the first year of operation period, and accumulative surplus capital in the calculation period is $9,249,300.

5.6 Analysis of Benefit Capability

Construction period of the project is counted as two years, normally operation period is 20 years, and basic FIRR is 10%. From calculation, FIRR of total investment is 11.35%, FNPV is $868,763, return period of financial investment is 9 years.

Cash flow of total investment is shown in table 8

5.7 National Economic Evaluation

5.7.1 Investment and Cost

5.7.1.1 Benefit Calculation

Annual benefit of power station is through the national economic calculation by using shadow electricity price of $0.0828/kWh.

5.7.1.2Treatment of Transfer Payment

Electric power sale and its additional, income tax is counted as internal transfer payment of national economy, not as the project cost.

5.7.2 Financial Evaluation Index

Dynamic calculation method is used to calculate the financial evaluation index of national economy. Economic calculation period is 22 years, including 2 years of construction and 20 years of operation period. Investment of renovation is not considered in the calculation period, and floating capital is returned in the end of calculation period. The social discount rate of this construction project is 12%, and economic cash flow is shown in table 9.
By calculation ,EIRR is 13.4%, and ENPV is $862,483 .

5.8 Comprehensive Evaluation

5.8.1 Financial Evaluation

The fixed assets investment of the Laughlands is $10,400,000. If the interest of $1,117,500 in construction period and floating capital of $6,500 is included. then the total investment will be $11,524,000. All financial indexes are good, so this project is feasible in the financial point.

5.8.2 National Economic Evaluation

The shadow electricity price to grid is $0.828/kWh , EIRR is 13.4% and exceeds social discount rate of 12%, ENPV is $862,483 and greater than zero, so this project is reasonable in economy in the national point .

Table 4

Estimation of total cost

Unit : 10^4 US Dollars

No	Year		Operation period																			Sum
		1,2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
	Energy output to grid	0.0	2,095.4	2,095.4	[illegible]	[illegible]	[illegible]	2,095.4	2,095.4	2,095.4	2,095.4	2,095.4	2,095.4	2,095.4	2,095.4	2,095.4	2,095.4	2,095.4	2,095.4	2,095.4	2,095.4	2,095.4	41,908.0
	Sale income	0.00	173.50	173.50	173.5[illegible]	173[illegible]	[illegible]	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	3,470.00
1	Generation cost	0.00	143.85	139.35	134.7[illegible]	129.9[illegible]	[illegible]	119.73	114.28	108.65	10[illegible].80	96.7[illegible]	90.3[illegible]	83.82	76.97	69.86	63.18	63.18	63.18	63.18	63.18	63.18	1,915.10
1.1	Depreciation	0.00	51.83	51.83	51.8[illegible]	51.8[illegible]	[illegible]	51.83	51.83	51.83	51.83	51.83	51.83	51.83	51.83	51.83	51.83	51.83	51.83	51.83	51.83	51.83	1,036.60
1.2	Repair cost	0.00	5.76	5.76	5.7[illegible]	5.7[illegible]	[illegible]	5.76	5.76	5.76	5.76	5.76	5.76	5.76	5.76	5.76	5.76	5.76	5.76	5.76	5.76	5.76	115.20
1.3	Salary and welfare	0.00	4.90	4.90	[illegible]	4.90	[illegible]	4.90	4.90	4.90	4.90	4.90	4.90	4.90	4.90	4.90	4.90	4.90	4.90	4.90	4.90	4.90	98.00
1.5	Interest payback	0.00	80.67	76.17	71.5[illegible]	66.7[illegible]	[illegible].75	56.55	51.10	45.47	39.62	33.54	27.21	20.64	13.79	6.68	0.00	0.00	0.00	0.00	0.00	0.00	651.50
1.6	Other costs	0.00	0.69	0.69	[illegible]	0.69	[illegible]	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	13.80
2	Operation cost	0.00	11.35	11.35	11.3[illegible]	11.3[illegible]	[illegible]	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	227.00

Table 5

Profit and lost chart(continued)

Unit :10^4 US Dollars

No.	Year		Operation period																			Sum
		1,2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
9	Profit which can be distributed	0.00	16.89	[illegible]	[illegible]	21.81	27.66	31.23	33.73	36.92	40.25	43.73	47.34	51.08	54.98	59.03	62.82	62.82	62.82	62.82	62.82	62.82	886.11
10	Undistributed Profit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.25	62.82	62.82	62.82	62.82	62.82	62.82	387.17
11	Accumulative undistributed Profit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.25	73.07	135.89	198.71	261.53	324.35	387.17	
12	Profit after loan payback	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.25	62.82	62.82	62.82	62.82	62.82	62.82	387.17

Table 5

Profit and lost chart

Unit: 10^4 US Dollars

No.	Year	1.2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Sum
			Operation period																				
	Energy output to grid (10^4 kwh)	0.00	2,095.40	[illegible]	[illegible]	[illegible]	2,095.40	2,095.40	2,095.40	2,095.40	2,095.40	2,095.40	2,095.40	2,095.40	2,095.40	2,095.40	2,095.40	2,095.40	2,095.40	2,095.40	2,095.40	2,095.40	41,908.00
	Electricity price(US Dollars/kWh)	0.0000	0.0828	[illegible]	[illegible]	[illegible]	0.0828	0.0828	0.0828	0.0828	0.0828	0.0828	0.0828	0.0828	0.0828	0.0828	0.0828	0.0828	0.0828	0.0828	0.0828	0.0828	
1	Generation sale income	0.00	173.50	[illegible]	[illegible]	[illegible]	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	
2	Sale tax added	0.00	0.83	[illegible]	[illegible]	[illegible]	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	16.60
2.1	Additional fee of city construction and maintenance	0.00	0.52	[illegible]	[illegible]	[illegible]	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	10.40
2.2	Additional education fee	0.00	0.31	[illegible]	[illegible]	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	6.20
3	Total cost	0.00	143.85	[illegible]	[illegible]	[illegible]	124.93	119.73	114.28	108.65	102.80	96.72	90.39	83.82	76.97	69.86	63.18	63.18	63.18	63.18	63.18	63.18	1,915.10
4	Total profit	0.00	29.65	[illegible]	[illegible]	[illegible]	48.57	53.77	59.22	64.85	70.70	76.78	83.11	89.68	96.53	103.64	110.32	110.32	110.32	110.32	110.32	110.32	1,554.90
5	Income tax	0.00	9.78	[illegible]	[illegible]	[illegible]	16.03	17.74	19.54	21.40	23.33	25.34	27.42	29.59	31.85	34.20	36.41	36.41	36.41	36.41	36.41	36.41	513.11
6	Profit after income tax	0.00	19.87	[illegible]	[illegible]	[illegible]	32.54	36.03	39.68	43.45	47.37	51.44	55.69	60.09	64.68	69.44	73.91	73.91	73.91	73.91	73.91	73.91	1,041.79
7	Surplus accumulation fund	0.00	[illegible]	[illegible]	[illegible]	[illegible]	3.25	3.60	3.97	4.35	[illegible]	5.14	5.57	6.01	6.47	6.94	7.39	7.39	7.39	7.39	7.39	7.39	104.18
8	Commonweal fund	0.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.37	2.57	2.78	3.00	3.23	[illegible]	3.70	3.70	3.70	3.70	3.70	3.70	52.10

Table 6

Loan payback calculation

Unit: 10^4 US Dollars

No.	Year			Operation period														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
1	Accumulative loan																	
1.1	Accumulation of load principal & interest at the beginning of year	[illegible]	[illegible]	[illegible]	1 088.21	1 022.40	951.67	882.21	807.10	730.02	649.64	566.07	479.16	388.78	294.79	197.06	95.43	0
1.2	Loan this year	[illegible]	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
1.3	Interest this year	[illegible]	[illegible]	80.67	76.17	71.55	66.76	61.75	56.55	51.10	45.47	39.62	33.54	27.21	20.64	13.79	6.68	0
1.4	Principal payback this year	[illegible]	[illegible]	[illegible]	66.10	68.73	71.46	74.31	77.68	80.38	83.57	86.91	90.38	93.99	97.73	101.63	95.43	0
1.5	Interest payback this year	[illegible]	[illegible]	80.67	76.17	71.55	66.76	61.75	56.55	51.10	45.47	39.62	33.51	27.21	20.61	13.79	6.68	0
1.6	Accumulation of payback principal and interest this year	[illegible]	[illegible]	141.21	142.27	140.28	138.22	136.05	134.43	131.48	129.04	126.53	123.92	121.20	118.37	115.42	102.11	0
2	Source of payback																	
2.1	Profit	[illegible]	[illegible]	16.89	19.45	22.08	24.81	27.66	31.23	33.73	36.92	40.26	43.73	47.34	51.08	54.98	48.78	0
2.2	Depreciation	[illegible]	[illegible]	46.65	46.65	46.65	46.65	46.65	46.65	46.65	46.65	46.65	46.65	46.65	46.65	46.65	46.65	0
2.3	Interests expenditure included in operation cost	0.00	[illegible]	80.67	76.17	71.55	66.76	61.75	56.55	51.10	45.47	39.62	33.54	27.21	20.64	13.79	6.68	0
2.4	Others	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0

Table 7

Source and utilization of capital

Unit: 10^4 US Dollars

No.	Year		Operation period																			
		1,2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Sum
1	Source of capital	1 151.75	81.46	[illegible]	[illegible]	[illegible]	100.40	105.60	111.05	116.68	122.53	128.67	134.94	141.51	148.06	155.47	162.15	162.15	162.15	162.15	162.15	162.80	3,743
1.1	Profit	0.00	29.63	[illegible]	[illegible]	[illegible]	48.57	53.77	59.22	64.85	70.70	76.78	83.11	89.68	96.33	103.64	110.32	110.32	110.32	110.32	110.32	110.32	1,554
1.2	Depreciation	0.00	51.83	[illegible]	[illegible]	[illegible]	51.83	51.83	51.83	51.83	51.83	51.83	51.83	51.83	51.83	51.83	51.83	51.83	51.83	51.83	51.83	51.83	1,036
1.3	Lond-term loan	1 151.75	0.00	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.151
1.4	Floating capital return	0.00	0.00	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0
2	Utilization of capital	1 151.75	73.97	[illegible]	[illegible]	[illegible]	90.34	95.62	99.92	104.97	110.24	115.72	121.41	127.32	133.18	129.63	36.11	36.41	36.41	36.41	36.41	37.06	2,818
2.1	Fixed assets investment	1 040.00	0.00	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.040
2.2	Interest of construction period	111.75	0.00	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	111
2.3	Floating capital	0.00	0.65	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
2.4	Income tax	0.00	9.78	[illegible]	[illegible]	[illegible]	16.03	17.74	19.54	21.40	23.33	25.34	27.42	29.59	31.85	34.20	36.41	36.41	36.41	36.41	36.41	36.41	513
2.5	Payback principal of long-term loan	0.00	63.51	[illegible]	[illegible]	[illegible]	74.31	77.88	80.38	83.57	86.91	90.38	93.99	97.73	101.63	95.43	0.00	0.00	0.00	0.00	0.00	0.00	1,152
2.6	Payback principal of floating capital	0.00	0.00	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0
3	Surplus capital	0.00	7.49	8.61	[illegible]	[illegible]	10.06	9.98	11.13	11.71	12.29	12.89	13.53	14.19	14.88	25.84	125.74	125.74	125.74	125.74	125.74	125.74	925.
4	Accumulative surplus capital	0.00	7.49	15.10	[illegible]	[illegible]	44.80	54.78	65.91	77.62	89.91	102.80	116.33	130.52	145.40	171.24	296.98	422.72	548.46	674.20	799.94	925.68	

Table 8

Cash flow chart (total vestment)

Unit: 10^4 US Dollars

No.	Year			Operation period																				sum
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
1	Benefit current	0.00	0.00	173.50	[illegible]	[illegible]	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	177.55	3,474.05
1.1	Sales income	0.00	0.00	173.50	[illegible]	[illegible]	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	3,470.00
1.2	Residue value of Fixed assets	0.00	0.00	0.00	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.40	3.40
1.3	Floating capital return	0.00	0.00	0.00	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0.65
2	Cost current	520.00	520.00	22.61	[illegible]	[illegible]	[illegible]	28.21	29.92	31.72	33.58	35.51	37.52	39.60	41.77	44.03	46.38	48.59	48.59	48.59	48.59	48.59	48.59	1,797.36
2.1	Fixed assets investment	520.00	520.00	0.00	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,040.00
2.2	Floating capital	0.00	0.00	0.65	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.65
2.3	Operation cost	0.00	0.00	11.35	[illegible]	[illegible]	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	227.00
2.4	Sale tax added	0.00	0.00	0.83	[illegible]	[illegible]	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	16.60
2.5	Income tax	0.00	0.00	9.78	[illegible]	[illegible]	14.37	16.03	17.74	19.54	21.40	23.33	25.34	27.42	29.59	31.85	34.20	36.41	36.41	36.41	36.41	36.41	36.41	513.11
3	Net current after income tax	-520.00	-520.00	150.89	[illegible]	[illegible]	146.97	145.29	143.58	141.78	139.92	137.99	135.98	133.90	131.73	129.47	127.12	124.91	124.91	124.91	124.91	124.91	128.96	1,676.69
4	Accumulated net current after income tax	-520.00	-1,040.00	-889.11	[illegible]	[illegible]	[illegible]	-298.29	-154.71	-12.93	126.99	264.98	400.90	534.86	666.59	796.06	923.18	1,048.09	1,173.00	1,297.91	1,422.82	1,547.73	1,676.69	7,191.65

Table 8

Cash flow chart(total vestment) (continued)

Unit: 10^4 US Dollars

No.	Year																							sum
				Operation period																				
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
5	Net current before income tax	-520.00	-520.00	160.6[illegible]	[illegible]	[illegible]	161.32	161.32	161.32	161.12	161.32	161.32	161.32	161.32	161.32	161.32	161.32	161.32	161.32	161.32	161.32	161.32	165.37	2,189.
6	Accumulated net current before income tax	520.00	1 040.00	-879.3[illegible]	[illegible]	[illegible]	[illegible]	234.0[illegible]	-72.7[illegible]	88.5[illegible]	249.91	411.23	572.55	733.87	895.19	1,056.51	1 217.83	1,379.15	1,540.47	1,701.79	1,863.11	2,024.43	2,189.80	

No.	Calculation index	Before income tax	After income tax
7	FIRR	13.3%	11.35%
	FNPV (ic=10%)	232.58	86.88
	Investment return period	9	

Table 9 **_National economic benefit flow chart_**

Unit: 10^4 US Dollars

No.	Year																						
				Operation period																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	S
1	Benefit flow	0.00	0.00	173.50	[illegible]	[illegible]	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	3,
1.1	Generation benefit	0.00	0.00	173.50	[illegible]	[illegible]	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	173.50	3,
1.2	Floating capital return	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.65	
2	Cost flow	520.00	520.00	12.00	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	1.
2.1	Fixed assets investment	520.00	520.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,
2.2	Floating capital	0.00	0.00	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
2.3	Operation cost	0.00	0.00	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	11.35	2
3	Net benefit flow	-520.00	-520.00	161.50	162.15	162.15	162.15	162.15	162.15	162.15	162.15	162.15	162.15	162.15	162.15	162.15	162.15	162.15	162.15	162.15	162.15	162.15	162.15	2,2
4	Accumulative net benefit flow	-520.00	-1,040.00	-878.50	-716.35	-554.20	-392.05	-229.90	-67.75	94.40	256.55	418.70	580.85	743.00	905.15	1,067.30	1,229.45	1,391.60	1,553.75	1,715.90	1,878.05	2,040.20	2,202.35	4,4
5	Calculation index																							
	EIRR	13.44%																						
	ENPV (ic=12%)	86.25																						

Annex 7

Annex 7

PEREZ-GUERRERO TRUST FUND Project INT/98/k06/A/95/99

Consultation to Clavellinas Project in Guatemala

EVALUATION REPORT

Submitted by

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CLAVELLINAS PROJECT.

Introduction.

Guatemala is a rich nation in natural renewable resources, as forest and animals. It has microclimate diversities and large bodies of water. Because of topographic conditions of our country many of these reserves became in rivers of large discharge and head, in which can development small hydropower resource.

One of the most major factors that determine the development of the rural communities, is with out any doubt the possibility to obtain the electric energy. The implementation of small and micro hydropower can contribute to the development of the rural communities, fare from national grid.

The rural zones of Guatemala have strong similarities among them in relation with their grade of social economic development and their pattern of demand and use of the electricity. In this zones there is renewable energetic resources that in most of the case are plentiful and can conduct to sustainable scheme of developments.

In this way, the Energy and Mine Ministry of Guatemala throughout the Energy General Management, that carries out the program for Improvement and Development of the Small Hydropower Resources and the profile of the priority projects. This is the case of the project called "Clavellinas". Placed in the municipal of Nebaj, belong to Quiche's department.

With a potential that varies between 0,5 and 3 Megawatt, this place is considered a key project, if integral development of the communities in the neighborhood is desired and that is important recognize that were one of the most affected by recently and overcome internal conflict in Guatemala.

The implementation of the Small Hydropower will bring notable social benefits, but not only by the obviously important mean. That implies to supply electricity to the communities that before do not have it, but too by the mean of the implementation of a regional technologic development project for encourage the local and national industry.

Nebaj is 260 km to far from Guatemala City, The total area of extension is 608 km^2 and 1907 m of altitude over level sea. proximately 10 000 families resident in Nebaj and 5 000 families lack a electric serves.

Norconsut Enterprise carried out the feasibility study over the hydraulic power, and the data preliminary were as follows:

Estimated active power	kW	3500
Estimated production of electric power	GWh	15 ~ 19.5
Estimated cost power	USD/kWh	3.3 ~ 4.5
Estimated periodic damping rate	%	21.8~ 28.3
Estimated tumbler cost	USD	5105000.00

Estimated gross head is between 150 ~ 170 m according to the flow of Cataratas and Azul river, (Waterfall and Blue river), combined.

Nebaj is crosswise by the Cataratas river, the flow to the river go to north, in the first two kilometers in the rivers have a waterfall with approximately 40 or 50 m of head, the head continue increasing to the Azul

Elevation was took by altimeter, respect the level sea:

Place	UM	Elevation	Head respect to confluence : total = 187m
One km upstream of the waterfall	M	1770	30
High part of the waterfall	M	1740	157
Confluence the two rivers	M	1583	0

Norconsult Enterprise in 1995 and Management General of power in 1999 took approximately the following value in the Cataratas river:

	Average seep calculated (m/s)	Area of reference section (irregular) (m^2)	Superficial seep (%)	Estimated flow (m^3/s)
Norconslt Enterprise (summer)	0.8	2.3	80 ~ 90	1.5 ~ 1.7
Management General of Power (winter)	0.84	3.48	80 ~ 90	2.4 ~ 2.6

Catchment area in the Catarata river is 46 km^2, the Catchment area in the Azul river is approximately between 14 and 15 km^2. The approximate flow in the Azul river are between 0.5 ~0.6 m^3/s (summer) and between 0.8 ~ 0.9 m^3/s (winter).

Hydraulic Turbine Selection

Altenative:1

1) Basic data required for turbine selection

Ntotal =	3453.00	kW	Hr =	160 m
Q =	2.50	m^3/s		
Nomber of unid=	2			
N_r =	1726	kW		
Q_r =	1.25	m^3/s		

Basic data for power plant

River development scheme
Anual runoff flow and regulating characteristics
General layaut of the power plant
Realationship curve of upstream and downstream.
Water temperature and water quality

Diversion type:	Hd= (0.95 to 1.0) Hmean
Dam type:	Hd= (0.90 to 0.95) Hmean
River bed type:	Hd= (0.90) Hmean

Hydrological data series:		U/M
H_{mean}	160.0000	m
H_{max}	165.0000	m
H_{min}	155.0000	m
Q_{max}	2.5000	m^3/s
Q_{min}	0.4000	m^3/s
$\nabla_{discharge}$		m
H_2O temperat.		°C

Hd = 160 m

2) Basic data of power system.

Load characteristics including maximun and mean load curves
Typical dily load curves and funtion of the power plant in the power system

3) Basic data of turbines

Chart of turbine series
Asplication ranges of turbines
Combined characteristic curves
That can be fine in catalogues and technical parameter provaided by the manufacturer.

Tubine type:	XL100	
Name	**Values**	**U/M**
Q'_1	0.2250	m^3/s
n'_1	61.5000	rpm
Cavit. Coeff.		
$N_{turbine}$	1726.5000	kW
Tubine Efisc.	0.906	

Q_{red} =	1.2941242	m^3/s
Q'_1 =	0.2029548	m^3/s

HL
Francis

Runer diameter determination:

$$D_1 = \sqrt{N / 9.81 * \eta_t * Q'_1 * H_d^{1.5}}$$

D_1 = 0.6531... m

Runner diameter series of reaction turbines (cm):

25	30	35	42(40)	50	60	71	84(80)	100	120
140	160	180	200	225	250	275	300	330	380

$D_{1standard}$ = 0.7100 m

Speed calculation:

$$n = \frac{n'_1 * \sqrt{H}}{D_1}$$

n = 1095.6624 rpm

F = 60 Hz

Pole number: 6

$$n'_{1max} = \frac{n_{sinc} * D_1}{\sqrt{H_{max}}}$$

n'_{1min} = 66.32811 rpm

$n_{sincronic}$ = 1200.0 rpm

$$n'_{1max} = \frac{n_{sinc} * D_1}{\sqrt{H_{min}}}$$

n'_{1max} = 68.4342868 rpm

HL
Turbine model: XJ100-WJ-71

$$\eta = \eta_m + \Delta\eta$$

Turbine Effic = 0.876

Turbine aoutput

[illegible]

N_t = 1972.6603 kW
$N_{t\,real}$ = 1779.3814 kW

Turbine flow

[illegible]

Q = 1.4347 m^3/s
Q_{real} = 1.2941 m^3/s

Generator model: SFW-2000-?/1430

Generator output

$N_{gen} = N_t * \eta_{generator}$

Ngn = 1513.5 kW
Ngn real = 17?6 kW

Selection of turbine

Alternative No. 2

Data
Hmax = 165 m
Hrater = 160 m
Hmin = 155 m
Qmax = 2.5 m^3/s
Qmin = 0.4 m^3/s
N = 3453 kW

1.- Selection of the turbine type and number of units:

a) number of turbine n=3

b) preliminary selection of reaction turbine:

Pr = 3453 / 3 = 1185 kW

According to the design head (H= 160m) and unit output (N = 1726 kW) , use the chart of application range of small hydraulic turbine and it select preliminary turbine:

CJ22

2.- When:

Qmax = 2.5 m^3/S
Qr = 1.18 m^3/S
Qmin = 0.4 m^3/S
ηt = 0.82

Then

$$Q = P/(9.81\ H\ \eta t)$$

Q = 0.775 M^3/S

3.- Calculation of jet diameter.

$$do = 545\sqrt{Q/z\sqrt{Hr}}$$

.do=95.38 mm

Diameter standard : **do=110mm** do= 100

4.- Runner diameter.

D_1 = 8x do
D_1 =880mm

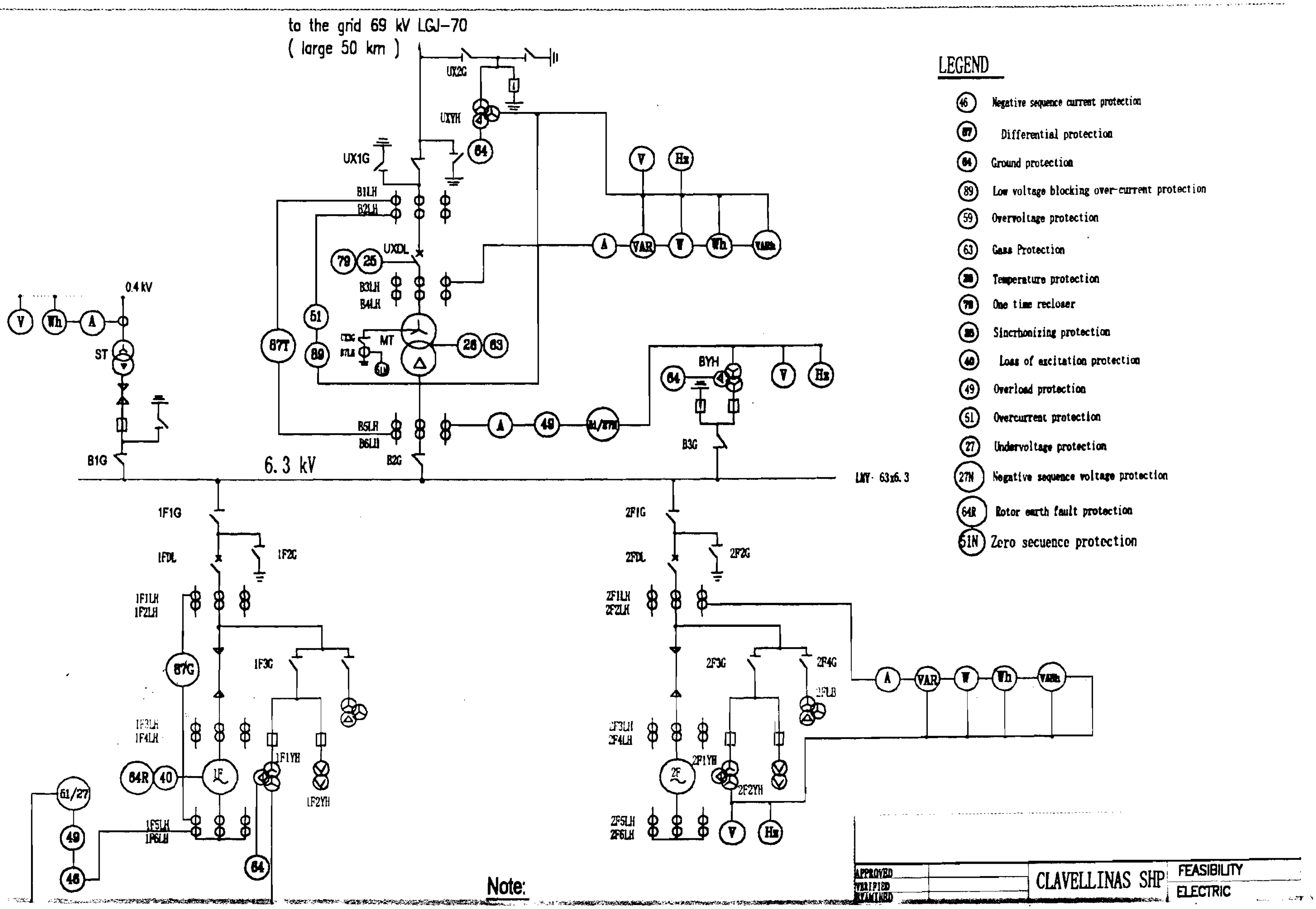
Standard D_1= 0.9 m

5.- Synchronous speed :

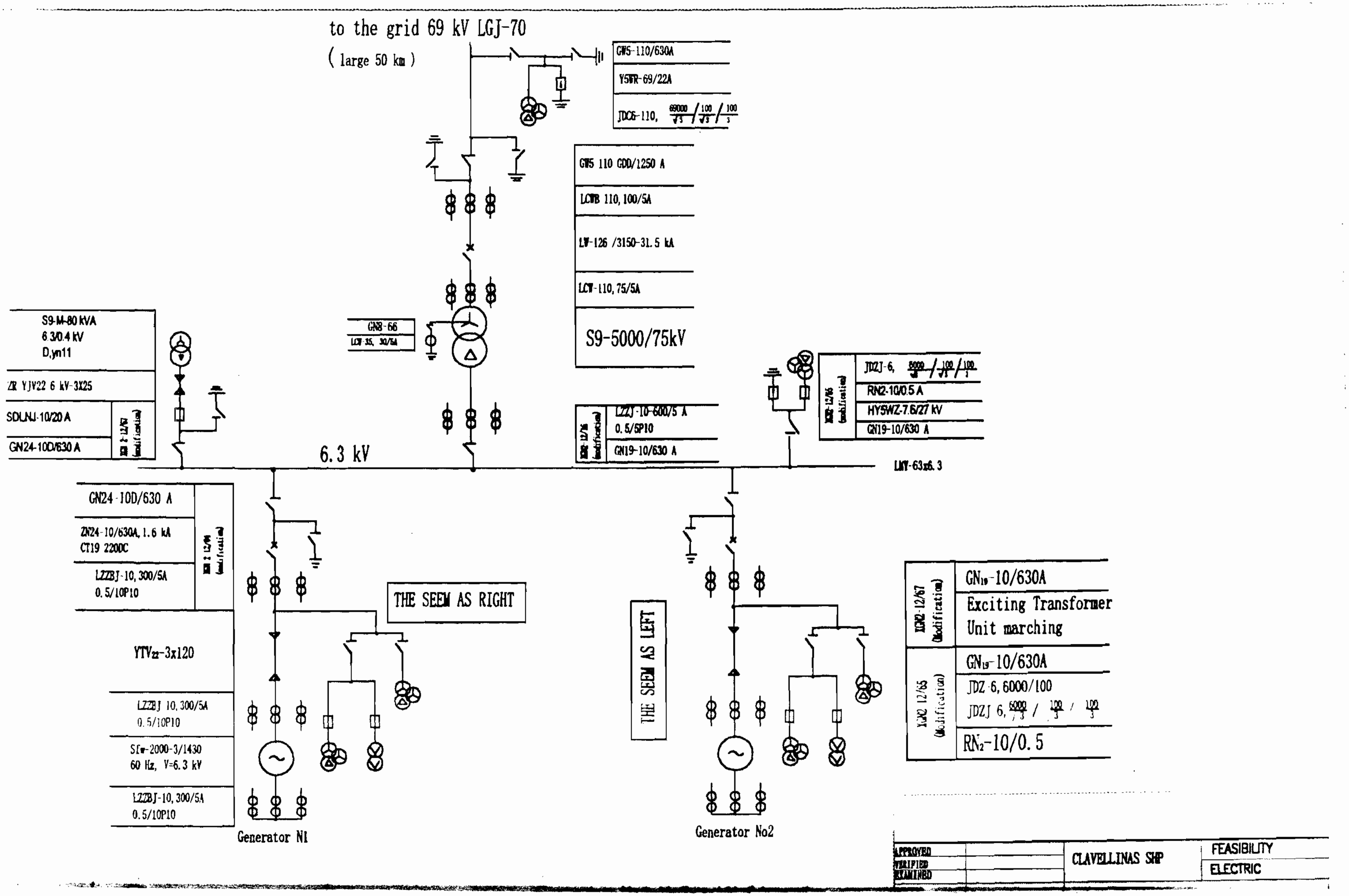
$$n = n_1 \frac{\sqrt{Hr}}{D_1}$$

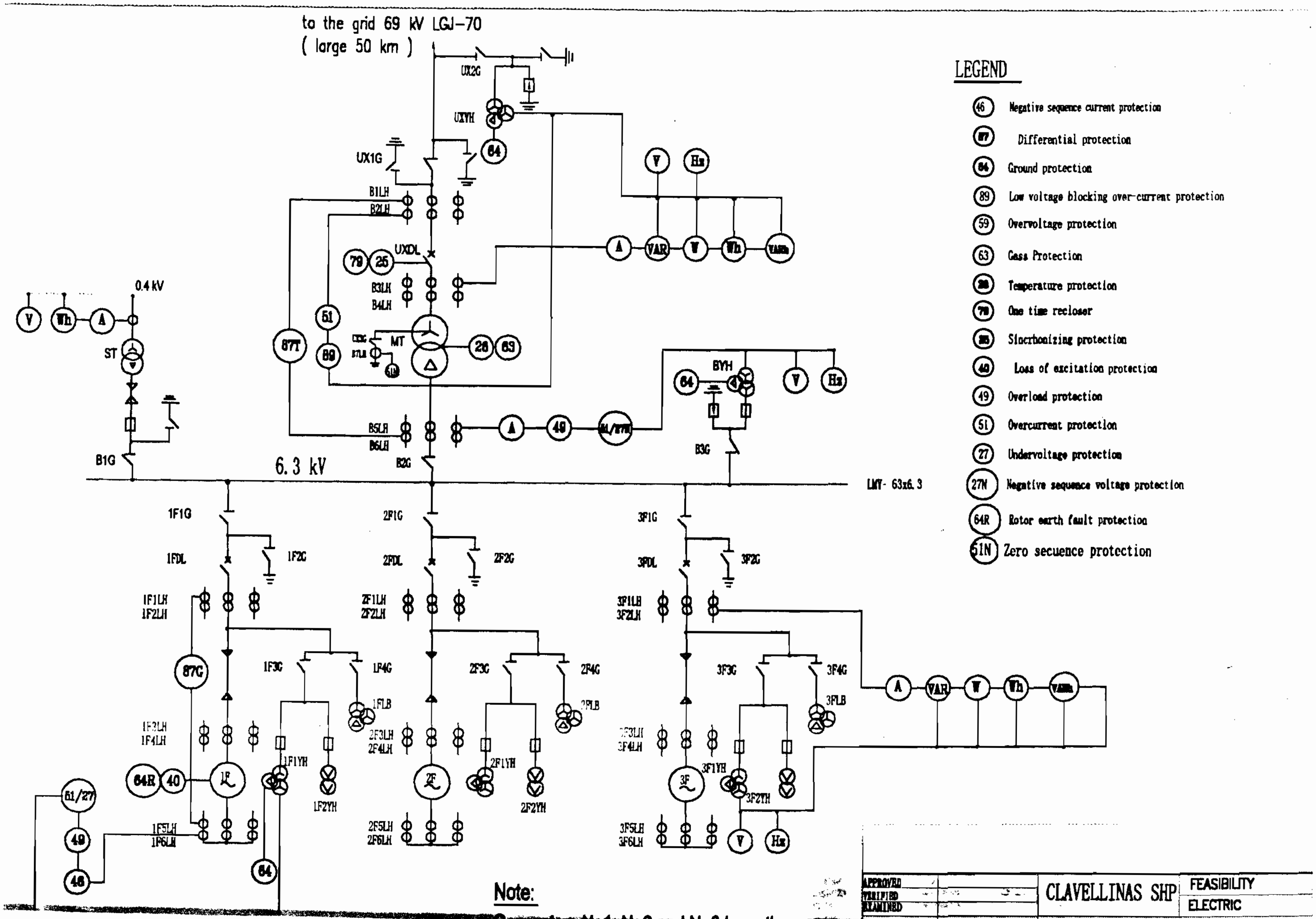
n = 562 rpm Then, p = 6 and n = 600 rpm
n_{1max} = 43.3 rpm $n_{1\,rat}$ = 42.6 rpm $n_{1\,min}$ = 42.0 rpm

Selection of turbine : CJ22-W-90/2x11
Selection of generator : SFW-1250-6/1730 V= 6.3 kV.

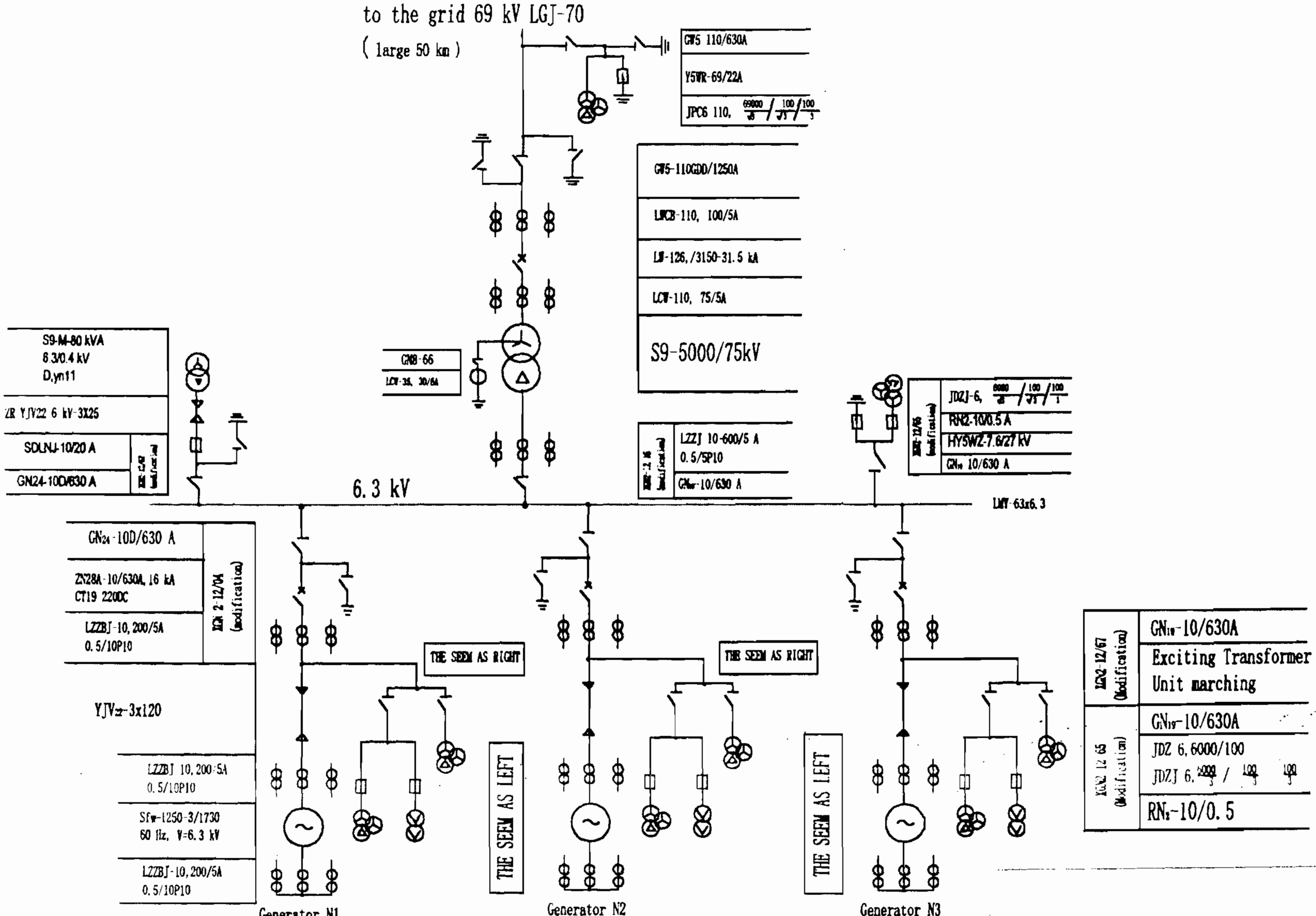


to the grid 69 kV LGJ-70
(large 50 km)
UX2G
UXYH
UX1G
64
V
Hz
B1LH
B2LH
UXDL
79
25
A
VAR
W
Wh
VARh
B3LH
B4LH
0.4 kV
V
Wh
A
ST
51
87T
89
MT
26
63
BYH
64
V
Hz
B5LH
B6LH
A
49
B1G
6.3 kV
B2G
B3G
LMY- 63x6.3
1F1G
1FDL
1F2G
1F1LH
1F2LH
87G
1F3G
1F3LH
1F4LH
64R
40
1F
1F1YH
1F2YH
51/27
49
46
1F5LH
1F6LH
64
2F1G
2FDL
2F2G
2F1LH
2F2LH
2F3G
2F4G
2FLB
A
VAR
W
Wh
VARh
2F3LH
2F4LH
2F
2F1YH
2F2YH
2F5LH
2F6LH
V
Hz
Note:
LEGEND
46 Negative sequence current protection
87 Differential protection
64 Ground protection
89 Low voltage blocking over-current protection
59 Overvoltage protection
63 Gass Protection
26 Temperature protection
79 One time recloser
25 Sincrhonizing protection
40 Loss of excitation protection
49 Overload protection
51 Overcurrent protection
27 Undervoltage protection
27N Negative sequence voltage protection
64R Rotor earth fault protection
51N Zero secuence protection
APPROVED
VERIFIED
EXAMINED
CLAVELLINAS SHP
FEASIBILITY
ELECTRIC


to the grid 69 kV LGJ-70
(large 50 km)
GW5-110/630A
Y5WR-69/22A
JDC6-110, 69000/√3 / 100/√3 / 100/3
GW5 110 GDD/1250 A
LCWB 110, 100/5A
LW-126 /3150-31.5 kA
LCW-110, 75/5A
S9-5000/75kV
GN8-66
LCW 35, 30/5A
S9-M-80 KVA
6.3/0.4 kV
D,yn11
ZR YJV22 6 kV-3X25
SDLNJ-10/20 A
GN24-10D/630 A
6.3 kV
LZZJ-10-600/5 A
0.5/5P10
GN19-10/630 A
JDZJ-6, 6000/√3 / 100/√3 / 100/3
RN2-10/0.5 A
HY5WZ-7.6/27 kV
GN19-10/630 A
LMY-63x6.3
GN24-10D/630 A
ZN24-10/630A, 1.6 kA
CT19 2200C
LZZBJ-10, 300/5A
0.5/10P10
YJV22-3x120
LZZBJ 10, 300/5A
0.5/10P10
SFW-2000-3/1430
60 Hz, V=6.3 kV
LZZBJ-10, 300/5A
0.5/10P10
Generator NI
THE SEEM AS RIGHT
THE SEEM AS LEFT
Generator No2
XGN2-12/67 (Modification)
GN19-10/630A
Exciting Transformer
Unit marching
XGN2 12/65 (Modification)
GN19-10/630A
JDZ 6, 6000/100
JDZJ 6, 6000/√3 / 100/3 / 100/3
RN2-10/0.5
APPROVED
VERIFIED
EXAMINED
CLAVELLINAS SHP
FEASIBILITY
ELECTRIC



to the grid 69 kV LGJ-70
(large 50 km)
0.4 kV
6.3 kV
LMY- 63x6.3
LEGEND
46 Negative sequence current protection
87 Differential protection
64 Ground protection
89 Low voltage blocking over-current protection
59 Overvoltage protection
63 Gass Protection
26 Temperature protection
79 One time recloser
25 Sincronizing protection
40 Loss of excitation protection
49 Overload protection
51 Overcurrent protection
27 Undervoltage protection
27N Negative sequence voltage protection
64R Rotor earth fault protection
51N Zero secuence protection
Note:
APPROVED
VERIFIED
EXAMINED
CLAVELLINAS SHP
FEASIBILITY
ELECTRIC



APPROVED		CLAVELLINAS SHP	FEASIBILITY
VERIFIED EXAMINED			ELECTRIC
CHECKED		SINGLE LINE DIAGRAM (Variant 3x1250-6.3kV)	
DESIGNED	Ramon Hidalgo Gonzalez		
DRAWN	Ramon Hidalgo Gonzalez		

Annex 8

Annex 8

PEREZ-GUERRERO TRUST FUND Project INT/98/k06/A/95/99

Proposal on Feasibility Study of Luckela and Chakata Falls Project Sites in Zambia

Submitted by

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PROPOSAL FOR UNDERTAKING A PRE-FEASIBILITY STUDY IN POTENTIAL SITES FOR DEVELOPMENT OF SMALL HYDRO-POWER STATIONS FOR ELECTRICITY GENERATION AND THEREAFTER ORGANISE A WORKSHOP OF VARIOUS STAKEHOLDERS

1. RATIONALE

Zambia is well endowed with hydro power resources. The main river catchment areas that have been developed are Zambezi and Kafue. On these rivers Zambia has developed the Kafue Gorge Hydro electric scheme (900MW), on the Zambezi River the Kariba North bank (600MW) and the Victoria power Stations (108 MW). The country has also developed mini-hydro power stations in north-eastern part viz.Lusivasi-12 MW, Musonda Falls-5MW, Chishimba falls-6MW and Lunzua 0.75 MW. The mini-hydro power stations serve the rural areas. The main power stations are interconnected into the main grid via a 330 and 220kV network. The total installed capacity of hydro-power is 1630 MW. There is untapped hydro-potential of about 6000MW.

Other rural areas particularly Mwinitung, Kabompo, Kasempa, Chizera and Zambezi of North Western Province, Kaputa of Northern province, and Luangwa of Lusaka/castern Province are supplied by diesel power stations. There is about 5 MW of diesel power stations for areas which are too far from the national grid to make interconnection economically viable. In addition, there are so many rural areas which have no electricity and far from the national grid.

2. OBJECTIVES OF THE PROPOSAL

One of the objectives of the proposal is to undertake a pre-feasibility study on exploiting potential sites as viable options for development of small hydro-power stations for electricity generation in isolated rural areas of Zambia. As part of the implementation strategy the second objective of the proposal is to convene a workshop aimed at:

I) Discussing the results of the pre-feasibility study aimed at development of substantive and viable mini-hydro power stations in Zambia

II) Exchanging information and experiences based on the need to promote and exploit micro and small hydro-power resources in Zambia based on the results of the pre-feasibility study and available appropriate micro and small hydro-technology.

III) Exploring the possibility of financial consideration on the utilization of Chinese aid/loan and export credit and other sources from other financial institutions for the implementation of identified feasible micro and small hydro power stations projects for electricity generation.

The workshop will be held for various stakeholders, which will include Ministry of Energy and Water Development, Ministry of Finance and Economic Development, Financial Institutions, Members of Parliament and District Councils of the identified sites, Zambia Electricity Supply Corporation (ZESCO), and private business people and other interested investors. The workshop will also be attended by UNIDO and a Chinese Delegation comprising of IN-SHP staff and senior officials from the Ministries of Water Resources and Foreign Trade and Economic Co-operation and Mangers of major hydraulic equipment manufacturers.

The duration of the workshop will be three days, whilst the pre-feasibility study will be undertaken in two months.

3. EXECUTING AGENCIES

The pre-feasibility study and organization of the workshop will be jointly undertaken by the International Network on Small Hydro-Power, known as IN-SHP and Centre for Energy, Environment and Engineering (Z) Ltd, known as CEEEZ.

IN-SHP is an international organization, founded in line with the spirit of TCDC/ECDC (Technical and Economic Co-operation among Developing Countries, and aims at the promotion of world-wide technical and economic co-operation in small hydro power (SHP) field through its consideration among developing countries, developed countries and international organizations, with developing countries as the basis.

CEEEZ is a non profit making organization whose mandate is to undertake studies, research consultancy and training in the area of energy, environment and engineering including science and technology for sustainable development, it also acts as a catalyst in socio-economic development in the areas of energy, environment and engineering applications.

The pre-feasibility study will jointly be undertaken by a two engineer delegation to work jointly with Zambian Counterparts comprising of a Project Manager and a Mechanical engineer, civil Engineer Hydrologist, Electrical Engineer and Economist. This arrangement will ensure that there is sustainable transfer of know-how to the Zambian counterparts as part of capacity building in the area of development of small scale hydro power stations. The Chinese delegation will visit Zambia for a period of at least 3 weeks.

The workshop on the other hand will be organized by the CEEEZ with an input from IN-SHP on the content of the programme and other logistics.

4. IDENTIFACTION POTENTIAL SITES

Four potential sites are to be considered in the pre-feasibility study. Two sites namely Luckela project for Mwinilunga and Chakata falls projet, Kabompo/Manyinga in North Western Province have already been identified and previous work in the form of preliminary investigations undertaken but without leading to any development, currently Mwinilunga and Kabompo are supplied with diesel power stations both with installed capacities of 750kW.

The Luckela mini-hydro site has a natural fall of 13 metres located down stream of the Mwinilunga?Ikelenge road bridge. The topography is ideal for construction of a headrace canal on the right bank. From there a 40 m long penstock can be constructed in easy terrain to the power station and rail race. A net head of 15m can be obtained with a 4 metre high dam and reservoir storage. The mean annual flow has been read at $8.5m^3/s$ and the guaranteed flow with 95% excedence is $1.0m^3/s$ from published data, but may be as high as $2.0m^3/s$ in reality.

The Chakata falls in Kabompo utilizes a natural fall of 1.2metre on the Kabompo river some 3Km upstream of Kabompo Boom. A recorded flow corresponding to $40m^3/s$ with a reliability of over 99% is available in the records.

Information on the head and topography of the other new sites for investigation namely Kaputa and Luangwa in Northern and Lusaka Provinces respectively is currently not available and will constitute part of the scope of work to be undertaken in this pre-feasibility study.

5. SCOPE OF WORK

5.11DATA COLLECTION AND GENERATION-to be undertaken by CEEEZ prior to the visit of the Chinese delegation.

I) Status of electricity supply and demand in Zambia

II) Identification of potential sites for small hydro power development and current supply and demand situation.

III) Load demand and projections around identified sites and circuits taking account of their economic and development status present and future.

IV) Electricity tariffs
V) Hydrology of identified sites.

5.2 TECHNOLOGY DESCRIPTION AND AVAILABILITY-To be undertaken by IN-SHP prior to visit to Zambia.

I) state of art of technology for micro and small hydro power electricity generation
II) Technology availability and characteristics
III) Cost of available technology and associated equipment
IV) Operation and maintenance costs of available technologies

5.3 HYDROLOGY AND SITE SURVEY-To be undertaken both by IN-SHP and CEEEZ during the 3 weeks visit of Chinese Engineers to Zambia

I) Examination and confirmation of existing hydrological data (Head, Flow, rainfall, design flood floor etc.)
II) Estimate hydrological data where there are unavailable by using rainfall statistics and run off assumptions.

5.4 SYSTEMS DESGN

I) Systems Layout and design of hydro scheme of identified sites to include weir and intake, spill ways, channels, materials, penstocks sizing and costing.
II) Choice of installed capacity and energy
III) Choice of generation turbine and associated equipment which include governor, drive system etc.
IV) Selection of generator, switchgear and transmission lines
V) Cost of all identified equipment
VI) Cost of maintenance of all identified equipment

5.5 FINANCIAL AND ECONOMIC EVALUATION-To be undertaken by CEEEZ and IN-SHP

I) Projected profit and loss statement based on unit plant factor and energy cost.
II) Projected Balance Sheer
III) Cash Flow Statement
IV) Indicators-NPV, Internal rate of return, simple and discounted payback period
V) Economic evaluation

6 PROPOSED BUDGET

6.1 Pre-feasibility Study

a)	Project Manager/Mechanical Engineer 45 man days	6,750.00
II)	Civil Engineer/Hydrologist 30 man days	4,200.00
III)	Electrical Engineer 30 man days	4,200.00
IV)	Economist 30 man days	4,200.00
b)	Saily Subsistence allowance: For 14 days to visit North-western, Northern and Lusaka Provinces 4 persons	6,720.00
c)	15% overheads	2,500.00
	Grand Total	36,306.00

6.2 Organisation and Management of Workshop

a)	Sponsored participants	7,200.00
b)	Workshop 20 total man days	3,000.00
c)	Report writing and communication	2,000.00
d)	Transport to conference site	1,000.00
	Sub Total	13,200.00
e)	Overheads 15%	1,980.00
	Grand Total	15,180.00

Annex 9

Annex 9

PEREZ-GUERRERO TRUST FUND Project INT/98/k06/A/95/99

Consultation for SHP Projects in Venezuela

EVALUATION REPORT

Submitted by

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The several waterfall steps are appeard in the point 8km away of upper Uaiparu river , the total height of waterfall is about 80m. The dam site can be selected in the upper stream of first waterfall where river width is about 15m , the catachment area forward to this point is around 42km ^{2} with a total amount of water of 75.6 million m^3 . The division channel of 500m with 1/1000 slope from dam site can be placed along the left river bank.

Regarding the population is about 1200 in this region, the installed capacity can be determined as 500 kW for recent years, the min. discharge is 1m^3/s in dry season. Meanwhile the waterfall can be sightseed as usual. But for the development in the furture, the intalled capacity can be determined as 1000kW . The cost for both alternative is shown as below.

Installed Capacity(kW)	unit No.	Civil work (m3)	Civil cost(US$)	Equipment cost(US$)	Total cost(US$)
500	1	1643	1,060,000	190,000	1,250,000
1000	2		1,670,000	375,000	2,045,000

The equipment include turbine, generator, governor , cubicle and some wire in the powerhouse, which price is based on the FOB Shanghai China.

1.1.3 Portugues waterfall

This points is located in upper stream of Uaiparu river 15km away from the Icabaru town. The height of waterfall is about 32m countering from El. 518m to El. 486m. The catachment area is 904km^2, the mean discharge yearly is 51.6m^3/s and 25 m^3/s in dry season respectively. The installed capacity will reached to 11,000-15,000kW , Since the customer is few and plant will be operated in isloated system. So the installed capacity of 12,000kW is suitable for this waterfall .

The dam can be put on the upper waterfall 5m away with length of 50m. The four penstocks with 520m length can be laid on the left bank . the cost for civil work is about US$8 ,370,000 , the cost of road is about US$1,470,000.

There are two problems for developping this river. First, Since the catachment area of upper Caroni river is about 30,000km^2, there may be a general plan for this river in the State. The second, this is a little large scale power station with higher cost. The demand of electricity for this region has not reached so level yet for recent years . So this is a point to be exploited later.

1.1.4 Playa Blance waterfall

This point is located the down stream of Uaiparu river near to a indian village. The height of waterfall and a abrupt slope is about 12m in the rang of 500m, the catachment area is over 1000km^2 with mean discharge yearly 57m^3/s and 25 m^3/s in dry season respectively. So the way of division without dam can be adopted which can be placed along the left bank

1. Brief condition

1.1 6 points in State of Bolivar

1.1.1 Cuyuni river

This point is located in the downstream of junction of Ven amo river and Cuyuni river , which flows from Guyana mountain zone to the sea, where there is a indian village named San Martin de Turmban with 1000 people. Since the river is in the plan zone, so the slope is only a litte bit. Normally it is not a good position to expoite the small hydro with small head and wider river surface, but this is only one river to be expolited , so the way of diversion without dam will be taken and the intake and channel will be located in the left bank. The powerhouse will be located at the place near the village 5km away from the intake.

The catachment of Cuyuni river is about 17.5 Kkm^2, the amount of water is round 3.15×10^{10} m^3 refering to the runoff feature of Guri power station, so the mean discharge yearly is 1000m^3/s and the 450 m^3/s at dry season. The allowance discharge to be taken is about 45 m^3/s.

The water head is around 3.5 m based on the channel length of 5km with 1/3000 slope. The installed capacity would be 640kW according to the demend of that village . The design discharge would be 24 m^3/s.

The advantage of this point is having good trafic condition and supply the electricity nearly, the transsmion line is short. The main problem is that the civil work is hard ,specially for channel excavitation is around 215km^3, even if the earth on the hill is sand loam structure with ease excavation. The cost for civil work can be estimated as follows based on the Lati Amertia contry:

Channel excavitation :	2.15 million US$
Lining for channel:	2.35 million US$
Cost of channel:	6.30 million US$
Civil work:	8.19 million US$

For this kind capacity and head , 2 sets Kaplan turbine are selected. The total cost for mechnical and electric equipment includeing turbines, generators, governors and cubicles is about US$ 1,047,000 FOB basis Shanhai China.

1.1.2 Pauji waterfall

This point is located in a little brench of Uaipru river at elevation of 1100m with length of 24km and catachment area of 60km^2, south-east of Bolivar State.

Beacuse this point is only 12km away from Icabaru town with 3000 population demending electricity of 1000kW(DG with total capacity of over 500kW can work as a stand-by ones.), the approach bank in front of intake should be used and channel will be placed in the left bank with discharge 12 m^3/s.

There are two alternatives scheme to develop this point for both purposes, one is to supply the electricity to a litte village near the point having population of 100, second is for the Icabaru town. Now the some features paraments of two schemes can be compared as followwing table.

	For a village	For Icabaru town and a village
Installation capacity(kW)	100	1000
Water head (m)	12	12
Discharge(m^3/s)	1.1	12
Unit No.	1	2
Unit output	100	500
Cost of civil work (US$)	377,300	2,522,000
Cost of equipment(US$ FOB basis)	6,000	466,500
Transmission line	0	600,000

1.1.5 Icabaru river

This point is located on the upper stream of Icabaru river 3km away. The catachment area is about 625km^2 with mean discharge yearly of 35.7 m^3/s and 9.6 in dry season. The water head is about 5 m. The dam with height of 5 m and length of 60-70m will be constructed. Th channel with 1km lengh will be placed in right bank.

According to the electricity demend of Icabaru town, the 800 kW of installed capacity is suitable. The cost of civil work is about US$5,040,000 and the cost of equipment is about US$850,000.

This point is not economic . So the best point to be exploited for Icabaru town is the Playa Blance waterfall.

1.1.6 Carpupa

This point is located on a litte stream around 50km away from the Bolivar city. The river in the bend place is about 1/200 slope having a head of 3m . The dam with height of 4m and 15m length can be put and discharge of 1 m^3/s can be obtained.

The installed capacity of 20 kW will be estimated to supply electricity for a litte village.

The cost of civil work is about US$92,000 . The cost of mechnical and electrical equipment is about US$10,000.

1.2 In State of Surce

1.2.1 Puerto Viejo

This point is located 1km away from the Carbin Sea. The catachment area is about with mean discharge yearly $0.13m^2/s$. The discharge of $0.2m^3/s$ is visualized during the rainy season.

The dam with height of 4m and width of 25m can be constructed to form a forebay and penstock with 600m length and 10cm diameter can be placed. The installed capacity is determined as 35kW. The civil work costs about US$410,000, and the cost of mechincal and electric equipment is about 20,000 TOB, Shanghai, China, the cost for transmission line is about 40,000 US$.

1.2.2.Isabel River
This point is located on the branch of Isabel river which is a larger river in this zone 9.5km away from the Carbin Sea beach. Catachment area of Isabel river is about 12 km^2 that the branch on the bank is about $8km^2$.

The dam with leight of 4m and 15width can be constructed in front of first step. The penstock with dia. Of 40 cm and 400m length will be placed along the left and the design discharge is $0.2m^3/s$, and the installed capacity is 125kW at head of 90m.

There, civil work is about US$430,000 exception of road and the cost of mechanical and electric equipment is about 41,000 FOB, basis China, the construction is about 95,000US4.

2.Conclusion and suggestion
2.1 Conclusion

The best points in the State of Bolivar are Pauji waterfall and Plays Blance waterfall through our perambulation. The best points in the State of Sucre are Isabel and Tacarigua.

2.2 Suggestion

It is in the moment of perambulation drawings as usual procudue. We are very interested in developing the small hydro for Venezuela. The suggestion for next step is to cooperatively explore the above points.

2.3 To sign the cooperation agreement at this stage for further work.

2.4 All mechanical and electrical equipment made in China can be adopted since which are in lower price and high quality, as well as series products.

Annex 10

Annex 10

PEREZ-GUERRERO TRUST FUND Project INT/98/k06/A/95/99

Consultation for Chelti River SHP Projects in Georgia

EVALUATION REPORT

Submitted by

International Network on Small Hydro Power

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Consultation Report of Georgia Chelti river's Small Hydro Power

According to 1999 IN-SHP WORK PLAN, a consultation team of two experts who were sponsored by G77 partly, were dispatched to Georgia to consult for the local site of small hydro power from Nov.17th 1999 to Nov.25 1999. Arranged by the Ministry Of Fuel and Energy Of Georgia, the team investigated the Chelti river's fall and gave the local people the technical consultation. Now the details as follows:

1. SITUATION – ACCESS

- CHELTI river is a Tributary on the left side of ALANZANI river in the district of KVARELI in the province of KAKHETI.

It takes its rise under two summits of the Caucase mountains: CHELTI (3063.30 m) and NIKITA CASTLE (3116.60 m).

The river is 28 km long between its spring and ALANZANI river.

Its total drop is 2030 meters, so the average gradient is 7.25%.

Its catchment area is 144 km^2, around 5 or 6 km wide and its average level is 1420 m.

- Access to Shilda, a big village near the confluence of CHELTI and ALANZANI

rivers, is by the network of bituminized roads. The journey from Tbilissi(capital) to Shilda needs around 2h 30'.

Afterwards, a track goes upstream. First, it follows the bed of the river, very wide in its lower path, then an elevated terrace on the left side of the river.

2. NATURAL SITE CONDITIONS

During a journey on the site in February, we have obtained some information on the natural site conditions.

2.1 Topography

To study this project, we received a map to the scale of 1/25000 established the 4th of April 1966.

This map has been scanned in order to draw up the plan view of a zone 50 meters wide on both sides of the river.

The average gradient of the river during its 15 lowest kilometers is:

Level	Average gradient
1300 to 1350m	11.1%
1250 to 1300m	10.0%
1200 to 1250m	7.7%
1150 to 1200m	6.25%
1100 to 1150m	7.1%
1050 to 1100m	9.1%
1000 to 1050m	10.0%
900 to 1000m	8.3%
850 to 900m	5.6%
800 to 850m	5.9%
750 to 800m	6.25%
700 to 750m	5.6%
650 to 700m	3.6%
600 to 650m	3.8%
584 to 600m	5.3%
534 to 584m	2.8%
484 to 534m	3.1%

The total drop is 816m, on a length of 15175m,so the average gradient of the river is 5.38%.

2.2 Geology

The Chelti valley takes place on the south side of Caucase mountain in clayey schist from the high and medium Jurassic.
There is an alternation of strata, 0.1m to 20m thick, with sandstone and diabase.
The dip of these strata is between 30° and 60° .

The valley crosses them nearly perpendicularly.

Although there are locally some small size debris cones, there is neither important land-slide nor considerable fault.

2.3 Hydrology

2.3.1 Annual discharge distribution

Discharges have been recorded between 1941 and 1950, in order to know approximately the average monthly discharge during this period.

Average monthly discharge (m^3/s)	Jan	Feb	Mar	April	May	June	July	Aug	Sep
1981					5.54	3.98	2.09	1.72	I.65
1942	1.30	1.32	I.63	4.06	5.01	5.94	3.62	2.77	3.59
1944	1.62	1.70	2.13	2.25	4.48	6.63	6.38	4.43	3.49
1946	1.18	1.16	1.42	2.40	11.40	5.83	3.24	1.07	1.06
1947	1.48	1.58	1.86	2.49	3.27	2.38	1.85	1.69	1.76
Average	I.395	I.440	1.760	2.800	5.940	4.952	3.436	2.376	2.316
Deviation	0.194	0.245	0.305	0.846	3.166	1.741	1.807	1.299	1.150

The average discharge at the record station is around $2.8m^3/s$.

The driest month is January, but average discharge in December, February, and March are not much higher.

The discharge is maximum during May and June (melting of snow).

2.3.2difference in the discharge with the level

the following table indicates the minimum discharge insured 75%and 97% of the time, at three points of the river.

1220	Record station	Shilda
1.25 m^3/s	1.80 m^3/s	2.28 m^3/s
0.85 m^3/s	1.23 m^3/s	I.56 m^3/s
32.5 km^2	50.0 km^2	72.2 km^2

The minimum discharge in Shilda is approximately 1.8 times the one at the top of
catchment area, although the ratio between areas of catchment is about 2.22.

The ratio between minimum discharges at the record station and in Shilda is 0.79 although the ratio between areas of catchment area is 0.69.

The ratio between minimum discharges at the record station and at the top of the catchment although the ratio between areas of catchment area is I .54.

2.3.3 Floods

The floods peak discharges are given by the following table, depending on the return period of floods.

Level	1220(m^3/s)	Record station(m^3/s)	Shilda(m^3/s)
Return period of the floods			
10years	95.2	118	141
20years	112	139	166
50years	151	188	224
100years	179	222	266

The ratio between the maximum discharges in Shilda and at the top of the catchment area is 1.48,although the ratio between the areas is 2.22.

The ratio between the maximum discharges at the record station and at the top of the catchment area is 1.24.

2.3.4 Average daily discharges

we find that .

- An important regularity of the flow in January:
  average: 1.649m^3/s,deviation0.082m3/s.
- Important variations in June: Maximum: 18.3m^3/s
  Minimum: 3.23m^3/s
  Average: 7.528m^3/s
  Deviation: 4.010m^3/s

3.DESCRIPTION OF THE PROJECT

The project consists of the realization of three or four hydroelectric powerhouses, with a total installed power of I 3 MW and an average annual generation of 90 millions of kWh

Some general documents are attached to this note:

- A plan view to the scale of I/50000.
- A longitudinal profile of the river to the scales of 1/50000 (horizontal) and 1/10000 (vertical).
- A surface relief of the whole place,

3.1.The lower part: SHILDA

The following pieces about this part of the falls are annexed to this note:

- A plan view of the lower part to the scale of 1/15000,
- A longitudinal profile to the scales of 1/15000 (horizontal) and 1/1500 (vertical)
- Some cross sections every 200 metres to the scale of 1/500,

- A schematic plan of the water intake and of the overfall (2 sheets).

3. I. 1. The penstock

3. 1.1.1 .Description

- The project forecasts a water intake at the level 699 m and a[restitution at 559 m. The fall is 140 metres high and the diverted discharge is 3.5 m^3/s. The diversion is about 4200 metres long and it is totally underground.

- The penstock is made of galvanized steel.

- The dimensions of the penstock are :
  during the first third(1400 metres) : diameter 1.50 m, thickness 10 mm,
  during the second third (1400 metres) : diameter 1.45 m, thickness 12 mm,
  during the third third (1400 metres) : diameter 1.40 m, thickness 14 mm.

- An expansion joint is designed about every 500 metres (if the penstock is underground, otherwise the spacing is about 100 metres). Seven manholes are put as shown on the longitudinal profile. And a support is placed every 12 metres.

- As shown on the plan view and the longitudinal profile, there are about 13 bends to
  angle lower than 45° .

3.1. I .2.Checking of the dimensions

- Thickness :

When there is an internal pressure, the stress in the steel is given by $\sigma = PR/e$.

At the bottom of the penstock the normal pressure is 1.4Mpa (140 metres of water). The checking must be done in case of water hammer : the over-pressure due to the water

hammer is : $\Delta h = cUo/g = 220m = 2.2$ MPa. (C~1000m/s, Uo=2.12m/s).

So P = 3.6 Mpa and $\sigma = 186$ Mpa < 235 Mpa = σ_e.

3.1.1.3.Head Losses

- Linear Head Losses :

The calculation of the linear head losses is made with Strickler's method .

The following table shows that linear head losses in the pipe, 4200 meters long, are about
7.5 meters

- Singular Head Losses:

They are due to all the singularities in the pipe: water intake, bends, compensators, narrowings, manholes, connections before the power house......
So, total head losses in the pipe are about 9.5 meters. Thus, the net head is about 130 meters.

3.1.2 Estimation of the average annual generation of the power station

The hypothesis of the calculation are:

- Net head:130m
- Efficiency of the turbine unit:82%(Francis turbine)
- Unit power:3.66MW(3 unit s of 1220 KW),with a rated discharge of 3.5 m^3/s.
- Discharge of the river at the water intake: recorded discharge(paragragh2.3.1) multiplied by the coefficient 1.266(paragraph 2.3.2)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total /Average
Discharges (m^3/s)	1.769	1.826	2.232	3.551	7.533	6.281	4.358	3.013	2.917	3.049	3.214	2.197	3.497
Available Power (MW)	1.850	1.909	2.334	3.660	3.660	3.660	3.660	3.151	3.071	3.188	3.361	2.297	2.984
Average annual Generation (10^6 kWh)	1.376	1.283	1.737	2.635	2.723	2.635	2.723	2.344	2.211	2.372	2.420	1.709	26.169

3.2The central part: CHELTI 2-3

The following pieces about this part of the falls are annexed to this note:

- A plan view of the lower part to the scale of 1/15000,
- A longitudinal profile to the scales of 1/15000 (horizontal) and 1/1500 (vertical),
- Some cross sections every 500 meters to the scale of 1/500,

3.2.1. The penstock

3. 2.1.1 .Description

In this note, we will consider the case of one single fall about 300 meters high.

The project forecasts a water intake at the level 1000m and a restitution at 700 m. The fall is 300 meters high and the diverted discharge is 3 m^3/s. The diversion is about 4500 meters long and it is totally underground.

- The penstock is made of galvanized steel.

- The dimensions of the penstock are :
  during the first quarter(1175 metres) : diameter 1.20 m, thickness 10 mm,
  during the second quarter (1175 metres): diameter 1.20 m, thickness 12 mm,
  during the third quarter(1175 metres) : diameter 1.20 m, thickness 14 mm.
  during the fourth quarter(1175 metres) : diameter 1.20 m, thickness 16 mm.

As shown on the longitudinal profile, there are around 8 compensators, 8 manholes, 14 bends, and a support every 12 meter.

3.2.1.2 Head Losses

- Linear Head Losses (m)15.76
- Singular Head Losses(m)2.44
- So, total head losses in the pipe are about 18 meters. Thus, the net head is about 280 meters.

3.2.2 Estimation of the average annual generation

the hypothesis of the calculation are:

- Net head:280m
- Efficiency of the turbine unit:85%(Pelton turbine)
- Unit power: 6.99MW(3 unit s of 2330 kw),with a rated discharge of 3 M^3/s.
- Discharge of the river at the water intake: recorded discharge(paragragh2.3.1)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total /Average
Discharges (m3/s)	1.395	1.44	1.76	2.80	5.94	4.952	3.436	2.376	2.316	2.404	2.534	1.732	2.757
Average Power (MW)	3.250	3.35	4.10	6.52	6.99	6.990	6.990	5.536	5.396	5.601	5.904	4.036	5.389
Average annual generation (10^6kwh)	2.418	2.25	3.05	4.69	5.20	5.033	5.201	4.119	3.885	4.167	4.251	3.002	47.28

3.3. The higher part:CHELTI1

3.3.1. The penstock

3. 3.1.1 .Description

- The project forecasts a water intake at the level 1170m and a restitution at 1010 m. The fall is 160 meters high and the diverted discharge is 2 m^3/s. The diversion is about 2000 meters long and it is totally underground.

- The penstock is made of galvanized steel.

- The dimensions of the penstock are :
  during the first third(667 metres) : diameter 1.05 m, thickness 10 mm,
  during the second third (667 metres): diameter 1.05 m, thickness 12 mm,
  during the third third (667metres) : diameter 1.05 m, thickness 14 mm.

We can forecast around 4 compensators, 3 manholes, 7 bends, and a support every 12 meters.

3.3.1.2 Head Losses

- Linear Head Losses (m)6.35
- Singular Head Losses(m)1.27
- So, total head losses in the pipe are about 7.5 meters. Thus, the net head is about 150 meters.

3.3.2 Estimation of the average annual generation of the power station

The hypothesis of the calculation are:

- Net head:150m
- Efficiency of the turbine unit:82%(Francis turbine)
- Unit power :2.4MW(2 unit s of 1220kw),with a rated discharge of 2 M3/s.
- Discharge of the river at the water intake: recorded discharge (paragragh2.3.1), divided by the coefficient 1.44

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total / Average
Discharges (m3/s)	0.97	1.00	1.22	1.94	4.12	3.440	2.390	1.650	1.610	1.670	1.760	1.200	1.915
Average Power (MW)	1.16	1.20	1.46	2.32	2.40	2.400	2.400	1.980	1.932	2.004	2.112	1.440	1.902
Average annual generation (106kwh)	0.86	0.80	1.08	1.67	1.78	1.728	1.786	1.473	1.391	1.491	1.521	1.071	16.68

4.CONCLUSION

as a result , the project of Chelti river's falls includes:

- A total installed power of:

Lower part: 3.66 MW
Central part: 6.99MW
Higher part: 2.40MW
Total 13.05MW

Annex 11

Annex 11

PEREZ-GUERRERO TRUST FUND Project INT/98/k06/A/95/99

Consultation Mission for SHP Local Grid Planning and Development in Kirghizstan

EVALUATION REPORT

Submitted by

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Project Report for SHP Projects in Kirghizstan

1. Project Introduction

With the prosperous development of China's small hydropower causes as well as more and more importance that international society attached to the benefits brought by small hydropower in fields like economy, environmental protection, poverty alleviation, a delegation of Kirghizstan Republic headed by Mr. President Secretary visited China to undertake an investigation on China's small hydropower development and prepared to promote the economic cooepration and technical exchanges between the two countries. Arranged by Ministry of Water Resources, Prof. Tong Jiandong, Director of HIC/IN-SHP heads a delegation to Nanjing and meets with the Kirghizstan delegation. During the meeting, the Kirghizstan delegation showed a great interest in Chinese experiences in small hydropower. After the friendly discussion, two parties have reached an initial agreement in fields of economic cooperation and technical exchanges within small hydropower. It has been agreed that both parties will send their own expert teams to visit, investigate and work together on some small hydro projects.

Since then, we make positive contacts with Ministry of Agriculture and Water Resources in Kirghizstan and further exchange ideas on mutual cooperation and reach a cooperative framework:

1. Kirghizstan shall select 3-5 stations and provide us with related technical materials for HIC's analysis and study;
2. We will invite a governmental delegation from Kirghizstan to undertake a investigation on China's small hydropower development and further discuss the detailed requirements and measures for cooperation;
3. HIC shall assign expert teams to Kirghizstan Republic to carry out small hydropower projects and technical consultation.

Ministry of Agriculture and Water Resources in Kirghizstan provide us with the main technical parameters of 6 small hydro sites and send us formal invitation for our expert team to make on-site investigation. Meanwhile our center also invites the first Vice Minister of Agriculture and Water Resources in Kirghizstan, Chancellor of Scientific & Technological Research Institute and Chief Expert in Rural Hydro to visit China.

Our center organizes engineers to make research on the technical data of 6 hydro stations and make initial comments. And we also study the possible ways and schemes regarding the cooperation with Kirghizstan.

2. Projects Evaluation

1) Technical Parameters Evaluation

In accordance with the technical parameters as provided by Ministry of Agriculture and Water Resources in Kirghizstan, initial results are derived after the analysis and evaluation of HIC experts.

Main Parameters of SHP Site in Kirghizstan:

	Stations	Installed Capacity	Head	Unit Discharge	Remarks
1	P. Tanac	1156 KW	22 M	7.0 M^3/S	
2	P. Kapa-Hapan	270 KW	2.5 M	1.8 M^3/S	
3	P. Ak-Bypa	1300 KW	21 M	5.0 M^3/S	
4	P. Koukopka	368 KW	9 M	4.0 M^3/S	
5	P. Apacah	1570 KW	7 M	3.0 M^3/S	
6	P. Hecnk-Ata	1440 KW	127 M	1.56 M^3/S	

Generally speaking, the site has comparatively little parameters. Based on the data available we found that the technical parameters of Project 1, 2, 6 are better than those of Project 3, 4, 5. In our opinion the Projects 1, 2, 3, 6 are feasible and worth further development.

2) Discussion on Economic Cooperation Scheme

The present market situation is: There are abundant hydro resources in mid Europe, especially republics of former Soviet Union like Kirghizstan and Georgia, which the technical force is strong and has good development conditions, while the manufacturing level is low and fund is short. According to the general target of our center as well as China's manufacturing situation for small hydro equipment, it is workable to make equipment supply for small hydro project in mid European countries. And both governments have shown positive attitudes and the responses from China's Ministry of Water Resources as well as Kirghizstan's Ministry of Agriculture and Water Resources are also positive and supportive.

Conclusion:

These projects in Kirghizstan are technically feasible and the both government also shown a positive response to the coming cooperation. The technical evaluation and consultation has put a solid base for the future cooperation between two parties. If we can succeed in finding possible funds from international organizations or export credit from Chines banks, we can continue the development of these projects in Kirghizstan.

Annex 12

Annex 12

PEREZ-GUERRERO TRUST FUND Project INT/98/k06/A/95/99

Covers of the Textbook Serial on SHP Design

Submitted by

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小型水电站计算机监控技术

XINBIAN QUANGUO XIAOSHUIDIAN PEIXUN JIAOCAI

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内 容 提 要

本书共 11 章，主要介绍小型水电站计算机监控的意义、基本概念；水轮发电机组、辅助设备、中央音响信号系统与断路器的计算机监控以及水电站计算机测量和保护；监控系统的上位机、通信、可靠性和干扰问题以及发展趋势等。

本书主要作为小型水电站技术工人培训教材，亦可作为水电技工学校相关专业的教材使用，并可供从事小型水电站设计、施工与运行管理的技术人员参考。

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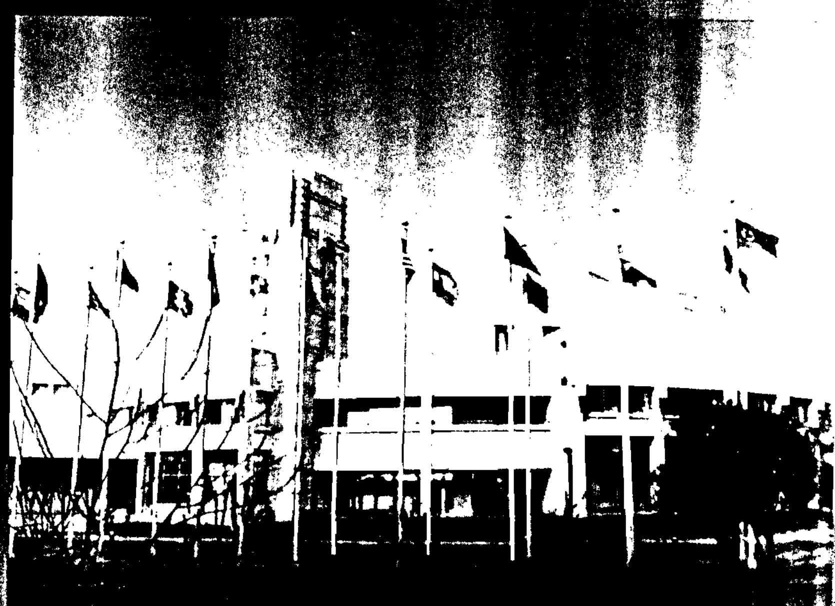

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内 容 提 要

本书共八章，第一章至第四章介绍小型水电站常用继电保护基本知识及线路、变压器、水轮发电机继电保护；第五章与第八章分别介绍小型水电站二次回路及电气自动装置；第六章介绍操作电源系统；第七章介绍二次回路运行维护等实用技术。

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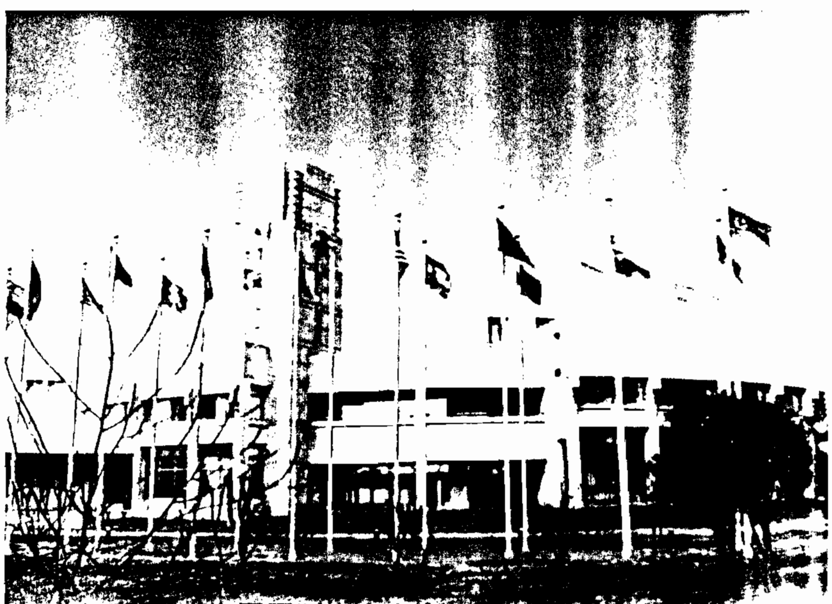

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本书共 12 章，主要介绍小型水电站常用的机械液压调速器的工作原理、结构、调试与故障处理实例；电气液压调速器的工作原理、结构以及可编程微机调速器等。

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本书共三章，第一章介绍水轮发电机组辅助设备的组成及构造；第二章介绍水轮发电机组辅助设备的运行与维修内容及技术；第三章介绍水轮发电机组辅助设备的运行控制自动化。

该书主要作为小型水电站技术工人培训教材，也可作为水电类技工学校相关专业的教材使用，并可供小型水利水电工程技术人员参考。

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内 容 提 要

本书共六章，第一章介绍小型水电站电气一次设备；第二章介绍电气主结线；第三章至第五章介绍发电机，变压器与配电装置的维护、检修和电气试验；第六章介绍防雷与接地装置。

本书主要作为小型水电站技术工人培训教材，亦可作为水电技工学校相关专业的教材，并可供从事小水电设计、施工、运行管理的技术人员参考。

电气一次设备维护与检修

主编 罗云霞 虞 放

☆

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小型水电站设备运行与操作规程

XINBIAN QUANGUO XIAOSHUIDIAN PEIXUN JIAOCAI

童建栋／主审　　唐文品／主编

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本书共七章，第一章至第六章着重介绍水轮机、发电机、变压器、配电装置、直流系统以及水轮发电机组辅助设备的运行、操作与事故处理；第七章扼要介绍水电站的运行管理。

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小型水电站设备管理办法

XINBIAN QUANGUO XIAOSHUIDIAN PEIXUN JIAOCAI

童建栋/主审 中国水利地电企协中小水电设备分会
联合国国际小水电中心/主编

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内 容 提 要

本书共 11 章，主要介绍小型水电站主机及主要设备选型、订货、出厂检验、设备运输、保管、开箱检查，设备安装的质量标准和质量评定标准，主机设备的试运行，设备的运行维护、检修、更新改造、评级及报废等设备管理办法。

本书主要作为小型水电站技术工人培训教材，亦可作为水电技工学校相关专业的教材使用，并可供中、小型水电站建设、安装、运行等单位和部门的管理人员和工程技术人员阅读。

小型水电站设备管理办法

主编 中国水利地电企协中小水电设备分会
联合国国际小水电中心

☆

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低压水轮发电机组运行与维修

XINBIAN QUANGUO XIAOSHUIDIAN PEIXUN JIAOCAI

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Ⅰ．低…　Ⅱ．①徐…②虞…　Ⅲ．①水轮发电机，低压－机组－电力系统－运行－技术培训－教材②水轮发电机，低压－机组－维修－技术培训－教材　Ⅳ．TM312

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内 容 提 要

本书共13章，主要介绍小水电资源开发；小型水轮机与低压水轮发电机组；小水电金属结构；低压机组辅助设备及水轮机调速器；电工、电子基础知识；电气一次、二次设备及电气二次图；低压水轮发电机组的运行和管理；日常维护和检修；异常运行和事故处理、安全运行和小水电站的技术改造等。

该书主要作为小型水电站技术工人培训教材，也可作水电技工学校相关专业教材使用，并可供从事小水电设计、施工、运行管理的技术人员参考。

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Ⅰ. 水… Ⅱ. ①徐… ②陈… Ⅲ. ①水轮发电机-机
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Annex 13

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Covers of Textbook *Small Hydraulic Turbine*

Submitted by

International Network on Small Hydro Power

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By: Prof. Tong Jiandong
Prof. Petr Fleischner

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ON SMALL HYDRO POWER

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Annex 14

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PEREZ-GUERRERO TRUST FUND Project INT/98/k06/A/95/99

Research Paper

Standards of Rural Electrification: Country Studies

Submitted by

International Network on Small Hydro Power

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中国水电农村电气化标准

（一） 用电水平

——农户通电率应不低于 98%（第二批应达到 100%）。满足家庭照明、取暖降温、广播电视、电炊、洗衣机和发展庭院经济等方面的用电需要。
——满足本县（市、团、旗、区）农田排涝提水、节水灌溉、农副业加工、农牧渔业产业化、城乡供水、城乡工矿企业、文化教育、科技信息、医疗卫生、旅游事业和发展小城镇等方面的用电需要。
——实行“以电代柴”等，为退耕还林、还草、还湖和相应的开发性移民、形象扶贫提供电力。
——满足上述用电需要，人均年用电量应达到 400-600 千瓦时，户均年生活用电量应达到 600-800 千瓦时。根据地域差异、经济发展水平差异，不同地区的用电水平应有所不同。中西部和少数民族地区原来没有建设初级电气化县（团、旗），人均、户均用电水平视实际情况确定。
——满足上述用电需要，大网补给电量比重应不大于 40%。全县（市、团、旗、区）用电保证率应不低于 95%。

（二） 经济与社会发展水平

——本县（市、团、旗、区）年 GDP 总值、农民人均年纯收入平均递增率应不低于全国平均水平，人均年 GDP 值应不低于 800 美元、农民人均年纯收入应不低于人民币 3000 元或均应不低于全国平均水平，财政实现自给有余。
——文化教育、科技卫生事业有较大发展，人民物质文化生活质量有明显提高。

（三） 生态建设、环境保护指标

——通过实行“以电代柴”和实行其它有效措施，减少森林砍

伐，森林覆盖、水土保持量化指标改善程度应不低于 30%。其它防水污染、防空气污染、节水等量化指标应有明显改善。

（四） 电源电网建设水平

——电源电网建设符合规划要求、建设程序、验收标准，电源布点、网络布局合理。
——体现了以开发中小水电资源为主，因地制宜建设其它配套电源和合理引入大网电源。
——水能资源丰富的县（市、团、旗、区），体现了商品电合理输出。

（五） 管理体制、机制要求

——水利部门对本行业水电及农村电气化建设统一实行行业管理，水电农村电气化建设由水利部门会同计委组织实施；坚持“自建、自管、自营”方针和“小水电要有自己的供电区”等政策。
——县（市、团、旗、区）及其以上的地区（市、州、师、盟）水利部门，应通过政府授权，确立自身的水利水电国有资产出资人代表的地位，建立健全对国有产权的有效监督管理机制。
——坚持电力工业方向，县（市、团、旗、区），及其以上地区（市、州、师、盟）中小水电企业，应是规范化的独立配电公司，是自主经营、自负盈亏、自我约束、自我发展的法人实体和市场主体。
——县（市、团、旗、区）独立配电公司，应对农村供用电实行统一管理和实现“五统一”（统一电价、统一发票、统一抄表、统一核算、统一考核）、“四到户”（收费到户、销售到户、抄表到户、服务到户）、“三公开”（电量公开、电价公开、电费公开）。

（六） 企业管理水平

——企业的劳动生产率、资产保值增值率、资产收益率等经济

指标，以及发供电生产经营的单位耗水率、高压电网综合网损率、低压电网线损率、设备完好率、频率合格率、电压合格率、供电可靠率、设备和人身事故率等指标均应不低于本省（区、市）中小水电行业平均先进水平。

——地方独立配电公司应建成地区级及以上优秀企业。

（七） 科技进步要求

——中小水电企业应加强科技开发力量和资金投入，大力应用新技术、新设备、新材料；推广应用自动控制技术，实现发电厂、变电站综合自动化，实行无人或少人值守；推广应用调度通讯系统、配电系统、办公系统自动化，提高发供电安全可靠性和办公效率。

（八）关于水电电气化地区（市、州、师、盟）所在地比照以上规定执行，除大网补给电量比重不受限制外，其余定量、定性指标均应达到和超过水电农村电气化标准。

——所辖各县（市、团、盟、区）均已达标验收。

——有规范化的地一级调度机构和独立配电公司。

——已形成地区电网或已实现产权联结关系、能够实施产权监管运营。

Annex 15

Annex 15

Research papers *An Overview of SHP Worldwide*

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Afghanistan

In Afghanistan the social and political situation has begun to stabilise. Now international non-governmental organizations and the Taliban authorities are both searching for hydro power Companies who would be interested in re-establishing and improving the country's power sector.

Afghanistan has a nominal installed capacity of around 500MW(for a population of 22M people). The bulk of the capacity is in charge thermal and hydro station. The thermal capacity is almost completely out of action of at present; the only operating plants are Paktia, a 600kW Plant in the province of Khost and a 48MW plant in Balkh province. Of the hydro Power station around half are operable(see table).In fact, the most successful plants are currently the small hydro Plants.

The reason that small hydro plants are still active is that they are managed independently and are not often part of a centralised grid. This has fitted well with the political administration, such as it has been where 'warlords' have Controlled discrete areas.

As a result, despite the continuing instability in the northern parts of the country, there are good prospects for beginning refurbishment in other areas in the near future.

Preparations for refurbishment were first started in 190, when the German co-operation agency GTZ began taking steps towards reconstruction and repair. GTZ's work was focused on two stations Filkoh near Kandarhar, and Asadfabad, near Jalalabad. These plants are located in the east of the country, an area which is very promising with regard to the cenelopment of agriculture and natural resources, and which has a history of co-operation with the Germans going back some 20years. Now, however, the GTZ programme is on standby, because of the 1997 takeover of the region by the Taliban militia

The Taliban are said to respect the work that is done by NGOs for the benefit of the rural population, but nevertheless relations between the two groups are very cautious.

Small hydroelectric stations have a number of technical advantages, compared to the stations associated with large dams, which gave in many cases undergone heavy siltation. The small plants feed isolated networks and on many sites operators are still in pace, who although they are very much older than the norm still have many skills and a deep knowledge of the plant.

Damage to these small plants from military activity has been slight, as they have been respected by local warlords. However, they have suffered much-increased wear and tear and preventive maintenance has been minimal.

The most important contributors to reducing the availability of these plant have been;

Lack of spare parts. Funds have not been available to make even minor purchases, and in any case maintenance materials such as grease or high pressure oils have not been available. As a consequence, even low-grade maintenance has been impossible.
Transmission lines have deteriorated greatly, in many cases as a direct result of military action.
Land mines have been placed near transmission lines.
There has been no access to workshop or transport facilities.
Despite these difficulties, operators are doing their best to keep the stations on line, they have also become involved in training young people - previously subject to recruitment into local militia - into operation and maintenance of the plant.

Am interesting example of the possibilities in small hydro plant refurbishment is the Darenta stationin Jalalabad, which originally had a capacity of 11.5MW. This plant was established in 1963-4 under the Daoud regime with the co-operation of the then-USSR, and all of the major equipment is still in place. It is connected to the Darunta multipurpose dam(whose other major function was to provide water for the now-defunct Hadda olive plantations), working under a head of 18.5 m.

Suffering heavily

Darunta has three Kaplan turbine/directcoupled generator machine sets form the famous St Petersburg works of Leningradsky Metalny zavod. Now, the main bearings are suffering heavily and some minor gaps already exist, promoting in their turn considerable vertical balancing problems. The thrust bearings have also deteriorated, and are getting worse. Thanks to leaking hydraulic conduits there is not really enough oil pressure to move the wicket gates or for turbine runner blade governing.

In the worst cases it has not been possible for many years to gain access to these important pieces equipment. As a consequence, grinding device, grinding devices have been used to cut thick bolts and dismantle equipment compounds

Russian companies are unlikely to invest in this plant, as their own economic pressures mean their priorities are elsewhere. The Jalalabad owners therefore need investment from elsewhere. They point out that Darunta has much to offer;

It is a showcase possibility for refurbishment and repair.
It could be used for hands-on training of a new technical generation-the Technical University of Jalalabad is very close and could use the hydro station as a model application.
There is a local market for the electricity. The 11.5MW plant previously provided electricity for 40,000 inhabitants. The population now numbers ten times as many, partly because inter-regional gas pipeline investments have held out the chance of economic growth in the area.
There are prospects for grid integration in future.
Reviving the power plant may help promote revival of the associated infrastructure. This would mean institutional strengthening, promoting new enterprises, improving irrigation and reviving rational water use-in the interim, much of the irrigation water has been diverted to poppy fields.
It will help in managing siltation behind the dam.
Projects such as this are an important contribution to the future of Afghanistan, and may be the beginning of projects to exploit the several thousand MW of hydro potential within the country.

Starting up a hydro industry in a country with geography as unforgiving as that of Afghanistan required a huge number of obstacles to be overcome. In the early years of this century, for example, roads did not exist in many areas and heavy equipment for the 1500kW Jabel seraj plant, north of Kabul, was brought in by elephant across the much-disputed khyber Pass. Other equipment followed this route, even into the 1930s. Now, overcoming the obstacles to rebuilding and expanding the industry requires as much persistence.

Most of the Afghan small hydro industry is in need of refurbishment. 'Rehabilitate, own operate' 'rehabilitate, own, operate, transfer' schemes are all available, and companies are invited to participate.

Habibullah Frahmand, formery with the Ministry of Planning, Kabul, now a consultant to German Agro Action, Peshawar, Pakistan, and P W Wicke, SOWISWAS, 38302 Wolfenbuttel, Germany

Albania

The republic of Albania covers an area of 28 748 km2 and has a population of 3.4 million.

Water sector

The average annual precipitation is about 1500 mm, and the total mean annual precipitation volume is about 45 km3/year, with total runoff of about 2 km3. Per capita water consumption is 650 m3/year. River flows total about 40 km3/year, with the average head of the river being 640 m.

The total land area under irrigation is 3700 km2.

The National Council of Water, directed by the Prime Minister, has recently been set up, as well as the National Technical Secretariat of Water and a National Technical Secretariat for Large Dams. Local authorities areresponsible for their own catchment area.

Per capita domestic water consumption in Albania is 150 to 200 litre/person/day in urban areas and 100 litres/person/day in rural areas, according to the General Directorate of Water Distribution, Ministry of Public Services and Transportation. Albania has 306 large dams in operation. The country's dams have a total water storage capacity of 3897×106 m3.

Energy and power sectors

The main sources of primary energy in Albania in 1996 were: electricity (25.1 per cent),oil (23.4 per cent), coal (1 per cent),gas (0.9 per cent) and imports (40.6 per cent). Total primary energy consumption was 1606.06 kTOE.

The main sources of electricity production were: hydro (96.43 per cent) and thermal plants (3.57 per cent).

The total electricity consumption in 1996 was 4388.7 GWh: it is estimated that this will increase by 5.88 per cent/year during the next 1O years. Demand is expected to rise by 5.64 per cent/year.

Per capita electricity consumption in 1996 was 1371 kWh/person/year. For many years Albania has produced surplus electricity for export and exchange with its neighbors and other European countries. It is interconnected by 400 kV transmission lines with Yugoslavia and Greece. During 1996, 503 GWh of electricity was imported, and 1409 GWh was exported. The Ministry of Energy and Industry is the national energy authority. The Albanian electricity Corporation (KESH) is in charge of electricity, including powerplants. It has a vertical structure, acting like a joint-stock company, and has been under an Authority Board since 1995, composed of members from different Ministries. The Albanian Oil and Gas Corp (Albpetrol) is similar to KESH in structure, also coming under the auspices of the Authority Board.

A Regulatory Electricity Entity (EER) has recently been established, under the Albanian Parliament, and the National Committee of Energy (NCE) under the Council of Ministry acts with consultative status.

The Ministry of Foreign Reaction Economic Relationships and the Ministry of Public Economy and Privatization have recently been established.

In terms of organizational change, as outlined above, deregulation of the energy sector has take place, with the deregulated market having a vertically integrated structure. The electricity market involves power purchase agreements.

KESH now manages all Albania's hydro plants. However, the State still owns 1OO per cent of its shares.

Hydropower development

The gross theoretical hydropower potential of Albania is now estimated to be 40 000 GWh/year, and the technically feasible potential is 15 000 GWh/year (33 000 MW). The economically feasible potential is still 6380 GWh/year (1700 MW). About 43 per cent of the technically feasible potential has been developed so far, on the Drin river system.

Hydro provides 1437 MW of installed capacity, of a total powerplant capacity of 1650 MW. No further hydro capacity is under construction, but 260 MW is planned. The average annual generation of the hydro pants in operation is 5200 GWh/year; their generation in 1996 was 5539 GWh

Construction of the Banja hydro project on the Devoll river began in 1987, but slowed down after the country's political changes. Construction has been abandoned as a result of lack of funding. The project involved a 110 m-high rockfill dam and 60 MW hydro plant. The upstream cofferdam had been completed to el. 155 m, only 40 m below the final height of the main dam, while construction of the main dam was approaching half-way (by volume). The project may proceed on a BOT basis.

Lahmeyer International has recently carried out a study on rehabilitation of the Drin river cascade hydro plants, with EBRD funds. Rehabilitation and improvement to these plants according to the study, would allow for an increase in production of 100 GWh/year.

According to the National Technical Secretariats of Water and Large Dams, seven plants have been planned which would fully exploit the Vjosa river system,the second largest in Albania. The upper catchment of the Vjosa (2345 km2) lies in northern Greece, while most of the catchment (4365 km2) lies in Albania. The Seven plants would have a total capacity of 495 MW (2130 GWh/year). The upstream plant in the cascade would be Kaludhi(75 MW, 280 GWh/year), while the downstream plant would be Selenica (60 MW, 255 GWh/year).

The Devoll river is Albania's third largest catchment (aoubt 3500 km2). Its hydro potential has not yet been exploited. Ten possible plants have been idenitied, with a total capacity 312 MW (850 GWh/year).

There is no legal framework in place at present for environmental impact assessment or management.

Small hydro

There are 45 small, mini and micro hydro plants in operation(up to 10 MW), with a total capacity of 9.1 MW. However, there are also 41 which are out of service or unreliable (3.6 MW).The plans in operation generated 14.9 GWh in 1996.

The Institute of Energy has carried out development studies for more than 40 small scale hydro plans, including new and refurbishment projects, with a total capacity of 140 MW (680 GWh/year). Five have capacities of between 5 MW and 24 MW, while the others are between 500 kW and 5 MW; 19 of the plants would be at existing facilities for irrigation, potable water and reservoirs.

Future outlook

In view of the increasing electricity demand in Albania. KESH

will have to construct new powersplants during the next 10 years, especially hydro plants. A number of prefeasiblity and feasibility studies have been completed for new hydro plants.

The most important plants planned are completion of Banja on the Devoll river and the construction of Bushat, the stage furthest downstream in the Drin river cascade.

The civil structures for Banja, in the south of the country, are partially built. Completion of the hydro project would require completion of heightening of the main dam by about 90 m, and the addition of the powerplant. It would generate about 250 GWh/year, with a gross head of 82 m.

Bushat would exploit the 15 to 18 m head available between the tailwater of Vau Dejes and the sea. It would benefit from the flow regulation of the upstream reservoirs on the Drin river allowing for high quality energy production. Headrace and tailrace channels, each more than 6 km long, would be constructed, and 80 MW of capacity would be installed (330 GWh/year).

KESH has also carried out many studies on other rivers including some further plants on the Devoll:Lozhan (25 MW);Selce (35 MW); Moglice (30 MW}; and Bratile(60 MW).

Considering both these medium-sized plants and some small and mini plants studied by the Institute of Energy, it has been calculated that the average investment in hydropower is US$ 500 to 1350/kW. and that the hydro plants could generate power at an average cost of US$3/kWh. From the economic point of view, therefore, there is considerable potential for further hydropower development.

It is appropriate for hydro plants to be located at the middle section of the load duration curve, with the peak covered by small scale gas turbines, imports or small hydro plants.

With this in mind, the Albanian Government approved construction of the Kalivaci hydro plant on the Vjosa and the banja hydro plant on the Devoll river in may 1996, with a concession regarding the BOT form. The baushati hydro plant is now at the contract stage.

ALGERIA

Algeria is the second largest country in Africa, covering an area of 2 381 741 km2 . It has a population of 28.5 million.

Water resources
Annual average precipitation varies greatlly, from more than 2000 mm inthe coastl basins to leass than 20 mm inthe Sahara desert. The total mean annual precipitation volume is 100 km2, with total runoff 12.4 km3.

The Ministry ofEquipment and territorial Management is in charge of water resources. there are 48 regional authorities, known as Directory de'l Hydrauliques de Wilayas.

There are 98 large dams in operation, according to ICOLD's definition. Most dams have been built for irrigation, and potable water supply, and some for hydro generation. the total storage capacity of all reserviors is 4.57 km3.

There are 18 large dams under construction, the highest being Koudiat Acerdoune(112 m). There are also 22 dams or water transfer projects at avvanced stages of study, and 21 at the feasiibility study stage.

Energy and power sectors
The main sources energy in Algeria are petroleum and gas.

The main sources of electricity in 1995 were: thermal plants(99.3 per cent); and, hydro (0.87 per cent). the thermal production comprised: steam-fired(49.69 per cent); gas turbines (47.98 per cent); and, diesel(1.46 per cent) in the south of the country.

The Ministry of Mines and Energy is in charge of energy, while SONELGAZ(Societe Nationale de l'Electricite et du Gaz) is the national power authority. SONELGAZ has nine regional devisions. all the powerplants are publicly owned.

Total per capita electricity consumption is 7400 kwh/year/person/year.

Hydropwer development
There is 275 MW of hydro capacity in operation, of a total powerplant capacity of about 6 GW. the largest hydro plants in operation are Ighil Emda and Erraguene.

No hydro plants are under construction or planned, although 700 MW of pumped-storage capacity is planned.

Future outlook
The programme of dam construction in Algeria envisages the implemention of 30 large dams by 2010 and 20 others beyond this time

ANGOLA

Angola covers an area of 1 246 000 km2 and has a population of about 10.5 million. There are 15 large dams in operation.

Energy and power sectors
Angola's power supply is based on hydropower, which supplies about 75 per cent.

The national power authority, Empresa Nacional de Electricidade (ENE), is in charge of the country's three major grid systems, isolated systems, and the distribution of power in most provinces. Distribution in Luanda, the capital, is carried out by EDEL (Empresa de Distribuicao de Electricidade de Luanda). A 10 MW gas turbine plant is owned by Refinaria, of Luanda. In 1996, 100 kWh/person was available.

Hydropower development
Angola has an estimated hydropower potential of 150 000 GWh/year (not defined as technically or economically feasible), of which about 65 000 GWh/year is considered to be firm potential. Some 150 hydro plants could be built, excluding mini and micro plants (of less than 2 MW).

There are about 10 hydro plants in Angola. However, several are still out of service following damage sustained during the civil war. ENE had 358.3 MW of available capacity at the end

Of 1996, of the 601.4 MW of nominal capacity at its plants. Available hydro plant capacity was 208 MW, of 304 MW nominal capacity. There is also 260 MW of hydro capacity at the first stage of the 520 MW Capanda project.

ENE's hydro plants generated 846 GWh in 1996 (excluding Capanda), of a total production of 1047 GWh (80.8 per cent).

Further hydro plants are planned, including reconstruction of the Gove plant on the Cunene river, and the new Jamba Ya Mina project on the same river. The Epupa scheme on the Epupa river in the south could be carried out as a joint project with Namibia. It is also planned to recommission and refurbish a number of the existing hydro plants.

It is aimed to increase annual production to 1500 GWh/year through the addition of new capacity, to meet increasing demands. Electricity consumption could then rise to about 150 kWh/person/year.

Future outlook
The future development of the power sector in Angola is dominated by the urgent need to repair those powerplants and transmission lines that were damaged during the country's turbulent political changes.

Argentina

The Republic of Argentina has an area of 3 761 274 km2 and a population of about 34.5 million.

Water resources

The National water Resources Agency is now under the authority of the Secretariat of Natural resources and Sustainable development, rather than the Public Works Secretariat as it was formerly. The national gauging station network has been operated since 1993 by EVARSA, a private company. Private companies or mutual associations are responsible for water supply and water treatment inmost parts of the country's main cities.

Argentina has 103 large dams in operation. The total water storage capacity of all large dams is 130.4 km2.

Per capita domestic water consumption is 400 litres/person/day in urban areas, which is influenced significantly by the high consumption in Buenos Aires. Consumption in rural areas is 120 litres/perosn/day.

The Pichi Picun Leufu dam ,which is 48 m-high, is under consumption in the Neuquen province. The Nogoli dam is also under construction in San Luis.

Several planned hydro projects will include large dams garabi (81 m high, earthfill dam); Corpus 940 high, rochfill); Chapeton (50 m high, earthfill); elChihuido (145 m high, earhtill); Las Pavas (103 m high, RCC); Arrasayal (100 m high, RCC): Cambari (116 m high, RCC); and, Potrrillos 980 m high, rockfill).

The country's main civil contractors for dams and hydro projects are: Techint, Cartellone, benito Roggio and Sideco Americana.

In 1997, the Secretariat of State for Energy introduced a guidebook for the environmental management of hydroelectric water works projects involving new reservoirs. In additional, all concession contracts for hydro plants have clauses relations to environmental duties and tasks, including obligations for biological and water quality measurements.

The main hydro plants in Argentina, except for Yacyretaand Salto Grande which are binational, were built under license as a result of restrictions on water utilization. Those holding a licence for hydropower generation are also responsible for dam security and environmental control in the reservoir area.

Water utilization fuels for the reservoirs and environmental control of the river basins are prodived by local authorities. For supervision o dam safety control, technical organizations (known as ORSEPs) wereceated, and in this respect the country has been divided into four regions: Noa, Cuyo-Centro, Comahue and Patagonia. Within each of these regions, an ORSEP controls the monitoring of dams, the maintemce of civil structures and hydromechanical system, supervise the design and instrumentation of new dam projects, establishes technical rules and controls the execution of the obligatory tasks for each contract.

Energy and power sectors

The Ministry of economy and Public works, Secretariat of state for Energy, is responsible for energy and power.

During the early 1990s, Argentina began a thorough reform of its public sector, including restructuring and privatization of the electricity sector. This major change in policy was inended to attract capital and management.

The Electricity regulator framework Law created the National electricity regulator Commission (ENRE) as an independent entity that works within the scope of the Secretarial of State for Energy, and is responsible for drawing up regulations governing the electricity industry and ensuring compliance. The ENRE was subsequently commissioned by the Secretariat of State or Energy to administer hydroelectric concession contracts.

The deregulated market involves separated generation, transmission and distribution. The nature of the market is about 30 per cent power purchase agreement and 70 per cent pool bidding.

The main sources of primary energy in 1996 were: oil (41.2 per cent), natural gas (46.2 per cent), biomass (4.5 per cent), hydro 94.2 per cent0, nuclear 92.4 per cent) and coal 91.5 per cent). The total primary energy consumption (gross) was 59.6 million TOE;

The main sources of electricity production in 1996 were: hydro (17.8 per cent), natural gas 960.1 per cent), nuclear (10 per cent), petroleum products(7.2 per cent), coal (2.9 per cent), and others such as geothermal, solar and windpower91 per cent).

Total electricity consumption in 1996 was 58 709 GWh, representing per capita consumption of 1675 kWh/person.

During 1996, 278 GWh electricity was imported and 311 GWh was exported.

It is estimated that total energy consumption will increase by 2.8 per cent/year during the next decade, and electricity demand by 5.5 per cent/year.

About 59.2 per cent of hydro plants are privately owned Yaeyreta sn Salto Grande, which are very large plants, are binational and thus are not concession. About 65.5 per cent of the powerplant capacity is privately owned.

The average cost of kW of electricity generation capacity at Argentina hydro plants under construction is US$ 1600/kW for low head plant; US$ 1300/kW for medium head plants; and US$ 1000 or high head plants.

Hydropower development

The gross theoretical hydro potential of Argentina is 172 000 GWh/year estimated in 1993 and the technically feasible potential is about 130 000 GWh/year. At present, using private investment criteria, based on the cost of natural gas and interest rates, the economically feasible potential is very low. About 22 per cent of the technically feasible potential has been developed so far.

The total installed capacity of all powerplants in operation is 18 717 MW(1996), of which about 9800 MW is hydro capacity. About 15 hydro plants are part of multipurpose development. Hydro plants produce 45 per cent of electricity in an average year.

Construction of the 3100 MW Yaeyreta hydro projects is virtually completed. Commissioning tests for the 20th and final 155 MW unit were under way in March, with commissioning scheduled to take place by the end of March, two months ahead of schedule. Ten of the 20 units belong to Argentina.

The bi-national project's generation will serve the electrical system of Argentina and Paraguay, although the Paraguayan system currently only uses about 70 MW. The Kaplan units are at present operating at reduced capacity of about 90 MW in view of delays in the construction of the upstream resettlement works, preventing filling of the reservoir to its final operating level. A further 650 MW of capacity at Yacyreta is therefore classified as under construction.

In 1996, hydro plants generated 25 447 GWh; however, this was a dry year, particulary in the Comahue basin. The average annual generation from hydro plants will be about 32 000 GWh year when Yacyreta is fully operational.

The 250 MW pichi pictin Leufu project is under construction. with the first unit scheduled to begin operation in 1999 . It is being completed by Hidroelectrica Pichi Picun Leufu SA, a former

Government company, which was purchased in 1997 by the Argentinian company Perez Companc SA.

A further 8600 MW of hydro capacity is planned . at the following plants:

Garabi, 1500 MW, on the uruguay river (Argentina/Brazil):

Corpus, 2880 MW. Parana river (Argentina/paraguay);

Chapeton, 3000 MW, parana river:

El Chihuido, 835 MW, Neuquen river;

Las Pavas. 88 MW, Bermejo river;

Arrasayal, 93 MW. Bermejo river;

Cambari, 102Mw,tarija river(argentina/bolivia); and,

Potrerillos, 100mw,Mendoza river.

Garabi and corpus will have the additional purpose of navigational improvements, while the final four projects in the list above will also serve irrigation functions.

Two economically attractive alternatives for uprating Salto Grande are being analyzed .The first involves increasing the normal operating level of the reservoir by 1 m, to produce an additional 200 GWh/year (40 MMW increase),The second option involves refurbishment of the 14 turbines .

Argentina has 750 MW of pumped-storage capacity in operation. The generation in 1996 was 280 GWh, while consumption was 130.2 GWh.

Small, mini and micro hydro

Argentina has 33 small, mini and micro hydro plants in operation, with a total capacity of 40 Mw, others are under construction, and about 35 more are planned (42.8 MW).

The plants planned include the 380 kw Gutierrez Lake scheme, to be refurbished by Cooperativa Electrica de Bariloche, and the 570 kw Escondido Lake project, which is privately owned Other plants planned for te next three years include: Choljila (1 MW); Catarata (750 kw); Aarroyo Lindo (3.5 MW);SaltoAndersen (6 MW);San Martin (450 kw):San martin 1 (3.5 MW); Las pirquitas (2.25 MW); and , Rio Mitre (3.6 MW), Most of these will be new BOT projects, developed by private companies; San Martin will be a refurbishment project

Future outlook

The Secretariat of State for Energy is mainly considering scenarios for thermal plants in the near future. Even though gas reserves do not seem to be at risk, the hypothesis of gas exports to Uruguay, Brazil and Chile, along with the expected increase in peak power demand, could put hydropower back as an interesting economic alternative

The identification and technical permissibility studies for new hydro projects are considered to be the responsibility of the Government, while feasibility studies and project implementation for new projects will depend on the private sector for investment.

Of the hydro projects planned. Corpus is considered the best option. It would cost an estimated USS 2.67 billion and USS 915 million for transmission aspects

Hydropower units require a Government license and their production is subject to regulations relating to alternative water use and to their integration with other supplies according to economic criteria. The aim is for the best possible rational use of generation resources

Armenia

The Republic of Armenia is a small landlocked, mountainous country in the south Caucasus. It was formerly part of the Soviet Union. It is bordered by Georgia to the north., Azerbaijan in the east and southeast, Turkey to the west and Iran to the south. The population is 3.7 million.

Most of the territory, which covers an area of 29 800 km2, is between els.1000 and 2500. The Aragas Mountains rise to el, 4090 m, and Lake Sevan, at el.2000 m, is one of the largest natural mountain lakes.

The main rivers in Armenia are the Araxa, Hrazdam, Akhurian, Arpa and Vorotan: 16 large dams are in opertion.

The climate is continental, with very hot summers and extreme winters.

Energy and power sectors
Armenia was experienced severe economic and energy supply difficulties in recent years, partly as a result of the major earthquake of December 1988. It has also been suffering from inadequate electricity supplies since the Medzamor nuclear plant was taken out of services as a result of safety concerns; this has been partially recommissioned.

Armenia has almost no fossil fuel resources, and 95 per cent of oil and gas is imported. No gas or petroleum resources have so far been identified, although there may be limited reserves in some areas. There are also limited resources of coal, but of mediocre quality. The country has been hit by increasing costs of imported fossil fuels from CIS countries, where prices are rising sharply to world market levels.

The recent conflict with Azerbajan resulted in the blocking of gas pipelines necessary to supply thermal powerplants.

Armenia is now seeking to become less dependent on imported fuels. Options include the possibility of exploiting local oil and gas reserves, the introduction of energy saving technology, and further use of indigenous renewable energy resources9hydro, wind, solar, biomass).

Hydropower development
During the 1990s, hydro plants have supplied almost all of Armenia's electtricity, having an installed capacity of about 1000 MW.

One cascade of six plants has a total capacity of about 600 MW, supplied by water from Lake Sevan. Over-exploitation of the available water resources for these plants has had sever environmental impacts, notably an irreversible lowering of the lake level by 17 m.

There is another cascade of three plants, with a combined capacity of about 400 MW, in the south of the country, close to Iran.

A 30 MW hydro plant in the north, near Georgia, was damaged in the earthquake.

Small hydro
There are also about 15 mini hydropower plants, with capacities ranging rom 200 kW to 3 MW, but these have been poorly maintained. They are currently operating at about 25 per cent of their pre-1998 capacities.

It is the Government's policy to develop small and micro hydro plants further through the private the private sector, as well as to privatize existing plants. In an effort to build closer co-operation between manufacturers of hydro equipment, design and research organizations, potential customers and investors, a computerized database on renewable has been developed and is continuously being updated.

To identify the current status of renewable energy development in Armenia, a study was conducted involving about 50 organizations. Data were collected on energy systems up to 100 kw, but the software provides for inclusion of small hydro plants of large size; this work is under development.

In the early 1990s, EDF of France undertook a study, financed by the European Community, to assess the potential for rehabilitating Armenia's small hydro plants. It was concluded that these mini schemes could play a significant role in view of the national energy crisis, and some could be rehabilitated relatively easily.

Of 38 generation units, only nine were found to be in a state capable of producing electricity. Of about 40 MW total capacity, about 8 MW was grid-connected.

An urgent action plan was drawn up, and a rehabilitation plan was implemented with French assistance, with the priority being three plants close to the capital, Yerevan, which had been badly affected by the earthquake. At Ayroum, three units were recommissioned, which provided an increase of about 2 MW. At Dzora, two 8 MW units were refurbished, and local personnel were subsequently able to repair the third 8 MW unit. At Eracan 3, a 5 MW unit was repaired by the replacement of some components.

Eventually, it was possible to refurbish and re-commission about 10 MW of mini hydro for the Armenian frid (about 1 per cent of the original hydro capacity), at relatively low cost.

ECOTEAM, an NGO based in Yerevan, has recently studied the possibility of installing a small hydro plant to exploit the head available at an irrigation canal near Kosh, in the Aragatotn region about 35 km northwest of Yerevan, within the framework of the Renewable Energy Development programme. It was found that the project has good technical and economic parameters. It is believed that 40 small plants could be installed in the region, with a total capacity of 43 MW (134 GWh/year).

The development of small hydro stations in Armenia is one of the most promising prospects for increased utilization of renewable energy sources.

Australia

Australia has an area of 7 680 000 km2, and a population of about 18.3 million.

Water resources

There are 453 large dams in operation, according to ICOLD's definition.

Most water authorities and power authorities have now been privatized.

Hydropower development

Australia has a gross theoretical hydropower potential of 264 000 Gwh/year. Its economically feasible potential is 30 000 Gwh/year.

The installed hydro capacity of Australia is 7466 MW. The hydro plants generated 15 212 Gwh in 1996. Hydropower supplies about 10 per cent of hydro production.

Tasmania is the state which generates the most hydropower, having more than 2000 MW of hydro in operation, NSW. Victoria and Queenland also generate hydro, while output from the Snowy Mountains scheme(about 3750 MW)is shared between NSW and Victoria, with some poweer going to the Australia Capital Territory.

Austria

Austria has an area of 83 858 km2, and a population of about 8 million.

Water Resources
Average annual precipitation is 1190 mm. The total mean annual precipitation volume is 99.8 km3, of which 56.2 km3 is runoff.

Per capita domestic water consumption is 80 to 200 litres/person/day in urban areas, and 100 to 150 litres/person/day in rural areas.

The Water Resources Management division of the Federal Ministry of Agriculture and Forestry is responsible for water resources management. There are nine provincial governments which have water resources management sections, as well as other regional water authorities, giviag a total of about 120 regional water authorities.

There are 146 large dams in operation (more than 15 m high}: excluding river barrages there are 61. The total water storage volume of all dams is 1.6 km3.

There is a legal framework for environmental impact assessment. This is applicable to all projects larger than 15 MW.

The main domestic civil contractor for dams and hydro plants is Verpundplan Engineering.

Energy and power sectors
The Energy Section of the Federal Ministry for Economic Affairs is responsible for energy development.

The national power authority is the Austrian Electricity Board, Osterreichische Elektrizitatswirtschafts AG (Verbundgeesellschaft), which has five main subsidiaries (Tauernkraft, Draukraft, Ennskraft, Donaukraft, STEG). There are also nine main regional power authorities (EVN, KELAG, OKA, SAFE,STEWEAG, TIWAG, VKW, BEWAC, and Wienstrom).

The electricity market involves power purchase agreements. The final draft of a new electricity law is currently being discussed, and deregulation of the energy power sector is envisaged by February 1999 at the latest.

The main sources of primary energy in 1996 were: oil (38.9 per cent), gas (22.5 per cent),hydropower(15.1 per cent),coat(11.1 per cent),biomass and other fuels (11.8 per cent) and environmental beat (0.6 per cent). Total primary energy consumption was 1223 × 106 GJ.

The main sources of electricity production in 1996 were: hydro (64.9 per cent), coal (9.6 per cent), oil (3.4 per cent), gas(18.9 per cent) and others (3.3 per cent). Total electricity consumption was 53 906 GWh, repressenting per capita consumption of 6693 kWh/year. During 1996, 9428 GWh of electricity was imported and 8476 GWh was exported.

Energy consumption is expected to increase by 0.6 per cent/year during the next decade, and electricity demand by 1.9 per cent/year.

Owner and operator of the powerplants are: the subsidiaries of: Osterreichische Elektrizitatswirtschafts AG: the provincial power authorities: city societies for electricity supply/communities; industrial autoproducers; private property owners (in particular, small hydro); and, the Austrian Railways. A recent change has been the concentration of operating responsibility for some hydro plants within a new Verbund subsidiary.

About 5.2 per cent of hydro plant capacity is currently under private ownership, while 9.5 per cent of the total powerplant capacity is privately owned.

Hydropower development

Austria's total gross theoretical hydro potential was calculated in 1956 to be 150 TWh/yeer. Of this 53.7 TWh/year (18 300 WM) is technically and economically feasible, according to a study carried out in 1992. About 67 per cent of this feasible potential has so far been developed.

The country's total installed capacity is about 17 600 MW, of which about 11 450 MW is hydro capacity. The average annual hydro production is about 37 000 GWh/year. Actual generation in 1996 was 34 440 GWh. Most of Austria's hydro plants are run-of-river. Hydro contributed 64 per cent of national electricity production, or 64.9 per cent including pumped-storage plants.

About 100 MW of hydro capacity is under construction, and 436 MW is planned.

The 172 MW (1052 GWh/year)freudenau hydropower barrage is now being commission. It is part of chain of plants on the Danube and has secondary, purpose of groundwater management, stabilization of the river bed and flood control. Five of in its six bulb units had been commissioned as we went to press. The Langkampfen project on the Inn river (28.8 MW,163 GWh/year) is also under construction and scheduled to be completed during 1998.

The cost per kW of constructed hydro capacity in Austria is US$ 4500 to 7500 for low-head plants, US$ 2700 to 5500 for medium-head plants and US$ 140O to 2000 for high bead plants.

New hydro plants planned include: Lambach(Traun river,14MW, 71 GWh/year). Deutschfeistritz (Salzach river, 15.5 MW, 74 GMh/year). Deutschfeistritz (Mur river, 12 MW, 60 GWh/year) and Nussdorf (Donau Kanal, 8 MW, 40 GWh/year). However, in view of the liberalization of the European electricity market, the construction schedules are uncertain.

It is estimated that about 400 GWh/year could be contribution by the uprating of existing hydro plants.

There is 2060 MW of capacity at mixed-type pumped-storage plants, none under construction and 101 MW planned; there are no pure pumped-storage plants. During 1996, the generation from pumped-storage plants was 1280 GWh and the consumption was 1880 GWh. It is planned to increase the capacity of the Ranna/Falkenstein pumped-storage scheme from 19 MW to 120MW.

Small hydro

The total number of small, mini and micro hydro plants (up to 5 MW) in operation is about 1700, representing an installed capacity of 620 MW (3100 GWh/year). It was planned that, by the year 2005, 500 GWh/year will be produced from small mini and micro hydro plants, but details of current plans are not available.

Future outlook

The propose for future development of Austria's remaining feasible hydropower potential are affected by several factors. Confilicts of interest frequently arise in connecton with new plants because of the differnet uses demand. Political decisions can ultimately result in the abandonment of a project or discontiunation of work already started. Moreover, at present, the operators of hydro stations are very cautious regarding new investments and tend to be restrained when it comes to funding further hydro developments. This has to be seen in connection with the endeavors of the European Union to liberalize and thus open electricity markets. In view of economic considerations, the prospects for realizing new large hydro projects n the near future are therefore quite small.

Azerbaijan

Azerbaijan is situated west of the Caspian Sea. It is surrounded by Russia to the north, Georgia and Armenia to the west, and by Iran to the south. It has an area of 86 600 km2 and a population of 7.8 million, 55 per cent of whom live in urban areas. The country includes the enclave of Nagorno Karabakh, lying inland adjacent to the Aras river, which is entirely surrounded by Armenia. A dispute with control of this region with Armenia led to civil war in 1993-1994.

The main mountain ranges are the Greater Caucasus in the north, the Lesser Caucasus in the west and the Talish Mountains in the south.

Water resources

The main rivers are the Kura and Aras, which flow eastwards, before combing and discharging into the Caspian Sea.

Coastal areas are subtropical, but the interior experiences extremely cold winters. 17 large dams are in operation.

Energy and power sectors.

The availability of indigenous fuel resources in Azerbaijan has allowed for the development of a strong power sector. The country has considerable reserves of oil and natural gas.

During the past 12 years, the installed powerplant capacity of the Republic's grid, which includes nine thermal plants.

However, despite fairly modern plants, the technical and economic indices of the grid remain low, since obsolete equipment is operated in parallel with new equipment, and non-design fuels must often used.

Since the Integrated Trans-Caucasian Grid ceased to operate, Azerbaijan's grid has had insufficient peaking power. The country's thermal powerplants, intended for baseload operation, have had to operate as semi-peak or peak-load plants, which has decreased reliability and economic efficiency of the grid. Further development of the power sector is considered critical for the development of the country's entire economy.

1996, plants on the grid generated 15 400 GWh. By 2005 it is planned to increase power production to 25 000 GWh/year. These plans are based on expected growth in domestic demand, as well as demand from the oil-refining, chemical and petrochemical industries and light industries. However, in view of the current transition to a market economy, detailed information on development trend s in the economy are not available at present.

The state-owned joint-stock power utility of Azerbaijan is Azerenerji.

To improve the structure of the generating capacity, and to improve the technical reliability and economic aspects of the grid, it is planned to reconstruct the Severnaya regional electrici station, the Baku and Sumgayit thermal plants, and the Mingechaur hydroelectric plant. It is also planned to complete construction of the Yenikend hydro plant.

Hydropower development

The water resources of Azerbaijan are derived from the the middle reaches of the Kura river and its numerous tribtaries which flow down the slopes of the Great and Small Caucasus, the Area river on the border, which descends into the Kura river, and several small mountain rivers which flow into the Caspian Sea.

Azerbaijan has an estimated hydropower potential of 43 500 GWh/year, of which about 16 000 GWh/year is technically feasible. About 10 per cent of this technically feasible potential has been developed so far. There is thus significant remaining potential to develop, once economic situtation in the country becomes more stable.

About 89 per cent of the hydropower resources are concentrated in Kura river basin, the other 11 per cent being in the basins of the rivers flowing directly into the Casoian Sea.

During 1996, Azerbaijan's hydro plants generated 1540 GWh, representing 10 per cent of power production. Hydro plants saved an estimated 21 000 GWh/year of potential for small hydro, of which 4900 GWh/year is technically feasible at present.

Development of the hydro resources of Azerbaijan began with construction of the 370 MW Mingechaur hydro plant on the Kura river, which was commissioned in 1995. At the time, this plant solved the country's economic problems, and was the largest peaking plant in the whole Trans-Caucasian integrated power system. The plant has six units and generates 1400 GWh/year. It includes an 80 m-high dam, with a crest length of 1500 m. Azerenerji is soon to undertake a refurbishment programme at Mingechaur, which includes repalcement of several of the generators.

The Varvara hydro project, completed in 1957, regulates the daily discharges from Mingchaur to satisfy irrigation requirements. The hydro plant is equipped with three units, with a total capacity of 16.5 MW (90 GW/year).

The Sarsang hydro scheme on the Tartar river was commissioned in 1997. It includes a 125 m-high, 570 m-long earthfill dam. The scheme has improved the water supply to existing irrigation systems over an area of 118 300 ha, and allowed for the construction of a new will cover 25 500 ha. The powerhouse accommodates two units with a total capacity of 50 MW(123 GWh/year).

The Shamkir multipurpose project, commissioned in 1984 in the middle reach of the Kura river, solved shortages at that time, by providing 380 MW of hydropower from two units (800 to 850 GWh/year), irrigation of 75 400 ha for agriculture in the Ganja_kazakh zone, and 120×106 m3 of potable and industrial water for Ganja, the Republic's second largest city.

After the completion of Shamkir, construction of the Yenikend multipurpose project began as the final and furtherest downstream project in the middle-Kura cascade. It will have an installed capacity of 150 MW, will generate 320 GWh/year, and will irrigate up to 6000 ha on the left bank of the Kura power grid. The project includes a 22 m-high earthfill dam. The powerhouse will be equipped with four 37.5 MW units. However, as a result of financing difficulties, the project was suspended before completion. The EBRD has recently allocated US$ 53 million to allow for completion of the project by the end of 1999.

The Tovouz multipurpose project, now at the design stage, is planned to meet future power and water demand. It will have a hydro capacity of 380 MW (870 MW GWh/year) and will allow for the irrigation of 12 000 ha. It will include a 62 m-high, 3650 m-long earthfill dam.

All surveying and design work for the hydropower project over the past 50 years in Azerbaijan has been carried out by the Bakuhydroproject Design and Survey Institute, which was originally formed to construct the Mingechaur project in 1945.

Bakuhydroproject also jointly carried out design and surveying work with Iran for the 44 MW bination Aras project in Iran, equipped with Kaplan units), commissioned in 1971. It was constructed at the same time as the Mil-Moghan diversion dam in Goradiz on the Aras river, which made it possible to develop new regions of the Mil and Monghan steppes, greatly improving water supply to the irrigated lands in southern Azerbaijan over an area of 250 000 ha.

Bakuhydroproject has also carried out design for other possible hydro projects in Azerbaijan, including the 1000 MW Shamkir pumped-storage project, the 100 MW Alazan (340 GWh/year) hydro project, and the 76 MW (284 GWh/year) Tartar 2 hydro project.

Design work is under way for two further binational projects with Iran: the Khoda_Afarin (two 100 MW hydro plants) and Qiz-Qalasy (two 40 MW hdyro plants) on the Aras river.

Bakuhydroproject has also participated in the construction of the : Chiryuri 1 and 2 hydro plants(72 MW and 9 MW respectively) on the Sulak river in Daghestan, Russia, completed in 1962; Vietnam's first large hydro project, the 120 MW Thac-Ba scheme on the Chay river in Vietnam, completed in 1970; and, the 1920 MW Hoa Binh project on the Da river in Vietnam, completed in 1994.

Future outlook

The development of water resources is paramount in Azerbaijan, especially for thoese regions which rely on irrigated agriculture. Therefore the existing and planned water projects are multipurpose, aimed at solving problems affecting industry, irrigation, water suuply, fisheries, and flood protection, for the urban and rural populations.

In view of constantly rising fuel prices, there is an increasing need to develop mini hydro resources on smaller water courses, as well as at existing and planned irrigation storage reservoirs and canals.

A number of complex multipurpose projects are planned, including the Tovouz project, the Ismailly hydro plant at an irrigation storage reservoir, and Khoda-Afarin and Qiz-Qalasy (the two joint projects with Iran mentioned above).

Besides this programme, it is planned to reconstruct existing small hydro plants and to construct new power stations at irrigation schemes. Construction of hydro plants on the Samur-Absheron canal and on the main Mil canal (28 MW) is planned, while another has been designed for the Moghan canal.

In view of the supply situation in the Nakhichevan Autonomous Republic, special attention is being paid to the development of the hydro potential of its rivers.

Construction of the Ordubad hydro project (36.6 MW) on a diversion canal from the Aras river, and two small hydro plants at irrigation schemes(Vayhir, 4.7 MW, and Arpachai, 12 MW) is planned.

Bangladesh

Bangladesh covers an area of 144 OO0 km2 and has a population of 128 million.

The Ministry of Water Resources is the national authority in charge of water, and there are several regional authorities, such as the Bangladesh Water Development Board (BWDB), WASA, BIWTA, and so in.

Energy and power sectors
The main sources of energy in Bangladesh are: natural gas(86.6 per cent), hydro (1O per cent) and others (3.4 per cent). The main sources of electricity production arc: thermal steamfired (59 per cent), gas (25 per cent), hydropower (1O per cent),

combined cycle (4 per cent) and diesel (2 per cent).

The national energy authority is the Ministry of Energy & Mineral Resources of the Government.

The national electricity and distribution is the Bangladesh Power Development Board (BPDB0), and regional authorities includes DESA and REB.

The per capita electricity consumption is 80 kwh/year.

Powerplants are owned and operated by BPDB. A further 2000 MW of capacity will be needed soon to meeting ingdemand. Many powerplanls and transmission lines are in need of rehabilitation.

A US$ 85 million state-of-the-art National Load Despatch Centre is to be implemented for the BPDP. Beca Worley International and SMEC of Australia were recently engaged to carry out planning, design and specification studies.

Hydropower development
By early 1995, the installed capacity of all powerplants was about 2800 MW, of which 230 MW was hydro capacity.

The production of the country's one existing hydro plant, the 230 MW Karnfuli plant, commissioned in 1962, is 796 GWh/year. It supplies 1O per cent of the country's electricity.

The plant's two 47 MW units are currently being rehabilitated in a project funded by the World Bank. A completely new Kaplan runner is being supplied for one unit, and new runner blades for the other.

There is no small, mini or micro hydro at present. Canal and river drops were recently studied by a working group from the Ministry of Power. Water Resources and Flood Control, which identified 15 sites in the Chittitanong Hill tracts. Sylhet district,

Mymensingh-Jamalpur and Rangpur-Dinajpur areas. Further investigation was suggested, although it was clear that the potential for high-head projects was very small.

Belgium

Belgium has an area of30 528 km2 and a population of 10 million. Average annual precipitation (in Brussels) is 780 mm, but rainfall is unevenly distributed throughout the country.

There are 15 dams more than 15 m high in operation.

Energy and power sectors

The total installed capacity at all powerplants is 15 646 MW(with production of 74 427.5 GWh/year gross, 70 631 GWh/year net), comprising: 13 598 MW from privately owned and 1032 MW from publicity owned plants in public service: 785 MW is from auto-producers, and 231 MW is from autonomous producers.

Per captia electricity consumption is 6400 kWh/year(1993).

Power development

The gross theoretical hydropower potential in Belgium is 1750 GWh/year; technically feasible potential is 1400 GWh/year; and, the economically feasible potential is 1000 GWh/year.

There is 101.9 MW of installed hydro capacity at 39 hydro plants (10 private and six publicly owned, all in public service, and 23 owned by autonomous producers). The plants are small, range from 11.6 MW (beberce), down to less than 100 kW.

The 10 privately owned hydro plants arc operated by Electrabel, which owns Beverce and nine plants of less than 2 MW. The six publicly owned plants art operated by SPE.

The plants owned by autonomous producers are mostly very small(less than 200 kW), with the six largest (of between 0.6 and 2.5 MW) owned by the Ministry Wallon de l'Equipement et des Transports (MET).

THE hydro plants in operation produced 238.1GWh in 1996, about 0.3 per cent of national electricity production.

Belgium has 1316 MW of installed capacity at two pumped-storage plants, which generated 961 GWh in 1996. The 1171 MW Coo Trois Ponts scheme on the Ambleve river comprises two plants. The Plate Taille dam, part of the Eau d'Heure complex, has a capacity of 146 MW and is owned by MET.

BENIN

The Republic of Benin, in West Africa, has an area of 112 622 km2. It is bordered by Togo to the east, Burkina Faso and Niger to the north, Nigeria to the east and the Atlantic Ocean to the south. Benin has a population of 5.7 million, with 63 percent living in rural areas. The population is increasing at an annual rate of 3.3 per cent. The capital city is Cotonou in the south.

The main mountain range is the Atacora range (up to 800 m). There is a zone of sedimentary rock in the south, lateritic in the centre and base and sedimentary rock in the north. Seismicity is negligible.

The main agricultural products are: maize, sorghum, potatoes, manioc (cassava) and cotton.

Water resources
The main river basin in Benin is the Oueme, with a catchment area of 46 990 km2.

The annual average precipitation is 1180 mm. providing a mean annual precipitation volume of 132.9 km3. The climate is tropical.

The Societe Beninoise d'Electricite et d'Eau (SBEE), Direction de l'Hydraulique (DH), is in charge of the country's water resources, including at regional level. Deregulation of the water sector is envisaged in the future.

Per capita water consumption in urban areas is 50 litres/day, while in rural areas it is 10 litres/day, an average of about 25 litres/day.

A total of 0.32 km2 is under irrigation, of which about 1 per cent is fed by reservoirs.

Benin has two large dams in operation, according to ICOLD's definition, Nangbeto and Yeripao, both built for hydropower generation and irrigation.

Energy and power sectors
About 73 per cent of primary energy comes from fuelwood, 25 per cent from crude oil/hydrocarbons, and 2 per cent is from electricity. Hydropower supplies 89 per cent of while 11 per cent is from thermal plants.

The total annual electricity consumption is 278.2 GWh, representing per capita consumption of 48.8 kWh/year. In 1996, 213 GWh of electricity was imported.

Energy consumption is expected to increase by 20 per cent/year during the next 10 years, with electricity consumption rising by 6 per cent/year.

The Ministere des Mines, de l'Energie et de l'Hydraulique (MMEH) is in charge of the country's energy, via its Direction d'Energie, and the national electrical authority is SBEE. With Communaute Electrique du Benin (CEB) a major regional electricity utility. Benin has a national grid system.

Powerplants thus come under public authorities. There has not been any deregulation yet, although it is envisaged in the future.

Hydropower development
The theoretical hydropower potential of Benin is estimated to be 1676 GWh/year; which is effectively the gross potential. This was evaluated in 1996.

There is 67.4 MW of hydro capacity in operation. of a total powerplant capacity of 93.75 MW (1995 figures). The generation from hydro in 1996 was 170 GWh. Almost all of hydro capacity in operation is at the 66.4 MW multipurpose Nangbeto development, which began operation in 1987.

A further 100 MW of hydro capacity is to be installed soon at the Adjaralla project, planned by the Governments of Benin and Togo at the border between the two Countries, and to be carried out by CEB. It would include a 50 m-high dam, which would be either a fill or an RCC and fill structure.

Three further medium-scale hydroelectric projects are planned: Ketou (72 MW, 41 m head), Olougbe (42 MW, 32 m head) and Assante (36 MW, 31 m head).

There is one small hydro plant in operation, Yeripao (1 MW), which generates about 8.6 GWh/year. No further plants are under construction or planned.

Future outlook

Great efforts have been made in the field of water resources development, as is also the case with the urban and rural environments. In the electricity sector, some major challenges lie ahead, particularly in the area of rural electrification. To date, consumption of electricity represents only 3 per cent of total energy consump

Bhutan

The Royal Kingdom of Bhutan has an area of 47 000 km2 and a population of about 1.78 million.

Hydropower development

The country's theoretical hydropower potential is equivalent to about 20 000 MW of capacity. About 100 potential sites for large or medium pl4ants which are considered economically feasible, with a total capacity of approximately 16 000 MW, have been identified. No assessment of the considerable potential for mini or micro hydro has been made.

The total installed hydro capacity is 355 MW, of which Chukha plant contributes 336 MW. There is only about thermal generating capacity of thermal generating capacity.

Hydropower supplies essentially all of the country's electricity requirements. Hydro generation in 1995 was 1710 GWh, representing 99.6 per cent of power production.

The Government of is now seeking to develop hydro not only for domestic use, but to provide revenue through power exports. This will help contribute to Bhutan's independence.

By the end of 1998, the preconstruction phase of the 1020 MW Tala hydro project, to be built for power export to India, will be completed. The project should be commissioned by 2004.

The Kurichi hydro project is being designed and built by NHPC of India and is owned by the Kurichi Project Authority of Bhutan. It comprises the construction of a 55 m-high concrete dam and 45 MW surface powerhouse, with provision for a fourth 15 MW unit in the future. It is on thhe Kurichi river, which rises at el. 7600 in the Himalayas in Tibet, flows for about 110 km through Bhutan, then forms the river Manas in India and flows into Assam, before joining the Brahmaputra. The project is being implemented with funding from India.

The 23.8 MW Basochhu hydro project, 90 km east or Thimphu in Wangdi Phodrang province, is being funded by Austria, and is scheduled for commercial operation by the end of 1999. The powerhouse will contain two 11.9 MW Pelton turbines, and will supply power to the capital region.

small hydro

Small and mini plants benefit many isolated communities in Bhutan. By the end of 1997, it was intended to recommission eight existing mini hydro Plants and to build one additional 2.2 MW small plant. Feasibility studies for several further small hydro plants have been corried out.

BOLIVIA

Bolivia has area of 1 100 000 km2 and a population of 7.9 million.

Water resources
The average annual precipitation is 650 mm, and the total mean annual precipitation volume is 550 000 m2, of which 20 per cent is runoff.

The national authority in charge of water resources is the Direccion Nacional de Manejo de Cuencas, and there are Prefecture government Departments for each major city.

There are six large dams in Bolivia, according to ICOLD's definition, and none under construction.

Energy and power sectors.
The main sources of energy in Bolivia are: natural gas, oil products and hydropower.

The main sources of electricity in 1995 were: hydro 957 per cent), natural gas (34 per cent) and diesel (9 per cent).

The national energy authority is the Secreataria Nacional de Energia, and the national power authority is the Superintendencia de Electricidad.

Powerplants are now owned and operated by: Empresa Eletrica Corani SA, Empresa Electrica Valle Hermoso S.A., Empresa Electrica Guaracachi SA, Compana Boliviana de Energia Electrica (COBEE) and Corporacion Minera de Bolivia (COMIBOL). About 90 per cent of capacity is privately owned.

Per capita electricity consumption is 413 kWh/year.

Hydropower development
Bolivia has a gross theoretical hydro potential of 178 000 GWh/year. The technically feasible potential has been estimated at 126 000 GWh/year and the economically feasible potential at 50 000 GWh/year. All these data were evaluated in 1984. Only, 1.75 per cent of the technically feasible potential has been developed.

There is a total of 895 MW capacity at all of Bolivia's powerplants, of which 315 mw is hydro capacity. In 1995, 1722 GWh was generated by hydro, representing 57 per cent of national power production.

A further 61 MW of hydro capacity is under construction, and about 700 MW s planned. Major new plants planned are: Misicuni (120 MW, 552 GWh/year); San Jose (126 MW< 840 GWh/year; and, Palillada (80 MW, 470 GWh/year).

Small hydro
There are 64 small, mini, or micro hydro plants in operation (up to 10 MW), with a total capacity of 104 mw. it is planned to implement about 52 MW of new or refurbished small hydro capacity during the next five year.

BOTSWANA

The Republic of Botswana has an area of 582 000 km2 and a population of 1.5 million.

Water resources

The Ministry of Mineral Resources and Water Affairs is ultimately responsible for Botswana's water resources, and management is carried out through the Department of Water Affairs. Urban water projects come under the authority of the Water Utilities Corporation, while major villages and rural areas are managed by either the Department of Water Affairs (DWA) or district councils.

The annual average precipitation is 450 mm, giving a total mean precipitation volume of 261.9 km3.

There are now four large dams in operation, according to ICOLD's definition, and the total water storage capacity of all dams is 0.35 km3.

Construction of the 34 m-high Letsibogo dam, part of the North South Carrier (NSC) project, was completed in 1997. This project resulted from the National Water Master Plan, undertaken between 1989 and 1992, which concluded that excess water from rivers in the northeast of the country should be diverted to the capital, Gaborone. Water will be transferred from the Letsibogo reservoir (100×106 m3) via an 18 km-long pipeline to the important mining, town of Selebi-Phikwe: and from there will be transferred south to Gaborone via the NSC.

The Lower Shashe dam, at the confluence of the Shashe and Tati rivers, about 50 km east of Francistown, is at the feasibility stage; construction is expected to be completed around 2010.

A legal framework for EIAs is currently under development. However, an EIA is already carried out for all major projects, especially those funded by international agencies and donors.

Energy and power sectors

The Ministry of Mineral Resources and Water Affairs is in charge of energy. The national power authority, Botswana Power Corporation (BPC), owns and operates all powerplants.

Electrical power is generated entirely from thermal sources,at two major coal-fired thermal plants. In terms of total electricity consumption, a significant proportion of electricity comes from imports, which is a mix of hydro and thermal. Thermal plants in Botswana (118 MW) generated 724 GWh in the year to March 1997, while a further 753 GWh electricity was imported from South Africa and Zimbabwe.

Future outlook

The largest existing plants are in the east of the country. The Limpopo river system in the southeast may also be exploited soon. Future plans are to develop schemes further north, in particular to exploit the Zambezi river system and the Okavango to meet water demands beyond 2020.

Brazil

Brazil covers an area of 8 512 000 km2 and has a population of 161 million.

Water resources

The average annual precipitation is 1954 mm/year, and the total mean annual precipitation volume is 16 630 km3, of which 32 per cent is runoff.

There are 594 large dams in operation in Brazil. Sereral major dams are under construction: Serra da Mesa (153 m-high rockfill dam); Ita (124 m-high CERD); Corumba (100 m-high, rockfill dam); Miranada (79 m –high RCC/gravity dam); and, Porto Primavera (60 m-high concrete gravity and earthfill dam).

The national water resources authority is the Ministerio do Mecio Ambiente, dos recursos Hidricos e da Amazonia legal. Most states have their own regional water authorities.

A legal framework is in place for environmental impact assessment and management, called AIA-RIMA (Avaliacao de Impacto Ambiental).

Energy and power sectors

The sources of primary energy in 1996 were: fossil fuels(28.7 per cent), biomass (27.2 per cent) and electricity 944.1 per cent). Total primary energy consumption was 7909×106 GJ.

The main sources of electricity in 1996 were; hydro (95.7 per cent), coal (1.5 per cent), fuel oil(1 per cent), nuclear (0.9 per cent) and diesel (0.9 cent).

The total electricity consumption in 1996 was 260 908 GWh, representing per capita consumption of 1736 kWh/year.

Total energy consumption is expected to increase by about 5 per cent/year to 425 TWh in 2006. Total electricity demand is expected to increase by about 4.7 per cent year during the next five year, to 57.6 GW in 2001.

During 1996, 40.7 TWh of electricity was imported, which was from Paraguay's half of the power generated the itaipu hydro scheme.

The national energy authority is the Ministerio de Minas e Energia, and the national power authority is the Departmento Nacional de Aguas e Energia (DNAEE). Most states have their own regional power authorities.

The Federal Government controls through ELETROBR AS several subsidiaries which own the majority of powerplants and the long-distance main transmission lines. It also co-ordinate the planning and operation of the system, and finances construction.

Most state own distribution companies, and a few own vertically companies which play an important role in generation, transmission and distribution, especially in Sao Panio, Minas gerais and Parana.

It is planned to interconnect the two large transmission system, in the south/southeast and north/northeast, in 1999.

Deregulation of the energy and power sectors was started in 1995. The format of the deregulated market will be separated generation, transmission and distribution. The electricity market involves power purchase agreements.

The Government is carrying out privatization of its subsidiaries and it aims to stimulated privatization of the stated-owned power companies.

Actions have recently been taken to attract private investors into the power sectors. A new regulating body, ANEEL (Agencia nacional de Energia eletrica) has been created, which will be able to delegate some of its duties to State agencies to avoid excessive centralization.

It is planned to provide free access to the grid and to implement transfers of energy. SINTREL has been created to establish a transmission charging methodology.

Hydropower development

Brazil has the largest amount of hydropower resources of South America. Up to date hydropower potential data are not available, but brazil's gross theoretical hydro potential feasible was calculated in 1991 to be 3020 TWh/year. The technically feasible potential has been estimated to be 1167 to 1433 TWh year; and, the economically feasible potential has been estimated at 720 to 806 TWh/year. So far less than a quarter of the technically feasible potential has been developed.

Brazil has about 52 427 MW of hydro capacity in operation, and hydro plants generated 262 TWh in 1996. The 3000 MW first stage of the Xingo project was fully commissioned by September 1997.

About 10 GW of hydro capacity is under construction; and about 15 GW is planned.

Some of the largest projects under construction (with expected first generation dated include:

Ita(1450 MW, 2000);

Porto Primavera (1814 MW, 1998);

Salto Caxais (1240 MW, 1998);

Serra da Mesa (1293 MW, 1998);

Tres Irmaos (810 MW);

MIRANDA (390 MW); and,

CORUMBA I (375 MW).

Among the many future medium-and large-scale projects planned are projects to add to 700 MW units at Itaipu (one for Brazil and Paraguay) and to add 4125 MW of capacity at the Tucurui plant (currently 4000 MW). A further 520 MW of uprating capacity has been identified at other existing hydro schemes.

New projects include: Cana brava 9450 MW): Salto Pilao (220 MW); Irae 9420 MW); Machadinho (1040 MW); Campos Novos (880 MW); Aimores (396 MW); Garabi (750 MW, which will be binational); Capim branco I (306 MW); Itapebi 9375 MW); Sapucaia (300 MW); Lajeado (800 MW); and, Serra Quebrada(1328 MW).

Small hydro

Brazil has about 25 TWh/year of technically feasible potential for small hydro plants (up to 10 MW). There are at least 351 small hydro plants in operation, with a total installed capacity of 117 MW. A further 700 MW is under construction or planned.

Bulgaria

Bulgaria has an area of 110 630 km2 and a population of about 8.8 million.

Water resources

The National Council of Water at the Ministry of Environment and Water is responsible for water resources development, and there are six regional water authorities.

Average annual precipitation is 673 mm. The total average annual precipitation volume is 74.5 km3, with total runoff of 20.1 km3 and per capita water consumption of 2360 litres/person/year.

The southeast region, covering only one third of the territory, and the higgest mountains, rila, Pirin and the Rodophi, yields two-thirds of the water runoff and has more than 90 per cent of the hydropower potential. The other areas, particularly the plans in the east and north, have insufficient water resources for irrigation and water supply. During the spring, 70 per cent of the total water flow is available, but much goes unutilized. While the average runoff is 20.1 km3/year, there is a 75 per cent probability of the total only reaching 15.3 km3, and in dry years it is only 9.25 km3.

To manage water resources for year-round utilization. 202 large multipurpose dams have been built, with a total reservoir capacity of 4.88 km3; 185 dams are at least 15 m high. There are also more than 2000 small dams, principally for irrigation.

The 72 m-high Kustendil dam, on the Slokoshnitza river is under construction, for the purpose of water supply.

During the past year, a general water strategy has been developed, with public participation in the discussion, which will be adopted.

Energy and power sectors

The Ministry of Energy is in charge of Bulgaria's energy sector. The National Electric Company is the national power authority, which produces 89.1 per cent of all electrical energy.

The main sources of electricity production in 1996 were: coal (39.3 per cent), oil (3 per cent), gas (8.5 per cent), nuclear (42.2 per cent) and hydro (7 per cent). Total electricity production in 1996 was 42 801 GWh, representing total per capita consumption of 5025 kWh/year, with about 1300 kWh/person/year for domestic consumption.

About 55 per cent of electricity was generated with imported fuels in 1996, of which 42.2 per cent was nuclear.

During 1996, 2252 GWh of electricity was exported (5.26 per cent), while 1803 GWh was imported.

Hydropower development

The gross theoretical hydropower potential is 26 410 GWh/year. The technically feasible hydro potential is 15 000 GWh/year. The economically feasible potential is now estimated be approximately 12 000 GWh/year, about 30 per cent of which has been developed so far.

The total installed capacity of all Bulgaria's powerplants is 12 580 MW, of which 2407 MW is hydro capacity (excluding pumped-storage plants). Thc average annual generation of the hydro plants in operation is 2507 GWh/year, which is on average 4.85 per cent of national electricity production (almost 7 per cent including pumped storage).

In 1996, there was 582 MW of pumped-storage capacity in operation (producing 500 GWh/year on average), including two 216 MW units at the Chaira pumped-storage station. The third 216 MW unit was commissioned during 1997, and the forth and final unit will be put into operation in late 1998. The 864 MW plant , 120 km southeast of Sofia is believed to have the world's highest head for a 216 MW single-stage pump-turbine, at 701 m.

Small hydro

There are 57 small, mini and micro hydro plants in operation, with a total capacity of 152 MW. Four other small plants are under construction and 76 are planned (about 40 MW total capacity, 170 GWh/year).

Future outlook

The main priorities for future development include the construction of a further 420 MW of hydropower capacity, already at the detailed design stage. Coal-fired and nuclear plants are also to be implemented, the latter after 2003. At present, 0.2 per of powerplant capacity is privately owned, but many small and large plants are being prepared for privatization.

BURKINA FASO

Burkina Faso has an area of 274 000 km2, and a population of 10.4 million.

Water resources

Water resources in Burkina Faso are managed by the Ministry for Environment and Water.

The total mean annual precipitation volume is 165 km3, of which only 9 km3 is runoff. The country has eight large dams in operation, of about 2100 dams in total. The total storage volume of all reservoirs is about 4.6 km3. A Burkina Committee on Large Dams has recently been established.

Work at two new dams began in Febuary 1998:

Ziga on the Nakambe river, which is 19 m high, will have storage capacity of 207×106 m3, and is being built for water supply to the capital, Ougadougou; and,

Diebuugou on the Brugruriba river, 18 m high, with a storage capacity 1450 x 106 m3, being built for hydropower (it will have a 12 MW hydro plant).

Several large dams are planned:

Nounibiel (30 m high, 11 000×106 m3 reservoir storage capacity, 60 MW hydro), to be built for hydro, and irrigation;

Samandeni (18 m high, storage volume 500×106 m3, for flow regulation, 2.5 MW hydro and irrigation),

Yengue (20 m high 30×106 m3 storage capacity, to be built for river regulation and irrigation): and,

Suo (15 m high, 20×106 m3 storage, also for river regulation and irritation).

Per capita domestic water consumption is 40 litres/day, in urban areas and 20 litres/day in rural areas. The Government's objective is to provide 20 litres/person/day of clean water for consumption, and a gross volume of' 2.5 km3/year for energy, irrigation, industrial and domestic supply and municipalities.

The government has adopted an environment Code for the assessment of all water-related projects. All types of dams are subject to this assessment.

The main domestic civil contractors in the field of dams and hydro projects are Ovmarou Kana Zoe and Fadoul Technibois.

Energy and power sectors

The main source of energy in Burkina Faso is wood and biomass (about 85 per cent); with fossil fuels, electricity and oth- ers supplies the other 15 per cent. Electricity currently represents between 2 and 3 per cent.

The main sources of electricity in 1995 were: imported oil (61 per cent); and, hydro (39 per cent). The total electricity consumption in 1996 was 225.7 GWh, which corresponds to only 18 kWh/person. Electricity demand is expected to increase by 6.4 per cent/year during the next decade.

Energy comes under the auspices of several ministries, principally the Ministry of Energy and Mines, but also the Ministry for Environment and Water, Ministry of Public Works and the Ministry of Commerce and Industry.

Electricity is managed by SONABEL, which owns and operates all powerplants, under the Ministry of Energy and Mines. Deregulation is envisaged, but not yet scheduled.

Interconnections with Ghana and Cote d'Ivoire grids have recently been established, which will yield about 50 MW of capacity. An important new feature of the electricity market is the establishment of power purchase agreements between Burkina Faso, Cote d'Ivoire and Ghana. However, no power was imported or exported during 1996.

The national grid system does not yet extend throughout the whole country. One of the main priorities for the future is the provision of additional interconnections.

Hydro plants are all publicly owned, while about 20 per cent of all powerplants are privately owned. The private sector only generates power for its own needs.

Hydropower development

The gross theoretical hydro potential of Burkina Faso has been re-evaluated. It is 150 MW (1316 GWh/year), and both the technically and economically feasible potential are now estimated to be 75 MW (about 215 GWh/year). About 45 per cent of the economic potential has been developed.

There is currently 34 MW of hydro capacity in operation, of a total powerplant capacity of 109.6 MW. The average annual generation from hydro plants is 95 GWh/year. Two hydro plants in operation are part of multipurpose schemes.

A further 12 MW of hydro capacity is under construction, at the Diebuugou dam project, and at least 62.5 MW is planned. The largest project planned is Noumbiel (60 MW).

Small hydro

There are two mini hydro plants in operation, with a total capacity of about 2 MW. None is under construction at present, although the 2.5 MW Samandeni project is planned.

The electricity authority is now conducting a campaign of investigation for possible small hydro sites, but it is not yet completed.

Future outlook

Burkina Faso is in the semi-arid area of Africa where water resources development is a great challenge. The concept of hiolistic basin area development is now being adopted for regional water resources and energy development, and a large project of integrated management for the water resources in the western part of the country is under way. This project includes water storage dams, river regulation, irrigation, transport and hydropower generation.

Most water resources and hydropower projects will be implemented in the rainy, mountainous part of the country, in the west.

BURUNDI

Burundi covers 27 834 km2 and has a population of about 6.3 million.

Water resources

Average annual precipitation range from about 800 mm in the Imbo Plain to 2000 mm at the Zaire-Nile boundary crest. Total average precipitation is 18.38 km3, of which 12.25 km3 is runoff.

Per capita water consumption is 1864 m3 person/year in urban areas and 173 m3/person/year in rural areas.

The Ministry of Environmental and Land Planning is in charge of the country's water resources. The power organizations mentioned in the next section are responsible for water distribution in urban and rural areas.

There are two large dams in operation, built for hydropower generation. No major dams under construction or planned.

Energy and power sectors

The main sources of energy in Burundi are wood and its derivatives (92 per cent); petroleum products (6 per cent); hydropower (1 percent); and others. Hydropower provided virtually 100 per cent of electricity in 1995, although in April 1996 a set of standby diesel units with a capacity of 5.5 MW was installed.

The Ministry of Energy and Mines, Directorate General of Energy (DGE) is in charge of energy. The national power authority is REGIDESO (Regi des Distribution d'Eau et d'Electricite), which owns all powerplants, except for those below 150 kW, and is responsible for power distribution in urban areas. It operates in Bujumbura and Gitega and adjacent rural areas, while the Direction Generale de l'Hydraulique et des Energies Rurales (DHER) independently develops rural electrification projects. There is no private ownership of hydro plants.

Per capita electricity consumption is 6300 kWh/year total and 1948 kWh/year for domestic consumption.

The main priority for the future is to build a new hydro plant on the Mpanda river (10 MW, 43 GWh/year), and another on the Kaburantwa river (20 MW) in the northwest.

Hydropower development

The theoretical hydropower potential of Burundi is about 6000 GWh/year (1371 MW), evaluated in 1994. The technically and economically feasible potential, evaluated in 1995, is 1500 GWh/year (300 MW). So far, about 10 per cent of this potential has been evaluated.

Burundi has about 43 MW of installed capacity, all of which 32 MW is at hydro plants (excluding the 5.5 MW standby diesel sets). This includes the 26.6 MW Ruzizi II station, shared by Zaire, Rwanda and Burundi.

In 1995, the generation by hydro was 147 GWh/year, 100 per cent of power production.

No hydro capacity is under construction, but an additional 36.2 MW of hydro capacity is planned.

The Mpanda project is to be built for hydro and irrigation. It will provide 10 MW (34 GWh/year) and allow for the irrigation of 5550 ha. Bidding documents will be prepared by March 1997 by the DGE. The project cost is US$ 55 million. It will include two Pelton units, operating under a head of 850 m.

A feasibility study, for the Kabu 16 project was completed in January 1996. It will have a capacity of 20 MW (117 GWh/year), is also to be developed by DGE, and will cost US$ 44.8 million.

For both projects, the major problem is finance. Efforts are now being made to secure financing. It is hoped that Mpanda could be in operation by 2000 and Kabu 16 by 2002-2003.

There are 27 small hydro plants in operation (defined as plants up to 1 MW), with a total capacity of 2.93 MW.

Future outlook

Priority is to be given to the rehabilitation of plants and transmission lines for the 110 kV high voltage grid.

The country is currently seeking fund to construct the two new hydro plants mentioned above, to meet its foreseen energy deficit within the near future.

It is hoped to increase the water supply infrastructure with a view to supplying the whole population by 2000. Rehabilitation of the infrastructure and training of the population concerning the maintenance of public works will be required, and measures will be taken to protect water resources from pollution.

Byelarus

The Republic of Byelarus covers an area of 207 600 km2 and has a population of 1O.4 million.

water resources
The average annual precipitation is 600 mm. The total annual precipitation is 125 km3, with runoff of O.364 km3.

Per capita water consumption is 250 m3/year.

The national water authority is the Ministry of Natural Resources and Environment Protection. There are six provincial ecological committees.

Byelanrus has no large dams, by ICOLD's definition, but there are about 180 smaller dams (less than 15 m high).

Energy and power sector
The main sources of energy in Byelarus (in 1993) were: oil(48.9 pet cent) end natural gas(39.2 per cent).

Almost all electricity production is from thermal plans (district stations, 54 per cent, and central heating/powerplann. 46per cent). with hydro supplying about 0.1 per cent.

The national energy authority is the Ministry of Fuel and Energetics, which owns and operates all powerplants. There are also six provincial organizations for energy and electricity.

Per capita electricity consumption was 3410 kWh/year in 1993, but it used to be higher (478n kWh/year in 1991).

Hydropower development
The gross theoretical hydropower potential of Byelarus is only 7500 GWh/year; the technically feasible potential is 3000 GWh/year; and, the economically feasible potential is 2500 GWh/year. These data were calculated in 1960.

The installed capacity of all powerplants in 1995 was 7390 MW, of which 7 MW is hydro capacity. Hydro generated 20 GWh in 1995.

The Vilias plant in Minsk province (1.8 MW, two units) is under construction and should be commissioned soon.

About 1O MW is planned at new hydro plans by 2000 including Novopolot (O.6 MW). Several refurbishment projects are also planned.

Future outlook
The main priorities for future development are the introduction of more thermal powerplant, the planning of a nuclear power station, and further hydroelectric development.

Cambodia

Cambodia has a total land area of 181 035 km2 and a population of 1O.6 million.

Water resources

Annual precipitation varies between 1300 mm and 1500 mm, with 90 to 95 per cent falling in wet season.

The Ministry of Agriculture is responsible for the development of water resources for irrigation. An area of about 890 km2 is under irrigation. There are two large dams in operation, none higher than 15 m. A number of small embankments have been built, mostly for irrigation purpose.

Energy and power sectors

Cambodia imports about 97 per cent of its energy, from Singapore, but also from Thailand, Laos and other countries.

The Ministry of Industry, Mines and Energy is responsible for hydropower development, and the national power authority is Electricite du Cambodge, which owns and operates powerplants. There is no private ownership at present, although this is to be encouraged in the future.

Per capita power consumption is only about 30 kWh/year.

An agreement has been reached with Laos on future energy Co-operation, and the two countries will co-operate in a feasible study for the construction of powerplants on the Sckong river, as well as at the Khone Phapheng Waterfall in southern Laos for power export to Cambodian towns.

Hydropower development

The country's hydro potential is under evaluation at present. The technically feasible hydro potential was estimated in the past as 83 000 GWh/year.

The installed hydro capacity is about 11 MW (74 GWh/year).

CAMEROON

The Republic of Cameroon has an area of 475 000 km2 ,and a population of 13.5 million.

Water resources
Average annual precipitation is 2131mm. The total mean annual precipitation volume is about 1012 km3, with total runoff of 253.3 km3.

The Ministry of Mines, Water and Power (MINMEE) is responsible for water resources. There are regional subsidiaries for the country's ten provinces.

There are nine large dams in operation.

A major reservoir is planned, Lom Pangar, with a capacity of 7.5 km3 and covering an area of 6100 km2.

Energy and power sectors
MINMEE is responsible for energy development, and its Department of Energy is responsible for the electricity sector. There are 10 provincial power authorities.

Per capita power consumption is 218 kWh/year. Hydropower plants produce about 97 per cent of electricity, with thermal plants supply the balance.

Societe Nationale d'Electricite du Cameroun (SONEL) is the National Electricity Corporation, with responsibility for generation, transmission and distribution of electricity.

Powerplants are generally publicly owned (93 per cent), the remaining 7 per cent of privately owned stations being covered by the French Development Fund.

Hydropower development
The gross theoretical hydro potential of Cameroon is 294 000 GWh/year (1983 Survey). Of this, 115 000 GWh/year is considered technically feasible, and 103 000 GWh/year economically feasible. Only about 5.5 per cent of the technically feasible capacity has been developed so far.

Of the country's total installed capacity of 802 MW, 723 MW of capacity is at hydropower plants. The average annual generation from hydro stations is 2423 GWh/year, the actual generation in 1995 being 266/2 GWh.

No hydropower schemes are currently under construction, but an additional 250 MW of hydro capacity is planned for the future.

It is considered that the uprating and refurbishment of existing hydro plants could play a substantial role in strengthening the national power system. In particular, it is considered necessary to increase the discharge for tile equipment installed it tile Song Loulou (384 MW, eight units) and Edea I, II and III (204 MW total, 14 units) hydro plants.

The first unit at Song Loulou has recently been fully repaired and reconnected to the grid. Repair work on a second unit is being carried out during 1998. The Edea plants need to be assessed and rehabilitated. One of the units at the Lagdo plant (72 MW, four units) often fails and needs to be repaired.

There are plans for a number of new projects:

Lom Pangar on the Lom river. This major reservoir would provide 56 MW of hydro capacity, which could be upgraded.
Bini a Warak, on the Vina-North river in the north (75 MW).
Nachtigal on the Sanaga river (267 MW);

Memve'Ele on the Ntem river (202 MW); and,
Kader (15 MW).
Construction of the new Lom Pangar dam and reservoir, with a capacity of 7.5 km3 will allow for full use of the Song Loulou and Edea hydro plants, providing an increase in guaranteed power during low water periods of 216 MW for the south Cameroon grid.

The 56 MW hydro plant at the toe of the Lom Pangar dam would supply electricity to the isolated province of East Cameroon.

The 15 MW Kader hydro project is an alternative option for the supply of power to the East Province. This plant would also be at the foot of the Lom Pangar dam. The construction of the Kader plant would not preclude consideration of the other option.

The Bini a Warak hydro project in Adamaoua province, which is one of three provinces served by the North Cameroon interconnected grid, is also under consideration.

Future outlook
An evaluation of the energy and power sectors is foreseen this year, in view of the launching of an appeal for offers concerning privatization of the administration.

Canada

Canada has an area of 9 911 000 km2 and a population of about 28.4 million.

Water resources

Environment Canada is responsible for overall water resources development, but each Province also has one or more department(s) with jurisdiction for water. Natural Resources Canada is responsible for hydropower regulation.

The energy and power sectors

The National Energy Board advises the Federal Government on electricity matters, but electricity is primarily within the jurisdiction of the provincial utilities.

The main sources of electricity production in Canada in 1995 were: hydropower (62 per cent), nuclear (17 per cent), coal (15 per cent), gas (3 per cent), oil (2 per cent) and others (1 per cent). At the end of 1995, about 8 per cent of Canada's total electricity generating capacity was non-utility generated. Of this, 72 per cent was owned and operated by industrial establishment and the remainder by independent power producers.

Hydropower development

The gross theoretical hydropower potential of Canada is 1332 TWh/year, of which the technically feasible potential s estimated to be 981 TWh/year. The economically feasible hydro potential is estimated to be 536 Twh/year.

Canada has about 116 000 MW of installed capacity at all its powerplants, of which 65 678 MW is hydro capacity in operation. In 1996, the generation from hydro plants was 349 198 Gwh.

A further MW of hydro capacity is under construction at Hydro-Queec's Sainte_marguerite-3 project. The two units are scheduled to be commissioned in May and June 2001. By early 1998, the dam had been constructed to a height of about 120 m, of its total 172 m.

Qubec and new foundland have recently agreed to formal negotiations with a view to constructing a new hydro plant on the Churchill river in Labrador. The project would involve a new 2200 MW plant at Gull Island and the addition of 1000 MW at the existing Churchill Falls scheme. Newfoundland & Labrador, while Hydro-Quebec would own 34 per cent. The initial agreement is expected to lead to a final by the end of 1998.

Small, mini and micro hydro

There are more than 200 small, mini or micro hydro plants in operation in Canada (less than 10 MW), with a total capacity of about 1450 MW; a further 100 MW of small hydro capacity is planned. The Government is currently encouraging small hydro development through tax incentives.

Future outlook

About 12 GW of additional hydro capacity is planned, although there is increase uncertainty about the rate of development, so that most completion dated cannot be confirmed. Some of the major projects planned involve renovation, rehabilitation and upgrading of existing plants.

Chile

Chile covers an area of 756 626 km2 (continental area only and has a population of 14.2 million.

Water resources

The average annual precipitation is 1552 mm, and the total precipitation volume is 1150 km, of which 80 per cent is runoff. The national authority is in charge of water resources is the Ministerio de Obras Publicas, direccion General de Aguas.

There are approximately 87 large dams in operation.

The 120 m-high Pangue RCC dam and 450 MW hydro plant, were recently commissioned . other large dams under construction include the 75 m-high Corrales dam near Santiago and Puelaro, an 83 m-high rockfill dam; both are for irrigation.

The 570 MW Ralco hydro project, planned for completion in 2002, including a 155 m-high RCC dam a few kilometers upstream of Pangue dam on the Bio-Bio river in central Chile.

Energy and power sectors

The main sources of energy and power in Chile are oil, coal and hydropower. Hydro supplied 61.6 per cent of electricity in 1995, with coal supplying the remainder.

The national energy authority is the Comision Nacional de Energia(CHE).

Most powerplants in Chile are owned and operated by private companies. In the central grid (sic). Private ownership represents 86.3 per cent. And in the northern grid (SING). 71.6 per cent of plant capacity is publicly owned. Hydropower provides 81 per cent of the capacity of the SIC. Medium and large-scale hydro plants will continue to be considered for additional capacity.

The per capita electricity consumption is 1800 kWh/year.

Hydropower development

According to an evaluation in 1991, Chile's gross hydro potential is 227 245 Gwh/year, and the technically feasible potential is 162 232 Gwh/year, of which about 12 per cent has been developed so far. The economically feasible potential has not been evaluated recently.

The total installed capacity at powerplants of all types is about 6000 MW, of which 3740 MW is at hydro plants. The generation from hydro plants in 1995 was 18 408 Gwh/year.

The 195 MW cortaderal hydro project is under construction in central Chile. It is a run-of-river project. On the Cachapoal river, and is being built by a consortium of Bechtel Corp (of the USA)and Andrade Gutierrez (of Grazil). Most of the generation will be used by a state-owned mining company. With the remainder being sold to the SIC. The project is expected to be completed during 2000.

A further 2000 MW of hydro capacity is planned for construction over the next ten years .

Future outlook

The country's hydro potential is one of the most important resources . However, most of the resources are in the southern part of the country, far away from the load centres.

China

The Peoples Republic of China covers an area of 9 597 000 Km2 and the worlds largest,1.2 billion.

Water resources

The Ministry of water Resources continues to be in charge of water resources Commissions for the Yangtze,Yellow,Pearl,Haihe and Haihe rivers,as well as Provincial Water Resources Bureaux.

The average annual precipitation is 648 mm. The total mean precipitation volume is 6190 km3, of which 2711.5 km3 is runoff. China has 31 611 large dams in operation higher than 15m(4345 of which are higher than 30 m). In October 1997, there were 88 dams higher than 60 m under construction . of which 23 will be higher than 100 m.

The total water storage capacity of all dams is 457.1 km2.

Energy and power sector

National energy authorities are the Ministry of electric Power, the Ministry of Coal Industry,, the National Oil and Natural gas Corp, and the National Nuclear Industry Corp.

The Ministry of Electric Power is the national power authority, in addition to which there are five regional Power Groups, varies Power Corporations, and Provincial electric Power companies. The regional and provincial companies own and operate power plants.

Hydropower comes under the auspices of the Ministries of Water resources' and Electric Power.

There have not been any significant organizational changes in these sectors during the past year.

The main sources of primary in 1996 were: coal(1398 MT), Oil(157 Mt),gas(20.1109m3),hydropower(187 000 gwh), and nuclear(14 3000 kWh). The total primary energy consumption was 1388 Mt standard coal.

The main sources of electricity production in 1996 were: thermal (81.4 per cent), hydro(17.3 per cent), and nuclear and other (1.2 per cent).

Thc annual growth rate of energy consumption during the next 10 years is expected to be about 10 per cent/year. While power generation will increase by 8 to 9 per cent/year.

There was 236.5GW of installed capacity at powerplants in China in 1996, which is expected to increase to 290 GW by the end of thc century

The main priorities for the future are: to optimize the generation source mix; to achieve nationwide interconnection of power networks: and to promote nationwide energy conservation.

Hydropower development

China has a gross theoretical hydro potential of 5922.2 TWh/year (767 GW), and technically feasible potential of 1923.e TWh/year (378 GW); these were evaluated in 1980.The economically feasible potential is 1260 Twh/year(290 Gw). evaluated in 1993.

About 15 per cent of the technicality feasible hydropower potential of China has so far been developed.

Of the 236.5 GW of powerplant capacity in 1996, 56 Gw was hydro capacity. The generation from hydro plants in 1996 was 187 TWh.

Hydro capacity is scheduled to increase to 70 GW in 2000, and to 135 GW by 2010. Projects under construction will Provide approximately 50 GW of hydro capacity, and a further 80 GW is planned.

The large hydro plants under construction include Three Gorges(18 200 MW), Ertan (3300 MW) and Xiaolangdi (1800 MW).river closure for thc Three Gorges and Xiaolangdi Projects was achieved on schedule during 1997.

The largest plants planned are: Xiluodu (14 400 MW),Xiangjiaba (6000MW), Longtan (4200MW initially)and Xiaowan(4200MW).

There is now 2300 MW of capacity at pumped-storage plants in operation. A futher 3000 MW is under construction, and about 10 000 MW is planted.

Small hydro

The total number of small hydroplants in operation (defined as up to 25 MW)is now 45 174, with a total capacity of about 19.2 GW, that is, about a third of China's hydro capacity. About 14.5 Gw of capacity is that plants of up to 10 MW.

The current of commissioning of new small hydro capacity is about 1000 MW per year.

COLOMBIA

Colombia has an area of 1 142 000 km2 and a population of about 36.2 million.

Water resources

The total mean annual precipitation volume is 3400km3, and the total mean annual runoff is 1700 km3. There are currently 49 large dams in operation, according to ICOLD,s definition. The total storage capacity of all dams is km3.

Three major dams are under construction, all of which are associated with hydro projects:

Porce 11)(RCC dam, 118 m high, 1300×103m3 volume, 234×106 m3 reservoir capacity, 392 MW hydro plant, due to be completed in 1999); and

Urra I (earthfill,73 m high, 5000×10 3 m3 volume, 1200×10 6 m3 reservoir capacity. 400 MW hydro plant, due to be completed in 1999). kThis dam will also provide flood control; and

La Miel I(RCC, 188 m high. 1730×103 m3 volume, 565×106 m3 reservoir capacity, 400 MW hydro plant, due to be completed in 2002).

Several large CFRDs planned for future hydropower projects were listed in the 1997 world atlas.

The Ministry of Environment is responsible for water resources. And there are 26 regional authorities. There is a legal framework for environmental impact assessment and management.

Energy and power sectors

The main sources of primary energy in 1996 were fossil fuels and hydropower. The total primary energy consumption was 187 000 barrels of oil equivalent.

The main sources of electricity are: hydro (83 per cent in an average year), gas. Coal. And oil. No fuels are imported, although a small amount of electricity is imported.

The total electricity consumption in 1996 was 32 3000 Gwh, equivalent to per capita consumption of 888 kWh/year. Both energy consumption and electricity demand are expected to increase by 5 per cent/year during the next decade.

The national energy/ power authorities are: ICEL (InstitutoColombiano de Energia Electrica) ISAGEN(for generation)and ISA(for transmission)There are four regional power authorities: CCORELCA CCCCCVC CHEC and EEB

Fifty per cent of the electricity system is being privatized. Deregulation of the energy/power sector is under way. The electricity market operates with pool bidding. The deregulated market will vary regionally. With some regions being vertically integrated and others involving separated generation, transmission and distribution

In view of the privatization of the electricity sector, there have been many changes in the ownership and operation of hydro plants. Most powerplants of all types are now 50 per cent privately owned.

Hydropower development

The gross theoretical hydropower potential of Colombia is 1000 Twh/year. Of which 200 Twh/year is technically feasible and 140 Twh/year is economically feasible. So far, about 8 per cent of the technically feasible potential has been developed..

There is now 7880 MW of hydro capacity. Of a total powerplant capacity of 10 600 MW. Hydro plants generate on average 37 000 Gwh/year, representing 83 per cent of power production.

A further 1167 MW of hydro capacity is under construction, and about 6000 MW more is planned, although none of the planned plants will be constructed immediately. The mean cost of the hydro capacity under construction is USS 1300/kw.

The largest hydro projects under construction are: Lporce 11(392 MW), scheduled for commissioning in 1999: Urra 1 (400 MW). 1999: and, La Miel I (400 MW). 2002.I

There is 20 MW of pumped-storage capacity in operation

Future outlook

Colombia has many reso9urces for generating electricity: hydro coal, oil. Gas and some geothermal. However, with privatization. Predictions for future developments are uncertain.

There is one major multipurpose dam under consideration: upia (Guaicalramok).T here are also further hydro developments related to the water supply system for Bogota. A number of hydro projects are at the feasibility study stage.

If economic development speeds up. There will be ample scope for foreign investment in hydro projects.

CONGO, Dem. Re.of

The Democratic Republic of the Congo, formerly known as Zaire, has an area of 2 345 000 km2 and a population of about 44.1 million.

Energy and power sectors
The Department des Mines et de l'Energie (DNIE) has primary responsibility for energy policy, and is responsible for technical supervision of the Societe Nationale d'Electricite (SNEL), the national power authority.

The four major grid systems are supplied by 16 hydro plants (with a total capacity of 2442.16 MW). The two largest hydro plants are Inga II (1424 MW) and Inga I (350 MW).

SNEL also has one natural gas powerplant (2.9 MW) and 28 diesel plants (35 MW total). There are also 12 independently operated hydro plants, with a total capacity of 80.8 MW.

Hydropower development
The Dem. Rep. of the Congo has by far the largest hydro potential in Africa, and among the largest of any country in the world. Its gross theoretical hydro potential is 1397 GWh/year and its technically feasible potential is 774 000 GWh/year (representing about 100 GW). Both these figures were evaluated in June 1997. The economically feasible potential was calculated in October 1991 to be 419 210 GWh/year (based on sites in operation, studied, and inventoried assuming a 100 per cent load factor). Less than 1 per cent of the technically feasible potential has been developed.

A total of 5740 GWh of electricity was produced in the interconnected system during 1996, entirely from SNEL's 16 hydro plants. Hydropower provides virtually all of the country's electricity.

SNEL also purchased 41 GWh electricity from SINELAC's tri-national Ruzizi II hydro plant.

Further hydro projects have been studied, including Ruzizi III and IV, which would also be joint projects with neighboring countries.

Future outlook
The problem of water shortages in the northeast part of the country needs to be addressed. There is also a need to rehabilitate existing powerplants and the transmission network, and to implement new hydroelectric plants.

Further interconnection with other countries in the Equatorial Lakes region of Africa is planned in the long term by the DME, so that electricity can be exported from the Inga powerplants.

There is potential to construct a very large hydro project on the Zaire river, La Grand'Inga, which could have a capacity of up to 35 500 GW. This Would be built if plans to export vast amounts of power from Zaire to north and central African countries, including Egypt, go ahead. A recent study concluded that such a large project was technically and economically feasible, and envisaged the construction of an 8000 MW first stage plant by 2010.

There is the possibility of using Lake Mobutu Sese Seko as a storage site for a multipurpose project for hydro and for regulation of Nile river flows.

CONGO

Congo covers an area of 342 000 km2 in west central Africa, and has a population of about 2.5 million.

Energy and power sectors

The Department of Electricity and Water Affairs is in charge of water resources. The Societe Nationale d'Electricite (SNEL) is the national power authority.

Hydropower supplies 99.5 per cent of electricity production, with other generation being from a small number of diesel plants.

In addition to the 353.87 GWh generated in the Congo during 1995, the country imported 166.21 GWh front the Democratic Republic of the Congo (formerly Zaire).

Hydropower development

Congo has a vast hydro potential, in view of its location within the catchment of the Congo river. The technically feasible hydropower potential is at least 50 000 GWh/year, with the gross potential being significantly hight. of

There is 89 MW hydro capacity in operation at two plants, Moukoukoulou (74 MW) and Djoue (15 MW), of a total powerplant capicity of 98.7 M (110.9 MW nominal capacity In 1995, these hydro plants generated 352.01 GWh of the total domestic production of 353.87 GWIL (99.5 per cent).

COSTA RICA

Costa Rica covers an area of 51 100 km2 in Central America, and has a population of 3.42 million.Water resourcesThe annual average precipitation is 3300 mm. The total mean precipitation volume is 168 km3, and the total mean runoff is 110 km3.

Instituto Costarricense de Electricidad (ICE), the national power authority, is responsible for the country's water resources; there are no regional authorities.There are nine large dams in operation, according to ICOLD's definition. The total water storage capacity of all the reservoirs in the country is 1.4 km3. Most dams have been built for hydropower generation.

Energy and power sectors
The main sources of primary energy in Costa Rica in 1996 were: imported petroleum products (36 per cent); biomass (22 per cent); and. electricity (42 per cent). The total primary energy consumption was 73 064 TJ.

The main sources of electricity in 1996 were: hydro (80.5 per cent); thermal (8.6 per cent); geothermal (10.4 per cent); and wind (0.5 per cent). The total electricity consumption was 5018 GWh, of which 8.6 per cent was generated using imported fuels. During 1996, 233 GWh of electricity was imported, and 109 GWh was exported.

Both energy consumption and electricity demand are expected to increase by 5.1 per cent/year during the next decade.

The Ministerio de Ambiente y Energia is in charge of energy, while Instituto Costarricense de Electricidad (ICE) is the national power authority. There are no regional power authorities.

Per capita electricity consumption is 5101 kWh/person/year total, and 2623 kWh/person/year for domestic consumption.

Deregulation has begun, and will completed during the next four years. The deregulated market will involve separated generation, transmission and distribution. Both ICE and private generators currently own and operate powerplants.

Hydropower development
Costa Rica has a gross theoretical hydropower potential of 223 000 GWh/year, evaluated in 1963. The technically feasible hydropower potential is 41 200 GWh/year, evaluated in 1990.

So far, 9.6 per cent of the technically feasible potential has been 1 developed.

There is 935 MW of hydro capacity in operation, of a total powerplant capacity of 1267 MW. The generation from hydro plants in 1996 was 3375 GWh, although in 1995 it was 3620 GWh. The two 5.5 MW units at the Rio Lajas hydro project, owned by Hydroeletrica Rio Lajas S.A., were commissioned by August 1997.

A further 230 MW of hydro capacity is under construction, and another 467 MW is planned.

The largest hydro plant and under construction is. Angostura (177 MW, due to be completed in 2000); this project involves construction of a rockfill dam, 36 m high, with a reservoir capacity of 10.9 x 106 m3.

The largest hydro plants which are planned are: Pirris (128 MW, due for completion in 2003); and, Guayabo (234 MW, due for completion in 2006).

Small hydro
In Costa Rica small hydro is defined as plants of up to 20 MW; mini hydro is up to 5 MW; and, micro hydro is up to 100 kW.

According to these definitions, there are 42 small, mini or micro plants in operation, with a total installed capacity of 143.4 MW. A further 168 MW is planned.

Future outlook

The main priorities for future development in the next 10 years are hydro plants, geothermal plants and thermal plants, in that order, with hydro plants expected to represent about 74 per cent of additional development.

Croatia

The Republic of Croatia covers an area of 56 538 km2 and has a population of 4.78 million.

Water resources

The average annual precipitation is 975 mm. The total average precipitation volume is 55 km3, of which 27 km3 is runoff.

The State Water Authority is in charge of Water Resources in Croatia, and there are no regional authorities.

There are 29 dams in operation, all of which are large according to ICOLD's definition. The total storage capacity of all dams is 1.17 km3.

Per capita domestic water consumption is 188 litres/person/day in urban areas and 117 litres/person/day in rural areas.

Energy and power sectors

The main sources of primary energy in 1996 were: fossil fuels(60.3 per cent). electricity(32.3 per cent) and biomass (7.4 per cent). Total primary energy consumption was 352.6×106 GJ.

The main sources of electricity production in 1996 were: hydro (60.4 per cent), coal (O.9 per cent), oil(12.6 per cent), gas (7.7 per cent) and nuclear (18.4 per cent). About 10 per cent of generation was from imported fuels. Total electricity consumption was 12 878 GWh, representing per capital consumption of 2694 kWh/year. The Ministry of Economy is in charge of energy and Croatian National Electricity (CNE) is the national power authority. CNE owns and operates all powerplants.

During the next 10 year, energy consumption is expected increase by 2.7 per cent/year and electricity demand by 3.75 per cent/year.

Hydropower development

Croatia has a gross theoretical hydropower potential 20 000 GWh/year, a technically feasible potential of 120 GWh/year, and an economically feasible potential of 10 500 GWh/year. All these data were evaluated in 1986. So far, about 46 per cent of technically feasible potential has been developed.

There is 2076 MW of hydro capacity in operation, of a total powerplant capacity of 3647 MW. Most of the hydro capacity (1667 MW) is at multipurpose projects. The average annual generation of the hydro plants is 6107 GWh/year and generation in 1996 was 6732 GWh. Hydro usually supplies 44.7 per cent of power production (47.4 per cent of power production including pumped-storage, but its contribution was 60.4 per cent in 1996.

No more hydro capacity is under construction. Two potential future projects were described in the 1997 World Atlas, but future development plans are currently being reassesse.

Croatia has 250 MW of pumped-storage capacity (236 MW of pumping capacity), which generated 458 GWh in 1996.

There is a legal obligation to study the environmental impact for all hydropower projects in Croatia.

Small hydro

There are 16 small, mini and micro hydro plants in operation(plant of less than 5 MW), with a total capacity of 24.7 MW(141 GWh/year). No more plants are under construction or planned at present.

A study of small hydro potential has shown that the technically feasible small hydro potential amounts to 570 GWh/year.

Future outlook

A study of the development of power generation projects in Croatia is currently being prepared. Therefore it is not possible at present to give definite development plans for hydropower projects.

Cuba

Cuba has an area of 111 000 km2 and a population 11 million. There are 49 large dams in operation.

Hydropower development

The island has more than 300 MW of undeveloped small hydro potential and more than 300 MW of large hydro potential. There are currently energy shortages, and the development of hydro could help displace production from oil, reducing greenhouse gas emissions.

There is 60 MW of hydro capacity in operation, of a total installed capacity of about 4200 MW.

There is one 42 MW hydro plant, four small plants (in the range 0.5 to 3 MW) and about 250 mini and micro plants. Only 22 of the small hydro plants are grid-connected. The grid connected plants generated 108 GWh during 1995, about 1 per cent of total power production.

A hindrance to hydro development is the lack of access to modern hydro technology, in particular control equipment, as a result of the country's economic and political isolation.

IT Power recently completed an assignment for the UNDP to prepare a Glogal Environment Facility (GEF) project to expand hydropower development in Cuba. This involved missions working with Instituto Nacional de Recursos Hidraulicos systems, which will help increase the efficiency of existing installations and reduce the new installations. It will also allow for easier interconnection with the grid.

Cyprus

The republic of Cyprus covers an area of 925O km2 and has a population of 736 000 (602 000 excluding the area occupied by Turkey).

Water resources

The average annual precipitiation is 515 mm. The total average annual precipitation is 4.6 km3 of which O.96 km3 is runoff.

Per captia domestic water consumption is 180 litres/person/day in urban areas and 120 litres/penon/day in rural areas.

The Water Development Department (WDD) of the Ministry of Agriculture, Natural Resources and Environment is responsible for planning, development, operation and maintenance of water resources. Deregulation of the water sector is envisaged in the future.

There are 52 large dams in operation and one under construction. The total storage volume of all of Cyprus's 101 dams is 0.3 km3.

With most of Cyprus's rivers already dammed for storage, the WDD is now concentrating on river control projects, the first of which involves the construction of four dams on the Ezousa and Dhiarizos rivers (two dams on each). The first is the 45 m high Arminou earthfill dam (430 000 m3 volume), now under construction, which will provide water storage of 4.6×106 m3. The water will be used for irrigation and the dam will be used to control flow through a 14 km-long diversion tunnel to the Kouris dam, as well as to recharge the aquifer. This dam should be completed during 1998. Several more large dams are planned, including: Kannaviou (for completion in 2001), tammasos (2000). Ay.Theodoros(2004) and Episkopi(2001): all are at the design stage.

There is a legal framework for environmental impact assessment and management of all public works which have an estimated total cost greater than CY £1 million (US$ 1.85 million).

The main civil contraction in Cyprus for dams include: J&P. Cybarco, Zachariades, Iacovou, GCC. Chapo and Medcon.

Energy and power sector

The main sources of primary energy in 1996 were: diesel(31 per cent); kerosene(20 per cent); petroleum(14 per cent);electricity(12 per cent); coal (6 per cent); heavy fuel oil(3 per cent); light fuel oil (4 per cent); liquid petroleum gas (4 per cent); and solar (6 per cent). Total primary energy consumption was 1.33 million TOE.

Fuel oil is used To produce virtually all of the country's electricity. Total. electricity consumption in 1996 was 2316 GWh, representing per captia consumption of 3603 kWh/year. Electricity demand is expected to increase by 6 per cent/year

during the next decade. No electricity is imported or exported.

The ministry of Commerce, Industry and Tourism is in charge of energy. The energy Authority of Cyprus is the national power authority, which owns and operates all powerplants.

The electricity market is currently a semi-Government monopoly. Deregulation is envisaged in five years time, leading to a vertically integrated market.

Hydropower development

Cyprus has a technically feasible hydropower potential of 23 500 GWh/yeat, which was evaluated in 1982.

Only one mini hydro plant is in operation, with a capacity of O.65 MW, of a total powerplant capacity of 657 MW. Hydropower contributes a negligible proportion of the country's electricity. No further hydro projects are under construction or planned, although several micro hydro plants may be installed at existing dams.

Future outlook

Future hydropower development is unlikely as a result of the small potential, although the possibility of some mini hydro plants cannot be excluded in the future.

In the water sector, the dams planned will facilitate further exploitation of the country's srface water. Further development will include the construction of desalination plants. A desalination Plant of 40 000 m3/day capacity is now in operation and another of the same capacity is at the tendering stage.

Czech

The Czech Republic in central Europe has an area of 78 864 km2, and a population of 10.4 million.

Water Resources

The average annual precipitation is 693 mm. The total annual runoff is 2.85 km3, of which 2.28 km3 is surface water. The major river basins were listed in the 1997 World Atlas. The Morava river has a catchment area of 26 580 km2.

Two Ministries are in charge of national water resources management: Ministerstvo Zivotnho prostredi and Ministerstvo zemdilstvi, both based in Prague. In addition there are regional authories for the major rivers: Povodi Vltavy as., Povodi Labe a.s., Povodi Ohre a.s., Povodi Moravy a.s., and Povodi Odrg a.s, based in Prague, Hradec Kralove, Chomutov, Brno and Ostrava, respectively.

There are 119 large dams in operation, 109 of which are higher than 15 m; many are multipurpose.

Per capita domestic water consumption in 1996 was 71 m3/year from the public water supply systems.

Energy and power sectors

The national energy authority is the Ministerstvo prumyslu a obchodu, based in Prague.

CEZ a.s. is the Czech joint-stock company whose primary business is the generation and transmission of electricity. It produces about 75 per cent of the country's electricity. There are eight distribution companies: Prazska energetika, a.s.(Prague), Stredoceska energetika a.s. (Prague), Jihoceska energetika a.s. (Ceske Budejovice), zapadoceska energetika(Plzen), Severoceska energetika a.s. (Decin), Vycbodocka energetika a.s (Hradec Kralove), Jihomoravska energetika a.s.(Brno), and Severomoravska energyetika a.s.(Ostrava.

The domestic natural resources used in 1996 were: solid fuels (87.8 per cent), liquid fuels (O.5 per cent), gaseous fuels (0.6 per cent)and primary heat and electricity (11.1 per cent). Total energy consumption was 1 755 838 TJ.

The sources of electricity in 1996 were: thermal plants (75 per cent), nuclear (20 per cent), hydro (3.8 per cent) and gas (1.2 per cent). Total electricity consumption was 48 348 GWh, representing capita consumption of 4687 kWh/year. During 1996, 8811 GWh of electricity was imported and 8814 GWh was exported.

The transition to a new economic system has already been largely achieved. Any estimate of the development of the future demand for electricity is thus difficult to make as there are too many certainties. Since 1994, there has been a growth in electricity demand each year.

Hyropewer development .

The gross theoretical hydropower potential of the Czech Republic is 13 1OO GWh/year, and the technically feasible potential is 3384 GWh/year.

The total installed capacity of all powerplants is 14 974 MW, of | which 869 MW is hydro capacity. A further 5 MW of hydro capacity is under construction; the amount planned is not definitely known. Hydro plants generated 2403 GWh in 1996.

There is now 1188.5 MW of capacity in operation at pumped-storage plants. During 1996, pumped-storage plants generated 851 GWh of electricity and consumed 596 GWh.

The 650 MW Dlouhe Strane (2×325 MW. 547 m head} and Stechovice II (1×46 MW, 219.5 m head) pumped-storage have recently been commissioned.

Small hydro
The total number of small (including mini and micro) plants is 1230(472 GWh/year), with a total capacity of 200 MW. Two more (4.6 MW) are under construction.

Future outlook
Restructuring, particularly of industry, is in thc initial stages. Completion of the privatization process is proceeding slowly and there are still political discussions on the time-scale for removing cross-subsidies that favour the residential sector.

The shortfall between demand and supply of electricity is being aggravated by the anticipated delay in commissioning of the Temelin nuclear power station. Demand has risen rapidly in the residential sector since 1993, leading not only to an increase in base load demand, but also an increase in daily, weekly and seasonal fluctuations in consumption. CEZ is thus analysing electricity demand scenarios involving many variables, including the phasing out of existing price distortions.

The analysis has so far revealed the need for 200 to 300 MW more peaking capacity by 2001 at the latest. Pre-project preparation has therefore begun for a new fossil fuel-fired base load unit, as well as a peaking unit. primarily in response to the uncertainties of requirements.

A desulphurization and modernization programme at the Czech Republic's thermal plants has made such progress that more than two-thirds of electricity is now generated al "clean". Sulphur dioxide emissions fell by 33 per cent during 1996 comnared with 1993 values.

The recent commissioning of two pumped-storage plants has significantly strengthened regulating capability within the grid.

Denmark

Denmark covers an area of 42 094 km2, and had a population of 5.2 million.

Water resources

The average annual precipitation is 712 mm, giving a total mean annual precipitation volume of 30 km3. Per capita water consumption for drinking only is 104 m3/year.

There are Six large dams, and the country's hydropower potential is negligible.

Energy and power sectors

Denmark has large resources of oil and gas in the North Sea, but very minimal hydropower resources. The main sources of energy are: oil (42 per cent), coal (42 per cent) and natural gas(13 per cent).

Oil and coal-fired thermal powerplants represent 97 per cent of power generation. Power is also generated at solar and wind powerplant, hay ovens and from organic waste. Hydropower supplies less than l per cent of power production.

There is only about 1O MW of hydro capacity (33 GWh/year)in operation, of more than 11 GW total capacity. Hydro generation in 1996 was only 16 GWh.

The Ministry of Energy and the Environment is the national energy authority. There are two regional power authorities. Community-owned corporations own and operate the powerplants. Per capita electricity consumption is 5790 kWh/year.

Dominica

The Commonwealth of Dominica has an of 751 km2 and a population of about 82 000.

Water resources

Average annual precipitation is 4450 mm, with an average total annual volume of 3.34 km3.

The Dominica Water and Sewerage authority is responsible for water resources. There are no large dams.

Per capita water consumption is 99.6 m3/s.

Energy and power sectors

Dominica Electricity services Ltd (DOMLEC) is the national energy and electricity authority. DOMLEC owns and operates 51 per cent of the powerplant, with the remaining 49 per cent being privately owned.

The main sources of electricity are hydro (77.9 per cent) and diesel 922.1 per cent). Per capita electricity consumption is 1821 kWh/year.

Hydropower development

The island's gross theoretical hydropower potential is 200 GWh/year, and the technically feasible potential is 136.3 GWh/year. The economically feasible potential was calculated to be 130 GWh/year in 1983. So far, 42.6 per cent of the technically feasible potential has been development.

The installed capacity of all powerplants is 14 MW, of which 7.66 MW is form four hydro plants. These generated 37.8 GWh in 1993. No hydro plants are currently under construction, although a new 1.5 MW hydro plant is planned or the year 2000.

ECUADOR

Ecuador covers an area of 270 000 km3, and has a population of about 11.22 million.

There are now eight large dams higher than 15 m in operation. Several dams are under construction or planned as part of new hydro projects

Energy and power sectors
The Ministry of Energy and Mines is in charge of energy and power. The national power utility is Instituto Ecuatoriano de Electrificacion (INECEL).

Plans were drawn up during 1997 by the Ministry and the country,s National Modernization Council which involved selling part of INECEL. In an effort to raise funds to help finance major power projects. such as construction of the Mazar dam at the paute hydropower project

The main sources of energy in Ecuador are : firewood (15.3 per cent). Cane (4.0 per cent). Electricity (8.4 per cent). Liquid gas (9 per cent). Gasoline/alcohol (21.9 per cent). Kerosene (2.9 per cent), diesel oil (26.5 per cent)and fuel oil (12 per cent).

The main sources of electricity are hydropower (63 per cent) and thermal (37 per cent).

The state owns and operates about 94 per cent of the power plants, with private companies representing 6 per cent .

The per capita electricity consumption is 543 kWh year.

Hydropower development
Ecuador has a gross theoretical hydropower potential of 144 634 Gwh/year. The technically feasible potential and economically feasible potential are 31 820 Gwh/year and 15 909 Gwh/year Respectively. All these data were evaluated in 1983.so far about 20 per cent of the technically feasible potential has been developed.

The installed capacity at all powerplants is about 2500 MW, of which 1490 Mw is hydro capacity Hydro plants generated 6748 Gwh/year in 15.

A further 130 MW of hydro capacity id under construction, at the Daule Peripa plants, which will be commissioned in 199. At this plant. Two units will operate under a head of 64.5 m .

A further 1010 MW is planned at the following plants: paute Mazar(180 MW, including a 170 m-high CFRD): S. Francisco(230 MW): Toachi (170 MW. Including a 76 m-high gravity dam): and, Coca (430 MW).

INECEL expects to open tenders for the USS 450 million paute Mazar hydro project during 1998. The final design was scheduled to be completed in early 1998.

There are 20 small. Mini or micro hydro plants (up to 5 MW) with a total capacity of about 30 MW.

EGYPT

The Arab Republic of Egypt covers an area of 1 001 000 km2 and has a population of 62.4 million.

Water resources
The ministry of Public Works and Water Resources is in charge of water resources in Egypt.

The average annual precipitation is about 150 mm, giving a total mean precipitation volume of about 8 km3, of which 1.4 km3 is runoff.

Per capita water consumption is about 1000 m3/year total and 70 m3/year for domestic consumption.

There are seven large dams, according to ICOLD's definition, of a total of nine dams in operation. Most dams are multipurpose. The most important is the High Aswan dam. The total water storage of all dams in Egypt is 162 km3.

Reconstruction of the Naga Hammadi barrage on the River Nile is to begin soon: it will incorporate a new hydro plant.

Energy and power sectors
The Ministry of Power and Energy(also known as the Ministry of Electricity) is in charge of energy and power and has jurisdiction over all the agencies in the sub-sector responsible for policy and co-ordination. This Ministry owns and operates all powerplans, via the Egyptian Electricity Authority. There is a national grid.

The main sources of electricity in 1995 were: thermal (78 per cent) and hydropwer (22 per cent).

Tile power sector is undergoing considerable growth in both size and complexity. It is estimated that the installed capacity will have almost doubled by the year 2000 compared with the figure in the late 1980s. The main priorities for the future are to extend regional grids with gas, coal and hydro powerplants.

Per capita total electricity consumption is about 1000 kWh/year.

Hydropower development
The technically and economically feasible hydro potential is about 50 000 GWh/year; this figure was evaluated in 1991. However, potential hydropower production depends on the flow of the River Nile, upstream requirements, and operational factors resulting from irrigation needs. Planning of hydropower projects has to be considered as an integrated process within the context of overall Nile Basin development.

There is 2825 MW of hydro capacity in operation, out of a total powerplant capacity of more than 17 GW. About 70 MW hydro capacity is under construction and 60 MW is planned

The economic feasibility of hydropower development downstream of Aswan is most favorable at the existing barrages. Therefore, the Masterplan for water resources development recommended hydropower developments only at: the Esna barrage; Naga Hammadi barrage (about 65 MW); and, Assuit (63 MW). These would be run-of-river plants, with firm power of about 95 per cent. The Esna barrage has recently been developed. The Naga Hammadi barrage, at which 60 to 70 MW is to be installed soon, is the middle structure of the three barrages on the Nile in Upper Egypt, 360 km downstream of the High Aswan Dam. The existing weir is 800 m wide and has an effective height of 5 m.

The hydro plants in operation generated 10 810 GWh in 1995. Some pumped-storage capacity is planned for the future, but no details have yet been established.

El Salvador

El Salvador covers an area of 21 041 km2 and has a population of about 5.9 million.

Water resources
The average annual precipitation is 1850 mm; and the total average precipitation is 56.7 km3, of which 11.8 km3 is runoff.

Per capita water consumption is 93 m3/year..

The Ministerio de Agricultura y ganaderia (MAG) is responsible for water resources. The Administracion Nacional de Acueductors y alcantarillados (ANA) is responsible for aqueducts and drainage for the potable water and distribution services.

El Salvador has five large dams in operation.

Energy and power sectors
The main sources of energy are: wood (49.5 per cent), petroleum (30. 6 per cent), geothermal (7.7 per cent), hydro 95.7 per cent)and biomass (6.5 per cent)

The main sources of electricity in 1995 were: hydro (60 per cent), thermal (23.8 per cent) and geothermal (16.2 per cent).

The Ministerio de Economia (Ministry of Economy) is the national energy and power authority. Powerplants are mostly owned and operated by the national utility, the Comision jecutiva Hidroelectrica del Rio Lempa (CEL); 2 per cent of the powerplant capacity is privately owned.

Per capita electricity consumption is 429 kWh/year.

Hydropower development
The gross theoretical hydropower potential of El Salvador is 7404 GWh/year, and the technically feasible potential is 5000 GWh/year (both valuations in 1982). The economically feasible hydro potential was evaluated in 1994 to be 1705.2 GWh/year. So far 23.8 per cent of the technically feasible hydro potential has been developed.

The installed capacity of all powerplant in El Salvador is 817.5 MW, of which 405 MW is hydro capacity in operation. Hydro plants generated 2045 Gwh in 1995.

No hydro plants are under construction, but several plants are now being refurbished or are soon to be refurbished under a program being funded by the IBRD. The plants includes: 5 de Noviembre (81.4 MW, 50 m3/s, five unit, in operation since 1954); 15 de Septiembre (156.6 MW, 30 m3/s, two units, in operation since 1983); and, Cerron Grande (135 MW).

It is planned to implement a further hydro capacity by the year 2000 year, through expansion of the 5 de Noviembre plant, as well as through the construction of new plants. Other planned projects include: expansion of Zapotillo (104 MW0, Paso de Oso (74 MW)AND El Tigre (500 to 600 MW). El Tigre will be a binational projects with Honduras. Technical characteristics of the planned hydro plants were given in the 1996 H&D World Atlas.

Small hydro
There are 11 small (0.5 to 10 mw)or mini (up to 0.5 MW)hydro plants in operation: a total of 15.9 MW of small hydro and 2.1 MW of mini hydro capacity. Additional plants are planned as follows: small (7.9 MW) and mini (5.9 MW).

Estonia

Estonia has an area of 45 215 km2 and a population of 1.6 million.

Water resources

The Ministry of Enviornmental Protection is in charge of water resources, and considers possible impact of Project. Estonian water resources have in general been fully developed. There are no large dams in operation.

The average annual precipitation in Estonia is 550 and 650 mm.

Per capita domestic water consumption is 200 litres/person/dayin urban areas and 120 lilres/person/day in rural areas

Energy and power sectors

The main sources of primary energy in 1996 were: oil shale (63.4 per cent); fuel oils (4.5 per cent); motor fuels (11.2 per cent); coal (O.5 per cent); gas(11.8 per cent); and, biomass (8.6 per cent). Total primary energy consumption was 230 OOO TJ.

Estonia's power sector is entirely based on burning oil-shale, which is locally mined, in thermal powerplant. Thermal power provided 97.8 per cent of production in 1996, the remainder being supplied by oil and gas and a minimal amount of hydropower. Total electricity production was equivalent to 104 894 TJ. Per capita electricity consumption in 1996 was 3687 kWh/year.

During the next 1O year, total energy consumption is expected to increase by 1 to 2 per cent/year, and electricity demand by 3.5 per cent/year.

The Ministry of Economy is the national authority for energy

and power.

In November 1997, Estonia was accepted for future membership of the European Union and therefore all of its laws must be revised in line with EU rules as quickly as possible.

US NRG of the USA presented its plan for the privatization of the major energy production facilities in June 1997. However, the first plan was refused by the Government, in view of strong public pressure. It was considered that the privatization proposed would result in NRG having too large a monopoly in the energy market, leading to the potential for uncontrolled price rises. The Government's Ministry of Economics is now preparing a document as a result of thc public demand to change the first plan and NRC is preparing a new business plan to be completed by April 1998.

The energy market will become vertically integrated. During 1995, the oil Shale and Electricity Price Committee must finish its investigation of thc energy market and give recommendations for energy prices in the near future. A New Energy Act was prepared by l January 1998, under which the cost of electricity will be regulated until 2000.

During 1995, an Energy Market Agency will be established, with the responsibility of controlling licences and regulating the market.

Hydropower development

Estonia has a gross theoretical hydro potential of 1500 GWh/year, of which only 150 to 400 GWh/year is technically feasible for development.

There are five mini or micro hydro plants in operation, with a total capacity of 0.8 MW. Three more are under construction(total 1 MW, 3 GWh/year) and 15 are planned total 18 MW. The hydro in operation generated 1.6 GWh in 1996.

The feasible hydro potential includes a 25 MW development on Estonia's border with Russia, on the Narva river, near the Peipus Sea. However, construction of this plant. Omuti. Would require a border agreement between Estonia and Russia.

There is a 120 MW hydro plant on the Narva river which, under the 1920 peace treaty between Estonia and Russia, is in territory belonging to Estonia. However, between 1940 and 1991 one side of the river, including the hydro plant, was annexed to Russian territory.

Mini and micro hydro

After the second world war, some mini hydro plants were built, but during the 1960s and 1970s when large thermal stations were constructed they tended to cease operation. Their reconstruction is being considered.

Two private companies were established in 1997 to manage Estonia's water and hydro resources: AS Eesti veejoud (Estonia Water Power Ltd.) and AS Generator.

The first company plans to finish refurbishment of the Kamari plant built in 1959. by the end of June 1998. The Plant will be supplied with two new 200 kW turbines from Waterpumps Ltd of Finland. AS Generator has already restored four mini hydro plants (50 to 300 kW) using secondhand equipment.

During 1997, the Nordic Project Export Fund commissioned Estonian Water Power Ltd and Drivetech International AB of Sweden to carry out a prefeasibility study of Estonian hydropower resources. The study will establish which plants are most suitable for renovation or uprating. During the early examinations, 15 plants were chosen for defaited inspections.

Four sites are now under consideration: two on the Jagala river (total 3 MW) and two plants at drinking water reservoirs near Tallinn (total 0.7 MW).

The ownership of each plant is different, and a principle may be adopted of forming a separate joint venture company, with 25 to 30 per cent of the capital coming from the existing owner and the rest from external loans.

Future outlook

The question of renovating or uprating existing small, mini or micro hydro plants has arisen in view of concerns for clean energy and possible increases in the price of electricity.

The question about the border between Estonia and Russia has still not been resolved, but it seems that Russia is seeking to retain the territory which has the 120 MW hydro plant on the Narva river as part of the Russian Federation.

ETHIOPIA

Ethiopia has an area of about 1×106 km2 and a population of about 56 million.

Water resources

Rainfall varies from an average of 2400 mm/year in the southwest to less than 150 mm/year in the north.

There are substantial water resources, including lakes, rivers and groundwater; but detailed up-to-date hydrometric data are not available. This has been a major obstacle to assessing the country's hydro resources in detail. Water resources are managed by the Ministry of Water Resources.

Energy and power sectors

Ethiopia relies heavily on traditional forms of energy: fuelwood and biomass account for 72 per cent of energy consumption; while crop and animal residues and residue-derived fuels provide 16 per cent. The other 6 per cent comes mostly from modern fuels: petroleum products (5.4 per cent) and electricity just 0.6 per cent).

Most traditional energy sources are used for cooking and lighting, and thus energy consumption is dominated by the domestic sector, which represents 89 per cent of energy consumed, mostly rural homes. Even in the industrial sector, 82 per cent of energy is derived from traditional energy sources.

Hydropower currently provides approximately 90 per cent of Ethiopia's electricity.

There is considerable disparity between regions, with some having electricity supplies, and others, particularly in rural areas, having no power. This has accelerated rural to urban migration.

The on-going and increasing use of traditional fuels is having serious effects on the environment, through emissions and soil erosion. The development of small hydro in rural areas is a promising solution, but so far progress has been minimal.

To improve the energy situation in the country, the first national energy policy has been developed recently, and this gives priority to the gradual replacement of traditional fuels with non-fossil energy sources. It indicates that in the long term the country will depend heavily on hydropower, which is the largest energy resource.

The policy allows for private participation in the hydropower sector, although such participation needs to be more clearly defined.

Ethiopia Electric Light and Power Authority (EELPA) supplies electricity to the central part of the country through the Interconnected System (ICS), fed by various hydro and thermal plants. Apart from a few small thermal plants, all the country's hydro plants and larger thermal plants are owned by EELPA, which is publicly owned.

Hydropower development

Ethiopia has a very large hydropower potential. Its gross theoretical hydro potential has been calculated as 650 000

GWh/year, and the technically feasible potential is more than 250 000 GWh/year (these figures include Eritrea). A study in 1982 estimated the economically feasible hydro potential to be between 15 and 30 GW. Development of the major rivers is still at the planning stage.

The Awash river (868 km long) has a gross hydropower potential of 4010 GWh/year. The potential of the country's other major rivers is as follows: T'ekeze (682 km) 12 720 GWh/year; Blue Nile (922 km) 51 017 GWh/year; Baro (289 km) 18 050 GWh/year (the highest energy density at 62.5 GWh/km.year); Omo (1056 km)27 430 GWh/year; Genele (700 km) 11 360

GWh/year; and, Wabi Shebele (1177 km) 8780 GWh/year.

The country nevertheless suffers from serious shortages of electricity, since the implementation of hydro projects has been slow. Several large plants are required, but there are severe financial limitations.

In 1995, there was 372 MW of hydro capacity in operation, generating about 1250 GWh/year (87 per cent of power production). Hydro generation in 1996 was about 1400 GWh, nearly 90 per cent of production. There was a further 180 MW of new hydro capacity under construction at the end of 1996, and more than 2000 MW identified at potential projects.

Construction is now beginning on several new projects, such as the 80 MW Tis Abay II hydro project, being built by EELPA to relieve power shortages in Addis Ababa.

EELPA is planning to build the 192 MW Gigel Gibe hydro project soon, about 250 km southwest of Addis Ababa. Selection of a contractor was under way at the start of 1998. This project began several years ago, with support from North Korea, but little work was completed.

Another planned scheme, Chemoga Yeda, could be developed in two stages. It would include the Halele Werabea scheme, with two dams on the Omo river (providing 85 MW at the upstream site and 350 MW at the lower project); and, the Beles project near Lake Tana (270 MW).

Small hydro

There are a few small, mini and micro hydro plants in operation, and numerous potential sites. About 10 per cent of the economically feasible potential is thought to be suitable for small scale developments.

EELPA has about ten small hydro plants in operation, with a total capacity of about 18 MW, and aims to construct about 25 small hydro projects between 1990 and 2000.

Small hydro could provide considerable help to the country, by: meeting the power deficit in the main interconnected grid system; substituting thermal plants in the main grid or isolated grids, helping reduce fuel imports; and, by electrifying remote rural areas.

However, in the short term, in non-grid areas not all of the power generated by small hydro plants would be needed at first, since economic activity is not developed and the population is scattered.

Future outlook

Domestic power demand is expected to increase to 13 500 GWh/year by 2020. To meet this demand, and possibly to provide surplus power for export, the large hydro potential of the Nile Basin could be exploited.

A preliminary assessment has identified 184 potential sites (103 600 GWh/year), of which 18 projects (43 970 GWh/year) have been tentatively proposed, with a construction schedule up to 2020. Of these, six multipurpose projects, with a combined output of 21 000 GWh/year, could provide Ethiopia's domestic power needs up to 2035, as well as providing for irrigation for an area of up to 1 00 000 km2.

The further development of small hydro plants is crucial to meet the needs of the scattered rural population.

A detailed and comprehensive study of the nations river basins needs to be made. There also needs to be an international agreement to define the country's claim on its transboundary rivers.

Fiji

The island of Fiji cover an area of 18 272 km2 and have a population of about 772 000.

Water resources
The Public Works Department is responsible for water resources development. Fiji has two dams more than 15 m high, Monasavu, built for hydro generation, and Vataru, built for water supply.

Energy and poweer sectors
The main sources of electricity production in 1997 were: hydro(87 per cent)and thermal(13 per cent). Per capita electricity consumption in 1997 was 536 kwh/person/year.

The Ministry of Energy is in charge of energy resources and the Fiji Electricity Authority(FEA) is the power authority. The total instaled capacity at all of Fiji's powerplant is 166.7 MW, of which about 13 MW is independent of the FEA, and is generated by the Fiji Sugar Corporation (FSC) and Emperor Gold Mine(EMG) for their own use.

Hydropower development
The technically feasible hydropower potential in Fiji is estimated to be 1089.1 GWh/year. So far about 36 per cent of this potential has been developed.

There is 84.2 MW of hydro capacity in operation in Fiji, none under construction at present, and about 6 MW planned for implementation over the next four years.

Hydro plants generated 404 GWh in 1997, representing 87 per cent of power generation(excluding FSC and EGM plants).

The largest hydro plant in operation is wailoa, at the Monasavu dam(completed in 1982), with a rated capacity of 83.2 MW and a firm capacity 0f 62.4 MW. Plans are now being considered to increase its capacity to gain an additional 21 GWh/year of firm energy, by heightening the Wainisavulevu weir and embankment.

There are two mini hydropower plants in operation: the 0.8 MW Wainiqeu run-of-river mini plant, owned by FES; and, 0.1 MW plant, Bukuya, which is privately owned.

Two other hydro projects are under consideration: the 2×10 MW Vaturu plant(40 GWh/year) and the 10 MW Wainikasou plant (59 GWh/year). A hydrological study is to be carried out son for Vaturu to cirfirm its potential. It would be built on an exsiting diversion tunnel at the Monasavu dam and would be implemented in conjunction with the Wainisavulevu heightening project

Future outlook
FEA is considering the development of the few identified hydro projects mentioned above. With the Government's proposed deregulation policies, interest is also being shown by various independent power producers in building power stations to supply power to the grid.

The development of other natural resources is being actively pursued to meet increased demand on the main island of Viti Levu.

Finland

Finland covers an area of 338 145 km2 and has a population of 5.09 million.

Water resources
The average annual precipitation is 600 mm, ranging from about 400 mm on the west coast to about 600 mm in the south. The total mean annual precipitation volume is 220 km3, of about100 km3 is runoff.

Per capita domestic water consumption is about 160 litres/day.

The Ministry of the Environment is the national water authority. There are 13 regional Environment Centres.

There are 55 large dams in operation according to ICOLD's definition. The total water storage capacity of all the country's reservoirs ss 4 km3.

Energy and power sectors
The Energy Department of the Ministry of Trade and Industry is the national authority in charge of energy. There are 20 cooperative areas' responsible for regional power. The main sources of primary energy in 1996 were: oil (27 per cent),nuclear power (14 per cent), hydropower (9 per cent),coal(12 per cent), natural gas(9 per cent) and peat (6 per cent), other domestic sources such as woodchips and lye (16 per cent), net imports (3 per cent), coke (l per cent), blast furnace gas and coke (2 per cent), and others such as windpower, municipal solid waste, residual heal from industry (1 per cent). The total primary energy consumption in 1996 was 1 338 237 TJ.

The main sources of electricity production were: nuclear (27 per cent), hydropower (17 per cent), coal (21 per cent), natural gas (10 per cent), peat(8 per cent). oil (2 per cent) other domestic sources (1O per cent) and imports (5 per cent).

Total electricity consumption in 1996 was 70 018 GWh: 5367 GWh electricity was imported, while 1706 GWh was exported.

There are several different organizations which own powerplants of which the largest is IVO. About 47 per cent of all powerplants are privately owned in terms of generation.

Per capita electricity consumption in 1996 was 13 643 kWh/person/year.

Energy consumption is expected to increase by 1.4 per cent/year during the next 1O year, while electricity demand is likely to increase by 3 per cent/year.

The trade of electricity is mainly based on bilateral agreement. The electricity exchange business is currently marginal, but will probably increase in the future.

Hydropower development
The gross theoretical hydropower potential in Finland is 46 000 GWh/year and the technically and economically feasible

Potential is 19 700 GWh/year. These data were evaluated in 1991. So far 64 per cent of the technically and economically feasible potential has been developed. However, more than half of the undeveloped feasible hydro potential is protected by special laws.

There is 2872 MW of hydro capacity in operation. 31 MW under construction and 364 MW planned. The average annual generation from hydro plants in 1995 was 12 788 GWh. Representing 19 per cent of national production. Hydro provides 15 to 20 per cent of national electricity production on average.

Hydro plants that are planned include:

Kelukoski (11 MW, 396 GWh/year), now at the detailed design stage and expected to be implemented during 1998-2000.

Uprating of the existing powerplants on the Kemijoki river main course (between 1996 and 2010), involving 18 turbines and generator(110 MW, 80 GWh/year).

Vutos reservoir and powerplant (37 MW. 356 GWh/year),design stage 1998-2003.

Sierila (55 MW, 138 GWh/year), design stage, 2004-2007.

additional units on the Kemijoki river main course (169 MW, 616 GWh/year), general planning stage. 2006-2016.

Small hydro

There are 204 small, mini and micro plants in operation according to these definitions, with a total capacity of 365 MW.

Further small hydro projects are being developed.

Future outlook

The addition of auxiliary machines at the hydro plans on the man course of the Kemijoki river will become feasible after the construction of the Vuotos reservoir. The Vuotos reservoirs and powerplant are now at the detailed design stage.

The uprating of machinery at plants on the Komijoki main courcse has starded, and will be completed in 2010.

France

France has an area of 549 OOO km2 and a population of 58.1 mil l ion.

Water Resources
The total mean precipitation volume is 400 km3, of which 41.6 is runoff.

The Ministry of Industry and Ministry of Environment are in charge of France's water resources.

Per capita water consumption is about 150 m3/person/year.

France now has 143 dams in operation which are higher than 20 m. There are 569 dams in operation which are classified as large dams according to ICOLD's criteria. The total storage capacity is about 7.5 km3.

The Chambonchard dam on the Chard river, which is plannled, will create a reservoir with a capacity of 50 to 80×1O6 m3.It will be built by EPALA (Organization for the Development of the Loire and its Tributaries) to increase low water levels in the River Loire and for irrigation: it is planned for commissioning in 2005.

Energy and power sectors
The main sources of energy in France in 1997 were: petroleum products (57 per cent); gas (18.5 per cent); electricity (19.5 per cent); and, coal (5 per cent).

The main sources of electricity production in 1997 were: nuclear (78 per cent), hydro (14 per cent) and thermal (8 per cent). Total generation is around 481 TWh/year; total electricity consumption in 1997 was 406.3 TWh.

The Ministry of Industry is in charge of the energy/power sectors.

New EU legislation may affect these sectors next year.

The Government-owned powerplants are operated by Electricite de France (EDF); others are owned by industrial concerns or private producters. About 90.4 per cent of hydro production is from which are publicly owned.

Per capita total electricity consumption is 7500 kWh/year. In 1997, 6100 GWh of electricity was imported and 71 400 was exported.

Hydropower development and dams
The gross theoretical hydropower petential of France is about 200 000 GWh/year. The technically feasible potential is 72 OOO GWh/year, and the economically feasible potential is 71 500 GWh/year.

The total installed capacity of all Francs powerplant is about 114 000 MW, of which about 25 000 MW is hydro. No hydro capacity is under construction.

The average annual generation of the hydro plants in operation is 69 800 GWh/year the actual generation in 1997 was 67 000 GWh.

France has 4300 MW of capacity at is pumped-storage plants; they generated 5300 GWh in 1997.

A 54 MW hydro project, Rizzanese, is planned in southern Corsica, including an RCC dam. Bid documents are expected to be prepared for the main contracts towards the end of 1998.

Uprating of the 240 MW Bort hydro scheme is planned by 2005, involving the provision of an additional 80 MW unit.

Small hydro

There are approximately 1350 small, mini or micro hydro plants in operation in France, representing about 1600 MW of installed capacity. A few small plants are under construction (about 2 MW), and approximately 1O are planned (5 MW).

Future outlook

The renewal by 2000 of 130 concessions governing a number of powerplants (1200 MW, 4600 GWh/year) will impose new constraints. There is expected to be great emphasis on managing the multipurpose operation of reservoirs, to look after the interests of all water users.

As part of the Loire Plan, implemented by the Ministry of the Environment, two hydro plants have keen shut down, and their corresponding dams have been or will be decommissioned and removed. Other plants may be shut down as a result of other requirement or because of a major decline in their profitability.

Apart from the Bort refurbishment project, no further hydro development is envisaged. However, rehabilitation and replacement operation are scheduled at various schemes.

including: strengthening of dams and upgrading of spillways, and the replacement of turbines and generation with new equipment. This will cover the period 1996 to 2010.

The Chombonchard dam should be scheduled and built by EPALA by around 2005.

GEORGIA

The Republic of GEORGIA covers an area of 69 700 km2 and has a population of 5.7 million.

Water resources

The average annual precipitation is 1390 mm, but range from 400 to 4500 mm. The total mean precipitation volume is 96.9 km3.

Georgia has 21 large dams in operation, total of 61 dams. The 200.5 m-high Khudoni arch dam is under construction on the Inguri river and will provide a total storage volume of 364×10m3.
Energy and power sectors

The main sources of energy are hydropower, coal, peat, natural gas, wind and solar power. Hydropower supplied 89 per cent of electricity in 1995. The country's main priority is to harmess the vast hydroelectric potential further.

The Ministry of Fuel and Energy state enterprise Energogeneraatsia is in charge of the energy sector. Powerplants are essentially owned and operated by Sacenergo; less than 1 per cent of hydro plants are privately owned.

Per capita domestic electricity consumption is 1 240 kWh/person year.

Hydropower development

The gross theoretical hydropower potential of Georgia is 139 TWh/year (about 15.5 GW), of which 68 TWh/year is technically feasible and 32 TWh/year is economically feasible. About 11.1 per cent of the technically feasible potential has been developed.

There is 2730 MW of hydro capacity in operation (at more than 60 hydro plants). which is 65 per cent of total installed capacity. Nominal average annual generation is 9415.7 GWh/year. However. actual generation in recent years has been quite low, as hydro stations have operated with restrictions resulting from both low water resources, ageing of hydromechanical and electrical equipment, decreasing efficiency coefficients and damaged plants.

a further 700 MW of hydro capacity is under construction at the Khudoni dam, and 400 MW is planned. The planned schemes include:Tvishi(100MW), Namakhvani(210 MW) and Zhoneti(90MW), all on the Rioni river.

The two Francis units at the 114 MW Khrami II hydropower scheme are scheduled to be refurbished soon. A total 1100 MW of pumped-storage capacity is also planned.

Small hydro

There are 14 small, mini and micro Plants (up to 10 MW) in operation, with a total capacity of 40MW. Another five are planned, with a total capacity of 12 MW.

Future outlook

In view of the restrictions at many of Georgia's hydro plants, the construction of new station as well as the maintenance, modernization and rehabilitation of existing ones, are considered be to great importance.

Germany

Germany covers an area of 356 974 km2 in center Europe and has a population of 81.3 million.

There were 311 large dams in operation in 1993.

Energy and power sectors

The main sources of primary energy in Germany iin 1996 were: oil (39.3 per cent), natural gas (21.4 per cent), hard coal (14.1 per cent), lignite (11.4 per cent), nuclear (11.9 per cent), hydropower (O.5 per cent), and others (firewood, sewage gas and pit gas)(1.4 per cent). Total primary energy consumption was 14 767 PJ.

The main sources of electricity were: nuclear (29.4 per cent); hard coal (27.8 per cent); lignite (26.2 per cent); natural gas(8.3 per cent); hydro(3.9 per cent); oil (1.3 per cent); and other(1.3 per cent). Total electricity consumption was 500 095 GWh in 1996, and 6098 kWh/person.

Germany imported 37 404 GWh of electricity in 1996 and exported 42 670 GWh.

The Ministry of Economics is the national energy authority. Each administrative region has its own power authority. The utilities own and operate powerplants.

Deregulation of the energy and electricity sectors is cxpected to take place during 1998.

Hydropower development

The gross theoretical hydropower potential of Germany is 120 000 GWh/year (evaluated in 1991). The technically feasible potential is 25 000 GWh/year (1991), and the economically feasible potential is about 20 000 GWh/year (1991). So far, about 64 per cent of the technically feasible potential has been developed.

The installed capacity of all powerplants in operation in Germany is 114 068 MW, of which 4304 MW is hydro capacity. Hydro plants generated 17 285 GWh in 1996. A further 9 MW of hydro capacity is under construction.

There is 4636 MW of capacity at pumped-storage plants, and a further 1060 MW under costruction. Pumped-storage plants generated 4381 MW in 1996, and consumed 5892 GWh.

The 1060 MW Goldisthal pumped-storage plant in eastern Germany is being developed by Vereinigte Energiewerke AG (VEAG). Construction began in October 1997 and is schduled to be completed during 2003.

Small hydro

There are some 6000 small hydro plants(of less than 10 MW) in operation, with a ttal capacity of approximately 1300 MW. About 100 MW of further small hydro capacity is envisaged.

GHANA

Ghana has an area of 238 500 km2 and a population of about 17.8 million.

Water resources

The average annual precipitation is 2500 mm, giving a total mean annual precipitation volume of about 596 km3 , of which 55 km3 is runoff.

The Water Resources Research Institute (WRRI), the Ghana Water and Sewage Corporation, and the Hydrological Division of the Ministry of Works and Housing, are responsible for water resources development.

There are five large dams in operation, the largest being Akosombo (134 m high) and Kpong (29 m high).

Energy and power sectors

The Ministry of Mines and Energy is in charge of energy, while the Volta River Authority (VRA) is the national power authority responsible for generation and transmission of electricity. All powerplants are publicly owned by VRA.

The main Sources of electricity in Ghana in 1996, were: hydro (97 per cent) and thermal (3 per cent). About 200 MW capacity of combustion turbines was scheduled to be commissioned by the end of 1997, which should change the main sources of electricity to hydro (82 per cent) and thermal (18 per cent) for 1998.

Per capita domestic electricity consumption in 1996 was, about 256 kWh/person/year, based on the 1996 total domestic consumption of 4097 GWh.

Hydropower development

Ghana has 1072 MW of hydro capacity, at the Akosombo (912 MW) and Kpong (160 MW) plants. These are capable of generation an average of 6100 GWh/year, which is about 58 per cent of the hydro potential, evaluated in 1985 to be 10 600 GWh/year.

One of the main priorities for the future is construction of the 400 MW Bui hydropower plant (scheduled for the year 2005). Other planned plants include Juale and Pwalugu.

Uprating Akosombo and Kpong could provide 120 MW of additional capacity.

Greece

Greece has an area of 131 957 km2 and a population of about 10.65 million.

Water resources
The total mean annual precipitation volume is 93 km3, with mean runoff of 37 km3.

The Ministry of Industry, Energy and Technology is in charge of the country's water resources.

There are 46 large dams in operation, according to ICOLD's definition, of a total of 44 dams. The total storage capacity of all reservoirs is 9.15 km3. Per capita total water consumption is 857 m3/person/year. '

Several large dams are under construction, including: Ilarion(earthfill, 130 m); and. Evinos (earthfill, 124 m). The 95 m higg Platanovryssi dam has recently been completed.

Major dams planned include: Temenos (concrete gravity,50 m high, planned for completion in 2001)and Agios Nikolaos (earth dam, 114 m high , 2004). Temenos is at the bid evaluation stage and Agios Nikolaos is at the revision of bidding document stage.

Laws No. 1650/86 and 998/79 constitute Greece's legal framework for environmental impact assessment and they relate to all technical projects regardless of type and size. Law 1739/89 relates to the management of water resources.

The main domestic civil contractors for dams and hydro projects are Aegek, Michaniki, TEV, Proodeftili, sarantopoulos, Meton and Tema.

Energy and power sector
The main sources of electricity production in 1996 were: lignite (68.8 per cent), oil (19.4 per cent), hydro (11.7 per cent, including pumped-storage plants), and other renewable(0.1 per cent).

About 3.4 per cent of electricity was generated using imported fuels.

Total electricity consumption in 1996 was 37 796 Gwh, representing per captia consumptionof 3546 kWh/year.

During 1996, 2664 GWh of electricity was imported and 1314 GWh was exported.

It is estimated that electricity demand will incrcase by 3.5 per cent/year during the next 10 years.

The Ministry of Industry, Energy and Technology is in charge of energy, and the Public Power Corporation (PPC) is the national power authority.

EC Directive No 96/92 relating to the liberalization of the EU electricity market will become valid for Greece by February 2001. Deregulation is envisaged after the year 2001.

Various scenarios are being considered for the format of the deregulated market, and final decisions have not yet been taken.

At present all powerplants, with the exception of only two or three private small hydro plants, are publicly owned by PPC, which practically has the monopoly of the electricity market.

hydropower development
the gross theoretical hydropower potential of Greece is 80 000 GWh/year, the technically feaible potential is 20 000 GWh/year. These data were all evaluated in 1960. So far, 24.6 per cent of the technically feasible hydro potential has been developed.

The total installed capacity of all powerplants is 9198 MW, of which 2230 MW is hydro capacity. In 1996, hydro plants generated 4487 GWh, representing 9.3 per cent of national electricity production. Hydro contributes 10.5 per cent of power production on average, and 11.5 per cent including pumped storage generation.

A further 636 MW of hydro capacity is under construction and another 697 MW is planned. The major plants under construction include Platanovryssi (100 MW, scheduled for commissioning in 1999) and Messochara (160 MW, 1999)). The mean cost per kw of the hydro capacity under construction is US$ 1500 /kw.

Planned plants include: Temenos (18.9 MW, 2001) and Agios Nikolaos (200 MW, 2004).

Greece has 315 MW of pumped-storage capacity in operation and 300 MW under construction. The plants are in operation generated 352 GWh in 1996.

Small hydro

There are 10 small, mini and micro hydro plants in operation in Greece, with a total capacity of 42 MW (160 gWh/year). Nine plants are under construction (10 MW) and 49 are planned(78 MW).Since the Law No.2244/94 was introduced, more than 70 applications have been submitted for the construction of private small hydro plants (mainly less than 3 MW). These are being considered by the Ministry of development.

Future outlook

PPC is giving priority to the development of domestic lignite as well as imported natural gas. The future outlook for hydro is rather uncertain

The gradual abolishing of PPC's monopoly in the electricity sector and the establishment of a competitive electricity market means that the focus for national hydro development beyong 2001 will be on medium or small projects

Greenland

Greenland has an area of 2 180 000 km2 and a population of 57 600.

Water resources

Precipitation is highest in the south. The total mean precipitation volume south of 71 N latitude is approximately 35 km3/year on the ice-free land between the coast and the ice-cap, and approximately 200 km3 on the ice-cap. Average annual precipitation is much lower in the north, not exceeding 100 mm at many weather station.

For the southern part of Greenland described above, the total annual runoff is approximately 155 km3, while approximately even 60 km4 is formed as glaciers.

Per capita water is about 163 litres/person/day in urban areas, but only 50 litre/person/day in rural areas, and even less than in very small settlements.

There is one dam in Greenland more than 15 m high, built for the Buksefjorden hydro projects, with a water storage capacity of 0.9 km3. There are seven dams higher than 3 m, built for water supply. The total water storage capacity is 1 km3.

Nukissiorfiit (Greenland Energy Company) is now responsible for water resources even in rural areas. Deregulation is not envisaged.

Energy and power sectors

The main sources of primary energy in 1996 were: gas oil(80 per cent), hydro (8 per cent), petroleum(8 per cent) and petrol(4 per cent). Total primary energy consumption was 2332 GWh.

The main sources of electricity in 1996 were: imported gas oil(61 per cent) and hydro(39 per cent). The total electricity consumption was 183 GWh, representing 2704 kWh/person/year.

Per capita energy consumption and electricity demand are not increasing, despite the increasing population, rising transport activities and large building projects, in view of the implementation of energy-saving measures. Energy consumption in the growing fishing industry will definitely increase, however, even if energy savings are implemented.

Nukissiolfiit(Greenland Energy Company), the national energy and electricity authority, is now responsible for energy even in rural areas of the country. Deregulation is not envisaged.

All powerplants are publicly owned. Each town has its own supply system, and the there is no grid linking towns. However, the price of electricity is the same throughout the country.

The total per capita electricity power construction in 1995 was 3323 kwh/person/year in urban areas and 1436 kWh/person/year in rural areas; domestic consumption is 1083 kWh/person/year in urban areas.

The maximum continuous load is 66 MW in urban arees and 8 MW in rural areas.

Hydropower development

Greenland has an estimated gross theoretical hydro capacity of 800 000 GWh/year, of which only about 15 000 Gwh/year is technically feasible; these figures were re-evaluated in 1995. Only 1.2 per cent of the technically feasible potential has been exploited.

Greenland has 30 MW of hydro capacity, principally at the Buksefjorden plant, of the 87 MW of total powerplant capacity, including standby units. Hydro plants generated 165 GW in 1996, which represented 39 per cent of electricity production. However, hydro supplies 59 per cent on average (32 per cent if supplies for heating are excluded).

No hydro plants are under construction, but 20 MW of hydro capacity is planned. The largest is a 12 MW plant in western Greenland, although it is not yet excluded.

There is an environmental authority, but no framework specifically for hydro plants. The aim is to reduce the impact of a hydro plant to a minimum through sensible planning and consideration for scenery and the environment during construction. The environmental authority has regulated hydro activities from the beginning, when Buksefjorden was built. It laid down strict rules governing the reindeer and char population in the area, and ensured that the impact on the landscape was as little as possible.

Small hydro

There are four mini or micro hydro plants, with a total capacity of 0.1 MW. A 7 MW hydro plant in the south and a 1 MW plant in the east are planned soon, although they are not yet scheduled.

Future outlook

Effort and resources aimed at an investigating and planning are at present concentrated on smaller plants for energy supply to individual towns. There prospective hydro plants, 12 MW, 7 MW and 1 MW, are being evaluated.

Guatemala

Guatemala has an area of 109 000 km2 and a population of about 11 million. There are four large dams in operation.

Energy and power sectors

Power is currently generated by hydro, oil-fired steam, combustion turbine and siesel units. It is planned to add more geothermal capacity by 2000.

The state power utility is INDE, which also operates the country's grid system.

Hydropower development

The estimated hydro potential is 5000 MW (about 21 500 GWh/year). There is also significant potential for geothermal plants, as well as small oil reserves.

There is 438 Mw of hydro capacity, of a total installed capacity of about 770 MW at the end of 1995. In 1996, hydro plants generated 2275 GWh, about 70 per cent of total power production, but about 85 per cent of grid-connected power production.

The 15 MW secacao hydro project, on the Tree aguas river in the centre of the country, was scheduled to be commissioned in March 1998. The owner is Hidroelectrica Secacao SA. Financing was secured from Mexico, France and Ireland, as well as Guatemala. The plant will supply electricity to the INDE grid, based on a long term power purchase agreement.

GUINEA

The Republic of Guinea covers an area of 246 000 km2 and has a population of 6.6 million.

Water resources
The average annual rainfall is between 1000 and 4000 mm. The per capita water consumption is 18.25 m3/year.

The national authority in charge of water resources is SONEG (Societe Nationale des Eaux de Guinee).

There are five large dams in operation, most of which were built for hydropower generation.

Energy and power sectors
The main sources of energy in 1994 were: fuelwood and charcoal (79.5 per cent), petroleum products (19.9 per cent): and, hydropower (0.6 per cent).

The sources of electricity in 1995 were: thermal plants (65 per cent) and hydro (35 per cent).

The Ministry of Energy and the Environment is in charge of energy, throgh the Direction Nationale de L'Energy et des Hydrocabures. The power authority is ENELGUI (Enterprise Nationale d'Electrite de Guinee), a publicly owned company commercial company with autonomous administration, which in 1987 superseded the Societe Nationale d'Electricite. The operator responsible for production and distribution of electricity is SOGEL.

There are three and systems: Samou (47 MW), Kinkou (3.2 MW) and Tinkisso (1.5 MW).

Per capita electricity consumption is 83.47 kWh/year

Hydropower development
Guinea has a gross theoretical hydropower potential of 26 000 GWh/year, calculated in 1986. 'I'he technically feasible potential is 19 400 GWh/year, and the economically feasible potential is 14 500 GWh/year. The last two figures were evaluated in 1991. Only about 1 per cent of the technically feasible potential has so far been developed.

The region known as Guinee Maritime has seven large river basins, where 33 per cent of the hydro resources are concentrated. The central part of the country also has seven large basins, with 52 per cent of the country's potential: today, however, only one 3.2 MW plant is in operation (known as Kinkon). The Garafiri hydro project (75 MW, 223 GWh/year firm energy) is under construction in this region .

There is 245.4 MW of installed capacity at all powerplants, of which 52.3 MW is hydro capacity (all operated by SOGEL) and 193.1 MW is at thermal plants.

Of the total installed capacity, 19.7 per cent is at SOGEL'S thermal plants, 21.2 per cent at SOGEL's hydro plants, 39.1 per cent at mines and 20 per cent is generated by auto-producters.

In 1995, hydropower supplied 191 GWh of 'the total production of 543 GWh.

An additional 91 MW of hydro capacity is planned, including Kaleta (80 MW).

There is 1.35 MW of pumped-storage capacity in operation.

Small hydro
About 150 mini and micro plants have been identified, with a total capacity of 14.24 MW.

One micro hydro plant is in operation, the Samanountelimele plant on the Samankoun river. This plant was constructed as a result of a technical and economic cooperation agreement between Guinea and North Korea, signed at the end of the 1980s.

Future outlook

The main priorities for the future include further development of hydropower and rural electrification.

GUYANA

The Republic if Guyana covers an area of 215 000 km2 and has a population of about 756 700.

Water resources

Average annual precipitation varies between 1500 to 2000 mm. The total mean annual precipitation volume is 376 250 m3

Per capita water consumption id 100 m3/year.

Guyana Natural resources Agency (GNRA) is in charge of the country's water resources. There is also the regional Georgetown Sewerage & Water Commissioners (GS&EC).

No large dams are in operation. Under construction or planned

The Government has recently embarked on a major institutional strengthening exercise for the drainage and irrigation Netherlands is to provide consultancy services with regard to strengthening the National Drainage and Irrigation Board (NDIB) and implementing policy reforms in the sector.

Energy and power sectors

The main sources of energy are: petroleum products (52.5 per cent). Bagasse (24 per cent)and fuelwood (23.5 per cent). Thermal power stations using petroleum Generate at least 98 per cent of electricity.

The Guyana National Energy Authority(GNEA) is in charge of energy resources and the national power authority is the Guyana Electricity Corporation (GEC). The Guyana Mining Enterprise (GME) is a regional power authority.

GEC, the GME and the Guyana sugar corporation. All of which are public enterprises, own and operate the powerplants

The main priorities for future development are hydropower

Hydropower development

The gross theoretical hydropower potential of Guyana is 7607 GGGGGWH/year (evaluated in 1976). Of which 7000 GWH/year was estimated to be technically feasible. A map of potential hydropower sites in Guyana was published in the 1996 World Atlas

There is nearly2 MW of hydro capacity in operation. Generating about 5 GWH/year and representing about 1.6 per cent of total power production. A further 56 MW is planned The country's first hydro plant is the 2×500 kW Moco Moco plant.

A BOO concession has recently been awarded to the Canadian consortium. Hydro Energi-Corp. By the Government of Ghana to develop and commission the 45 MW Tumatumari hydro project on the Potaro river. The plant will supply power to the Omai gold mine. A previous study will be updated prior to development. The consortium includes Hydro-Quebee International. Goralex Iinc. Hydro-Mecanique Construction and Fonds de Solidarite des Travailleurs du Quebec.

Future outlook

Despite the country's largest hydro resources, it has so far not been possible to attract the funding to develop this resources. However, the Government is inviting private investment in this area, in particular for the Tiger Hill hydropower site on the Demerara river. This site, if developed, would provide 265 GWh/year to the national grid. The Tumatumari hydro project will be the country's first major hydro schemes

Honduras

The REPUBLIC OF Honduras covers an area of 112 491 km2 and population of about 5.5 million.

Water resources

The average annual precipitation is about 1800 mm, and the total average precipittation volume is 202.48 km2.

The Ministerio de recursos Naturales is responsible for water resources development.

There are nine large dams in operation.

Energy and power sectors

The main sources of energy are: wood (61 per cent), hydro(8 per cent) petroleum (25 per cent) and biomass (1 per cent). The min sources of electricity is hydropower, which supplies about 90 per cent of electricity production.

The power authority is the National Electric Company, ENEE, which manages the national grid system. Plants are owned both by ENEE and the private sector.

Per capita electricity consumption is 314 kWh/year(1990.).

Hydropower development

The gross theoretical hydropower potential is 16 455 Gwh/year, according to a 1992 study. No data are available for the technically or economically feasible potential.

The total installed powerplant capacity is 581.8 MW, of which 482.2 MW is hydro capacity. Generation from hydro plants in 1993 was 2279 GWh.

It has been estimated that 160 MW (46 GWh/year)could be added to the system by installing more units at the Francisco Morazan station.

There is one mini hydro scheme in operation in the country at present, with a capacity of 1.2 MW.

Future outlook

A power system masterplant include consideration of four further hydro projects, with a total installed capacity of 1125 MW, which could be built over the next 20 year.

Hungary

The hungarian Republic has an area of 93 030 km2 and a population of 10.3 million.

Water resources

The total mean annual precipitation volume is 58 km3, of which 6 km3 is runoff.

The National Water Authority is responsible for water resources, and there are 12 regional water authorities.

There are 17 large dams in operation according ICOLD's definition.

Per capita water consumption in 1994 was 78.7 m3/person/year(total) and 45 m3/person/year domestic consumption.

Energy and power sector

The main sources of energy in 1994 were: hydrocarbons(67.5 per cent); coal (15.7 per cent); nuclear(12.6 per cent); others(2.3 per cent); and, imports(1.8 per cent).

The main sources of electricity in 1995 were: thermal plants (58.3 per cent); nuclear(41.2 per cent), and, hydro*0.5 per cent).

Hungarian Power Plc is the national energy and power authority.

Per capita electricity consumption in 1994 was 2801 kWh/person/year total, and 957.7 kWh/person/year dometic consumption.

The main priorities for the future are nuclear energy and gas turbine powerplants.

Privatization of power generation installations and service activities began in 1995 and is now under way. AVP rt is the State Holding and Privatization Company of the Government, which is organizing the sale of government-controlled generating companies.

The three largest hydropower plants (Kiskore, Tiszalok, and Kesznyeten) are now operated by two private companies. AVP Rt also expects to sell two other government-owned companies soon, which operate small, mini and micro hydro plants.

Hydropower development

The gross theoretical hydropower potential of Hungary is 7446 GWh/year. These figures were evaluated in 1984. About 5 per cent of the technically feasible potential has been developed so far.

The total installed capacity at hydro plants is 50 MW, of more than 7000 MW of total powerplant capacity. Hydro plants generate on averge 214 GWh/year.

No further hydro capacity is under construction or planned.

It is estimated that 15 MW of capacity could be obtained through uprating existing hydro plants.

There are 29 small, mini or micro hydro plants in operation in Hungary, with a total installed capacity Of 8.28 MW

Iceland

Iceland covers an area of 103 000 km2 and has a population of 265 000.

Water resources
The total mean precipitation volume is 200 km3, with 160 km3 being runoff.

Orkustofnun(National Energy Authority) is responsible for water resources. There are 20 large dams in operation.

Per capita water consumption is 16 091m3/year total, with 1966 m3/year being domestic consumption.

A storage reservoir, Hagongur, is currently under consumption.

Energy and power sectors
The National power authority is Land svirkjun, and there are three regional authority: sTate Electric Power Works, Sudurnes Regions Heating System and Westfjord Power Co. All powerplants are publiclly ownded, with Landsvirkjun owning all major hydro plants.

The main sources of energy in 1995 were: geothermal (47.8 per cnt); oil (30.9 per cent); and hdyropower(16.8 per cent).

Hydropower is the main source of electricity, supplying 95 per cent of the total power produced in 1995.

Per capita electricity consumption is 17 084 kWh/peerson/year total, and 2807 kWh/person/year for domestic consumption.

Hydropower development
The gross theoretical hydro potential of iceland is 187 000 GWh/year and the technically feasible hydropower is 64 000 Gwh/year, of which 7.7 per cent has been exploited. The economicall feasible potential of all powerplants is 1050 MW, of which 884 MW is hydro capactity. Hydro plants generate 4950 GWh/year on average; and generation in 1996 was 4764 GWh.

Iceland's largest hydro plant, Burfelll, has recently been uprated from 210 MW 288 MW. THE 132 MW Sultartangi project is now under construction and about 805 MW is planned, including the following projects:

Fljotsdalsvirkjun (252 MW);
Burfell(110 MW);
Villinganes (30 MW); and,
Vatnsfell (70 MW).
The Fljotsdalsvirkjun II plant, which has been studied, could add about 500 MW of capacity.

Small hydro
There are 84 small, mini and micro hydro plants in operation, with a total capacity of 67.5 MW.

Future outlook
Fljotsdalsvirkjun has several hydropower projects planned which with could be put to tender. For several years, the growth in power demand has been slow, but additional sales of electricity to the power-intensive have now started, and further sales are likely in the near future. Eight future projects are at the feasibility or permissibility study stage.

INDIA

The republic of India covers an area of 3.29 Million km2 and has a opulation of about 940 million.

Water resources The total mean precipitation volume is about 4000 km3, of which 62.5 per cent is runoff. About 130×106 km2 of land is under irrigation, with 75 per cent of national food production dependent on irrigated l and.

Water is a matter for the State according to the Constitution, and the Ministry of Water Resources and the Central Woter Commission are the national authorities for its development.

India has about 2041 large dams in operation, according to ICOLD's definition, of a total of 3796 dams.

Several major dams are under construction, including: Tehri (261 m high. TE/ER), Kishau (236 m. PG). Lakhwar (204 m.TE) and Sardar Sarovar (163 m. PG).

Energy and power sectors

The main sources of energy in India are: coal; oil; gas; nuclear power; and renewables.

The main sources of electricity are: thermal, hydro (25 per cent), nuclear, oil, animal products, wind-power, solar-power and co-generation.The Ministry of Power and the Central Electricity Authority are the national power authorities. There are also 25 Slate Electricity Boards, and other power corporations.

The total per capita electricity consumption is 397 kWh/year .A national grid system is currently under development. Central Government or State governments own 95 per cent of hydroplants.

Hydropower development

India has a technically feasible hydropower potential of 84 044 MW (at 60 per cent load factor), equipment to 600 TWh/year, evaluated in 1992. So far, about 12 per cent of the technically feasible potential has been developed.

There is 21 645 MW of hydro capacity in operation, of the country's total installed capacity of 86 000 MW. Hydro plants generated 72 283 GWh in 1997, representing 35 per cent of national power production.

A further 10 000 MW of hydro capacity is under construction, and 28 000 MW is planned. There is additional potential equivalent to 11 888 MW of capacity at existing hydro schemes.

The major hydro plants under construction are: Sardar Sarovar(1200 MW), Nathpa Jhakri(1500 MW), Tehri Satge I(1000 MW), Ranjit Sagar(600 MW) and Dul Hasti (390 mW),

Major hydro projects planned inclued Baspa Stage II (300 MW). India has 1284 MW of pumped-storage capacity in operation, 2620 MW under construction, and 1990 MW planned (with technical-economic clearance accorded). A total of 94 000 MW of pumped-storage potential has been identified.

Small hydro
There is 533.16 MW in operation at small and mini and macro hydro plants (up to 10 MW), a further 456,01 MW under construction and about 300 MW planned

There is a total small hydro potential of some 10 000 MW, and efforts are to be made to harness this potential with World Bank assistance.The mini-micro hydro potential of small canals and irrigation releases is estimated to be more than 5000 MW (around 25 TWh/year).

Future outlook

The commissioning of more hydro units in India is a great priority. Financial and environmental considerations are the main constraints.

INDONESIA

Indonesia comprises 17 508 islands with a total land area of 2 027 087 km2. The population is about 204 million.

Water resources

Average annual precipitation is 2100 mm and the total mean annual precipitation volume is 4257 km3, with runoff of 2138 km3/year. The total storage of all the reservoirs is about 6 km3.

Per capita water consumption is 43.8 m3/year.The country has 16 large dams in operation. The highest dams under construction are:Batu Tegi (rockfill, 120 m high), being built for irrigation, hydro and water supply in Lampung Province;

Wonoredjo (rockfill, 100 m), for hydro supply

Bili-Bili (rockfill. 73 m high), for flood control, irritation, hydro, water supply, fiesheries, and recreaton,Balambano (RCC, 92 m), for hydropower in south sulawe,

The Directorate Genera of waer resources, Department of Public Works, is responsible for water resources development.

Energy and power sector

The national energy and power authority is the Electricity Power Company, PT.PLN. the main sources of electricity is thermal power (82.8 per cent).

PT.PLN owns and operates 14 327 MW of powerplant capacity(63 per cent). while 8420 MW (37 per cent) is owned privately, by PT. INALUM, Perum Otorita Jailuh and PT. Cikarang Listrindo.

Per capita electricity consumption is 172 kWh/year.

Hydropower development

Indonesia has a gross theroretical hydropwer potential of 214 TWh/year. The technically feasible potential has be estimated to be 401 646 GWh/year (representing 74 976 MW of installed capacity) these data were calculated in 1983.

There is 3046 MW of hydro capacity in operation, representing about 4 per cent of technically feasible potential.

About 2100 MW of hydro is under construction: Cirata (500 MW), Musi(90 MW), Renun (80 MW), a Wonoredjo(6.2 MW). Construction has also recently begun the Bili-Bili and Balmabano projects.

Balambano is being developed by the major nickel productor PT.Internatioal Nickel Indonesia(PT INCO), which signed contracts with GE Canada, Elin Energieversorgung a Voest_Apline MCE of Austria, for the supply of the electrical mechanical equipment and hydraulic steel structures.

About 2 GW of hydro capacity is also planned soon, which includes: Maung (360 MW and Asab stage II (400 MW), for which detailed design have been completed; and Meragin 2 (340 MW), Tamput (330 MW), Capas(400 MW) and Cimandiri (353 MW), at the feasibility study stage.

The hydro plants in operation generated 12 390 GWh in 1995 representing 13.7 per cent of national electricity production. As well as the upgrading of Cirata, which is under way, there is estimated 128 MW of additional capacity which could installed in a second stage of the Bakuru scheme.

1000 MW of pumped-storage capacity is planned.

Small hydro

The Government plans to increase rural electrification to 45 per cent by 1998, which will require the electrification of 18 600 villages, based largely on small and micro hydro projects.

There was about 84 Mw small, mini, micro plants in operation (37 plants) at the end of 1996, a further 30 plants under construction(34 MW) and about 234 MW planned.

Iran

Iran covers an area of 1 648 000 km 2 and has a population of 65.8 million.

Water resources

The Iran Water and Power Resources Development Company (IWPC), a division of the Ministry of Energy is responsible for dam construction and hydropower development. There are 10 large dams in operation, which are mostly muitipurpose.

A number of very high dams are under construction, including: Karun 3 (205 m high, concrete arch); Masjed-e-Soleyman (177 m high, rockfill);Shooshtar (180 m high, rockfill);
Karun 4 (222 m high, concrete arch);
Maroun (165 m, rockfiil);
Karkheh (127 m high, embankment);Sazbon (152 m high, concrete arch);Seymareh (178 m high, concrete arch);
Gavoshan (116 m, earthfill); and,
Kosar (Tangeddok) (137.5 m, mass concrete)

In recent year 230 small, medium and large projects have been on the national agenda, of which about 60 have been completed, 40 are under construction and 130 being studied.

Energy and power sector

The main sources of energy are: crude oil and petroleum products(66.6 per cent), natural gas (24.25 per cent), solid fuels(2 per cent) and electricity (7.1 per cent). Despite vast reserves of oil and gas, Iran is seeking to develop most of its economic hydropower potential in the medium term.

The main sources of electricity are: oil and gas(87.1 per cent); and, hydropower (12.9 per cent).

The Ministry of Energy is in charge of energy and power, with its IWPC division being responsible for water and hydropower projects. Thc Ministry of Energy owns and operates all powerplants.

Per capita electricity consumption is 957.2 kWh/year(1993).

Hydropower development

The gross theoretical hydropower capacity potential of Iran is estimated to be 20 047 MW (176 TWh/year). The technically and economically feasible hydropower potential is estimated to be 16 000 MW, about 50 TWh/year. By far the majority of this potential(30 TWh/year) is on 840 km-long Karun river

Iran is moving ahead with a major programme to develop its hydropower resources, and aims to develop 80 per cent of the technically and economically feasible potential by 2020, that is 40 TW/year. Major development are under way in the Karun, karkheh and Dez river basins. Ten projects, either under construction or planned on the Karun river, will provide about 14 GW of hydro capacity (22.2 TWh/year).

At present, hydropower contributes about 9 per cent of national power production, but it has been calculated that it could theoretically meet up to 70 per cent of the country's needs.

The installed capacity at all hydro plants in operation is about 2500 MW. More than 7500 MW of hydro capacity is under construction.

Most of the very large hydro projects under construction are on the Karun river. Karun 3 is the largest. It will have an installed capacity of 2000 MW, to be uprated to 3000 MW in a subsequent phase. The Masjed-e-Solyeman projcct will have an initial capacity of 1000 MW, to be doubled to 2000 MW in a subsequent phase. Other projects under construction on the Karun river are: Shooshtar (2000 MW) and Karun 4(1000 MW).

Karun 2 (1500 MW), Khersan 1 (750 MW) and Khersan 3(750 MW) are under study on the same river.

The following projects are under construction in the Karkheh river basin: Karkheh (400 MW): Sazbon (500 MW); and Seymareh (640 MW). The 1000 MW Paalam project is study.

Two major projects are under study in the Dez basin: Rudbar-e-Lorestan (1000 MW); and, Bakhtiari (1500 MW).

Future outlook

Iran is carrying out one of the most ambitious programmes for hydropower development in the world, as part of a policy of multipurpose water resources development.

IRISH REPUBLIC

The Irish Republic covers an area of 70 283 km2 and has a population of 3.55 million.

Water resources

Average annual precipitation is 1150 mm. The total average precipitation volume is 81x 109 m3/year, with a total runoff of 45 x10 m3/year.

Per captia domestic water consumption is 175 litres/person/day.

There is no national authority in charge of water resources although there is some overall regulation by the Department of the environment. In general, local authorities deal with the water resouces with in the areas they govern. No deregulation is envisaged.

There are 16 large in operation and the total water storage capacity of all dams is about 1 km3.

The 21 m-high Pollan dam was completed during 1997 and will be commissioned during 1998.

The energy and power sectors

There is no national authority in charge of energy, although energy policy is in general regulated by the Department of Transport, Energy and Communications. The nation electricity authority is the Electricity Supply Board (ESB); there are no regional power authorities.

Deregulation of the energy and power sectors is envisaged in 2000. There will be vertical integration of generation, transmission and distribution, with open access to network for IPPs. Currently the electricity market involves PPAR, but after 2000 there will be pool bidding.

The main sources of electricity production in 1996 were: coal (37 per cent), gas (33 per cent), oil (14 per cent), peat (12 per cent) and hydro (4 per cent). About 51 per cent of electricity generated was using imported fuels.

Total electricity consumption in 1996 was 18 435 GWh, representing 5079 kWh/person/year. Electricity demand is expected to increase by 4 per cent/year during the next 10 years.

In 1996, 53 GWh electricity was imported and 182 GWh was exported.

ESB owns and operates almost all powerplants, with only about 2 per cent of capacity being privately owned (3 per cent of hydro plant capacity).

hydropower development

The gross theoretical hydropower potential of the Republic of Ireland has been calculated as 1400 GWh/year. The technically feasible potential is estimated to be 1180 GWh/year. and the economically feasible potential, 950 GWh/year. About 80 cent of the technically feasible potential has been developed.

The installed capacity of all powerplant is 4360 MW, of which 226 MW is publicly owned hydro capacity. A further 4 MW of hydro capacity is planned.

Of the hydro plants in operation, four are also used for water supply. The average annual generation of the hydro plants in operation is 725 GWh/year, representing about 5 per cent of national electricity production.

There is 292 MW of installed capcity at pumped-storage plants, generating 260 GWh in 1996 (and consumption 370 GWh).

Hydro plants, including pumped-storage, contribute 5.5 per cent of national electricity production on average.

There is a legal framework relating to EIA and management of powerplants larger than 300 MW, as well as for dams, waste disposal, refineries, metalworks and chemical works.

Small hydro

Small hydro is defined as plants of up to 10 MW, and mini hydro, up to 4 MW. There are more than 34 small hydro plants, with a combined capacity of more than 13 MW, in operation, which sell their electricity to ESB. Data for mini and micro plants are not available. A further 5 MW of small hydro development is planned.

Future outlook

In the power sector, the emphasis is now on gas/oil combined cycle plants, and ESB is currently adding 310 MW of combined cycle technology to its Poolbeg generating station.

IPPs are expected to enter the market to an increasing extent.

It is highly improbable that more large dams or hydro projects will be built in the future. However, small scale hydro developments are being encourage, and generation from such plants may increase.

ISRAEL

Israel covers an area of 21 946 km2, and has a population of about 5.8 million. It is located in Mediterranean region, adjacent to semi-arid region to the east and south.

Water resources

Precipitation varies greatly, ranging from 22 mm in the Eilat area to 763 mm in upper Galilee.

Per captia demestic water consumption in 1996 was 105 m3/person(289 litres/person/day).

There are no large dams in operation, under construction or planned.

The major water supplier is Mekorot Water Co, which distributes about 69 per cent of water supplies.

Israel's water Commissioner recently announced that Israel must begin to build major large scale desalination plants to help overcome its continuous problem of water shortages. Such large scale supplies will be needed by 2005 to 2010. Other options include further conservation, and increased use of treated wastewater of water imports.

Energy and power sectors

The main sources of primary energy in 1996 were: crude oil and its products (67 per cent), coal (30.4 per cent), and others (2 per cent). The total primary energy consumption was 16.38 KTOE.

The main sources of electricity in 1996 were: coal (69.4 per cent),crude oil and its productions(29.1 per cent), and other s such as solar and a very small amount of hydro (1.5 per cent). Almost 100 per cent of electricity is generated using imported fuels.

Total electricity consumption in 1996 was 29 600 GW representing 5200 kWh/person/year.

The Israel Electric Corporation(IEC) is responsible for energy and electricity.

Only about 2.7 per cent powerplants are privately owned. The electricity market currently involves PPAs.

In the west Bank Area, about 97 per cent of electricity consumed is bought from the IEC. This area has a population of about 1.6 million, of which 57 per cent are in rural areas. A number of villages in the north and south are not connected to the main grid, and depend on small local generating unit.

Some villages only have electricity for a limited number of hours each day, while some have no electricity at al. Electricity consumption is only about 500 kwh/person/year.

Hydropower development

The installed capacity of all power plants in Israel is about 7000 MW (generating 30 425 GWh in 1995). Less than 5 MW is hydro capacity, the largest hydro plant being Kfar Hanassi (2 MW).

Israel and Jordan have been considering an innovative pumped-storage development, known as the 'Red-Head project'. It could provide 200 MW of capacity for continuous operation or 800 MW for peaking power.

It is estimated that about 15 per cent of the electricity consumed in the West Bank area could bc supplied from local Small hydro projects.

This region has many hills and valleys, with the steeps valleys routed eastwards towards the Dead Sea(40 m below sea level), and rainfall in the area is about 600 mm/year. There also an estimated 400 springs. Discharging about 50 to 60×106m3/year.

The renewable water potential is about 850×106 m3/year, of which about 600×106 m3/year stored as groundwater. Of the 250×106 m3/year surface water. 20 per cent flows to the Mediterranean Sea. While 80 per cent flows into Jordan river. The steep slopping rivers flowing to Jodan river (many with more than 600 m head)represent significant potential for hydro development, particularly small hydro for decentralized rural electrification.

Construction of two or three dams with a capacity of 250×106 m3 for water supply as well as for hydropower generation could geratly affect agricultural development and the economy. Small seasonal storage dams for seasonal power production could help generate poweer in winter, while rainfall is highest.

At least 50 per cent of the potential of springs is currently wasted. They represent continuous and direct potential for small hydro.

Italy

Italy covers an area of 301 277 Km and has a population of about 57 million

Water resources

The average annual precipitation is about 1000 mm, and the total mean annual precipitation volume is 300 km3, of which 110 km3 is runoff.

Per capita domestic water consumption is 88 m3/year.

The national authority responsible for water resources is the Ministry of Public Works. The Ministry has local, regional offices.

Italy has 569 large dams in operation, of which NEEL owns 260.

There are several major dams under construction, including: Cumbidanovu(73 m high) and Melito/Gimignano(98 m high). The Castagbnara/Meramo(99 m high) and Menta(95 m high) dmas are almost complete. Several other major dams are temporally suspended A result of technical, economical, environmental or administrative problems, pending a new revi\ew and reassessment.

Energy and power sectors

The Ministry of Industry is the national energy and power authority, and there are offices fir each of Italy's 20 regions.

The main sources of electricity in 1995 were: thermal plants (81.2 per cent),hydro (17.3 per cent)

Powerplants are owned by : ENEL SPA(the National Electricity Board);municipal utilities (public services); and .companies producing for their own consumption. In 1993.84.3 per cent of power was produced by ENNEL and municipal utilities, and 15.7 per cent by private companies.

Hydropower development

The gross theoretical hydropower potential of Italy is 150 000 GWH/year; the technically feasible potential is 69 000 GWH/year; and the economic potential is 54 000 GWH/year.(These data were evaluated in 1991,1987 and 1991 respectively.)About 67 per cent of the technically feasible hydro potential have so far been developed.

The installed capacity of powerplants of all types in operation is about 66 000 MW, of which 14 927 Mw is hydro capacity(average 46 600 kWh/year).Hydro plants generated 43 480 Gwh in 1996.

A further 450 MW of hydro capacity is under construction. and another 1000 MW is planned.

The hydro plants currently under construction include S.Giaacomo al Vomano (340 MW, scheduled to be commissioned in 1998).A large hydro plant planned is villeneuve (184 MW,720 m head, two units, 2001).

There is 6948 MW of pumped-storage capacity in operation in Italy. A further 1000 MW is planned at the piedilago project.

Small hydro

There are about 1510 small, mini and micro hydro plants (up to 10 MW) in operation. With a total capacity of about 2000 MW(producing an average of 7300 Gwh/year).

Based on current laws, prorate developers have applied for concessions to ENEL for 74 small hydro plants. Of these, 56 with a total capacity of 220 MW have been granted. Their implementation will cover a five year time span.

ENEL also plans to construct four new small plants, with a total capacity of 16 MW by the end of 2002.

Future outlook

ENEL's plans include 35 new plants, including the 1000 MW pumped-storage plant mentioned above, and 13 projects to refurbish obsolete plants, giving a total capacity of 3100 MW and a production of 6100 Gwh/year within the next 10 years.

The main constraint on the construction of new plants relates to authorization,especially from local authorities. (see also full entry in 1995 and update in 1997.)

Jamaica

Jamaica has an area of 11 424 km2 and a population of about 2.6 million.

Water resources
The average annual precipitation is 1980 mm, and the total mean annual precipitation volume is 11 998 m3, of which 5527 m3 is runoff. Per capita water consumption is between 75 and 100 m3/year.

The underground Water Authority is the national authority for water resources. The National Water Commission is in charge of domestic water, and the National Irrigation Commission is responsible for irrigation water.

Energy and power sectors
The main sources of energy are: oil(88.3 per cent), biomass (10.4 per cent), coal (0.3 per cent) and hydro(1 per cent).

The main sources of electricity are: diesel (about 80 per cent), gas (19 per cent) and hydro. The contribution of hydro to national electricity production varies between 1 and 4 per cent.

The national energy authority is the Jamaica Public services Company (JPSCo), which owns and operates 90 per cent of powerplants; private sector groups own the other 10 per cent. The Rural Electrification Programme (REP) is responsible for rural electricity supply.

Hydropower development
The installed capacity of all powerplants is about 750 MW, of which 23.8 MW is hydro capacity. The generation of all hydro plants in operation is around 98 Gwh.

JPSCo owns eight hydro plants, of which Maggotty Falls(6.3 MW) is the largest, followed by Lower White River (4.9 MW). Upper White river (3.8 MW) and roaring River (3.8 MW).

About 16 potential hydro projects have been identified, the largest being Black Rio Grande (50.5 MW), Great River (8 MW0, Black Rio Grande Upper (6 MW), Martha brae River (5.4 MW) an Laughlans Great River(5.3 MW).

It is expected that by the year 2000 there will be about 10 Mw of new hydro capacity and 6 MW of additional capacity from refurbished stations.

Jamaica has 6 MW pumped-storage capacity in operation.

JAPAN

Japan has an area of 377 737 km2 and a population of about 126 million.water resourcesAverage annual precipitation is 1400 mm. The total mean annual precipitation volume is 653 km2, of which the total mean annual runoff is 420 km3. Per capita domestic water consumption in 1996 was 335 litres/person/day.

The total number of large dams in operation according to ICOLD's definition is 2483. The total water storage capacity of all dam is 21.4 km2.

Many large dams are under construction. 48 being more than 60 m high and 13 at least 100 m high. The highest is Tokuyama(161 m high).

Energy and power sectors

The national energy authority in Japan is the Ministry of National Resources and energy. There are 10 regional Electric Power Companies, which supply about 75 per cent of the power, responsible for generation. transmission and distribution in their respective areas. They are effectively private regional companies.

The main sources of power generation in 1996 were: thermal(60.8 per cent); nuclear (29.9 per cent); hydro (8.9 per cent); and. geothermal (0.4 per cent).

Per capita electricity consumption in 1996 was 7995 kWh/person. Energy consumption is predicted to increase by 1.9 per cent/year over the next 10 years, and electricity demand by 1.8 per cent/year.

About 3 per cent of the hydro capacity (1353 MW} is privately owned, and 10.3 per cent (24 400 MW)of all powerplants.

Hydropower development

The gross theoretical hydropower potential of Japan is 717 600 GWh/year, and the technically feasible potential is 134 200 GWh/year (estimated in 1995). The economically feasible potential was estimated in 1991 to be 114 267 GWh/year, but no more recent figure is available. About 67 per cent of the technically feasible potential has been developed.

The installed capacity of all powerplants in operation is 233 737 MW, of which 21 522 MW is hydro capacity (44 407 MW including pumped-storage plants). Hydro plants generated 89 390 GWh in 1996, 8 per cent of national power production. Including pumped-storage plants, hydro provides 8.9 per cent.

A further 666 MW of hydro capacity is under construction, and 3061 MW is planned over the next five years.

It is estimated that 350 MW of additional capacity could be installed at the hydro plants in operation.

The installed capacity at pumped-storage powerplants is 22 885 MW. A further 5420 MW is under construction, and 6596 MW is planned over the next five years.

Several large capacity variable speed pumped-storage units are in operation.

There is 350 GW of pumped-storage capacity at various planning stage.

The mean cost per kW for hydro plants in operation, under construction and planned is between

US$4500 and 6300. For pumped-storage plants it is US$1600.

The main domestic civil contractors for dams and hydroplants include:Maeda, Taisei, Obayashi, Hazama, Tobishima, Kajima Toda, Kumagai and Nihonkoudo.

Small hydro

Japan has a large poential for small-scal hydro projects, estimated to be 60 TWh/year of technically feasible potential. About 15 per cent of Japan's hydro capacity is at small plants.

Future outlook

Japan has almost exhausted the sites available for the construction of large scale hydropower facilities. Recent developments have tended to be on a smaller scale.

As the ratio of thermal and nuclear power generation facilities grows, the development of large scale pumped-storage powerplants to meet peak demand is making steady progress. As a result. the percentage of hydropower generation facilities that use pumped-storage equipment is increasing each year.

JORDAN

The Hashemite Kingdom of Jordan covers 93 000 km2 and has a population of 4.25 million. water resources

Average annual precipitation is 93 mm, Jordan has a total annual mean precipitation volume of 8.45 km3, of which 2 km3 is runoff.

Per capita water consumption is 57 m3/year total, and 45 m3/year for domestic consumption. Total water consumption has-doubled in the past decade, in view of high population growth and immigration.

Jordan has six large dams in operation according to ICOLD's definition, of the total of 19 dams. The total water storage of all reservoirs is 1.28 km3.

The Ministry of Water and Irrigation which is in charge of Jordan's water resources. has recently awarded a contract to Lahmeyer International and a local partner for planning and managemnet for extension of the water supply system in 13 selected districts in the north and south of Amman. Construction will take place between mid-1998 and 2001.

Several dam construction projects are under way:

Kafrein dam heightening(earth dam, 37 m hight, with a reservoir capacity 8.5×106 m3, for irrigation);

Karameh dam(earthfill dam, 44.5 high, with a reservoir capacity of 55×106 m3, irrigation); and

Jordan dam (earth dam, 15 m high, with a reservoir capacity of 2.3 ×1O6 m3 groundwater recharge dam).

It is planned to construct new dams on the Yarmouk river and in the southern part of thc country. Several dams are planned;

Mujib (52 m high, with a reservoir capacity of 35×106 m3,RCC dam. for industrial and drinking water)

Tannur (65 m high, with a reservoir capacity of 16.8×106 m3,RCC. for irrigation); Al Wehdah (1OO m high, with a reservoir capacity of 225×106 m3, CFRD);and, Wala (45 m high. with a reservoir capacity of 1O×106 m3, earthfill dam, for irrigation and recharge).

Energy and power sectors

The main sources of electricity in Jordan in 1995 were: thermal plants (99.7 per cent), using mostly oil (94 per cent) with the remainder using gas (5 per cent), and hydropower (0.3 per cent).

Hydropower development

There is 7 MW of hydro capacity (22 GWh/year), at the King Tatal hydropower station. No hydro plants are under construction, but an 8 MW hydro plant is being considered.

KAZAKHSTAN

Kazakhstan has an area of 2 724 000 km3 and a population of 17.4 million.

Water resources
The annual average precipitation in Kazakhstan is 200 mm, giving a total mean precipitation volume of about 545 km3. The distribution of rainfall is very varied. Total mean annual runoff is 197.1 km3.

Major changes are taking place in the water and energy sectors, with the introduction of private (mainly foreign) owners.

There are nine large dams in operation according to ICOLD's definition, out of 35 dams, most of which are multipurpose. No additional large dams are under construction or planned.

Per capita water consumption is 130 m3/person/year total.

Energy and power sectors
The main sources of energy in Kazakhstan in 1994 were: coal(70 per cent); oil (15 per cent); hydropower(1O per cent); and, natural gas (5 per cent).

The main sources of electricity in 1995 were: thermal plants, mainly coal-fired (87.5 per cent); and, hydro (12.5 per cent).

The Ministry of Energy is in charge of energy and power. There were 1O regional authorities until recently, but reorganization is currently under way. The Ministry of Energy owns all the country's powerplants.

Per capita electricity consumption is 6370 kWh/person/year.

Future developments in the energy sector will be based mainly on coal and natural gas.

Hydropower development
Kazakhstan has a gross theoretical hydropower potential 11O OOO GWh/year and a technically feasible potential of 60 000 to 65 000 GWh/year. The economically feasible potential is 25 000 to 35 000 GWh/year. All these figures were evaluated in 1985. So far about 13 per cent of the technically feasible potential has been developed.

There is 21 80 MW of installed capacity al hydro plants, of a total powerplant capacity of about 19 000 MW; however. only about 1700 MW is operational. Hydro Plants generated 9600 GWh in 1997, representing 20 per cent of Power production.

Three hydro plants are planned: Kerbulak(50 MW), Moinack(300 MW) and the second phase of the Shulba scheme.

Small hydro
There are currently 19 small mini or micro hydro plants in operation, with a total capacity of 79.9 MW.

KENYA

The Republic of Kenya covers an area of 582 648 km2 and has a population of about 28.8 million.

Water resources

There are 14 large dams in operation, according, to ICOLD's definition. The total water storage volume of all reservoirs is about 3 km3.

No major dams are currently under construction, but three are planned: Sondu Miriu (60 MW), at the tendering stage, and expected to be commissioned in 2002: Ewaso Ngiro (180 MW), detailed design state (2008-2009): and, Low Grand Falls/Mutonga (180 MW), feasibility study stage (2008-2012).

Kenya follows World Bank guidelines for environment impact assessment and management.

Energy and power sectors

The main sources of power in Kenya in 1996 were: hydro (82 per cent); geothermal (8 per cent): thermal (8.7 per cent), diesel (1.3 per cent): and, wind (0.01 per cent).

The total electricity consumption in 1996 was 4269 GWh, with 130 GWh of electricity imported and 1 GWh exported.

The Ministry of Energy oversees energy policy and resources.

The national power authority is the Kenva Power and Lighting Co. This company has recently been split into two parts, for generation (Kenya Power Company, KPC)and distribution/transmission (Kenya Power & Light Co., KPLC).

Two IPPs are now licensed to generate and sell electricity to the distribution and power company. The deregulated market thus involves the public sector and two IPPs for power, generation. The IPPs are Iberafrica, which has 48 MW capacity, and Westmont, which has 44 MW.

Distribution and transmission now has 50 per cent public sector participation, 42 per cent local, and 8 per cent foreign.

The electricity market involves PPAs with Iberafrica and Westmont Ipps.

The Chief Manager (Hydro) of KPC is now responsible for operation and maintenance of hydro plants, and reports to the Managing Director.

Kenya has a total installed capacity of 894 MW, including 92 MW owned by the two IPPs. About 30 MW of hydro capacity imported from the Uganda Electricity Board.

In addition to KPC, other hydro plant owners are: Kerio Valley Development Authority; Tana and Athi Rivers Development Co.; and, Tana River Development Co.

Hydropower development

The hydropower potential of Kenya, which was list estimated in 1991, is about 30 000 GWh/year (6000 MW). However, half of this is on small rivers and would not be economic to develop. Most hydro potential is on the Tana and Turkwel rivers.

A more realistic estimate of the hydro potential is 8860 GWh/year, representing 2107.5 MW of capacity.

It is estimated that the technically feasible hydro potential is4710GWh/year, of which 62 per cent has been developed.

There is 598.5 MW of hydro capacity in operation, which generated 3354 GWh in 1996 (82 per cent of national power production). Three of Kenya's hydro plants are part of multipurpose developments.

No hydro plants are currently under construction, but 520 MW are planned. The estimated potential for upgrading Kenya's existing hydro plants is about 18.5 MW.

Small hydro

There are six small, mini or micro plants in operation, with a total capacity of 13.64MW. Some of these have been undergoing repairs.

The energy sector in Kenya has been liberalized, and it is considered likely that the private investors will be interested in small and mini hydropower veneration.

Future outlook

The least cost development plan for Kenya's energy sector involves diesel plants, gas turbines, geothermal plants and hydropower.

Kenya does not have fossil fuel resources, so if the price of oil increases to US$20 per barrel, the least-cost development plan scenario would change significantly to favour geothermal and hydropower over thermal plants.

Establishing the infrastructure for community micro-hydro in Kenya

A development scheme for the micro-hydro sector in Kenya is just reaching completion by ITDG-East Africa and the Renewable Energy Department of the Ministry of Energy in Kenya. This is a groundbreaking project in a country where there was no infrastructure for micro hydro.

The project started in 1997, funded by the UNDP GEF small grants programme. A vital part of the project was to install the first pilot micro hydro scheme, which is due for completion in November 2000.

The ultimate aim of the project is to demonstrate that community micro hydropower schemes can reduce threats to the local environment and climate change. The goal is to improve the livelihoods of Kenyan communities living far from the grid and in remote areas, by tapping the micro hydropower potential to provide them with an alternative source of energy for productive end-uses.

Pilot project

The pilot project was launched in May 1998 with a feasibility study, which identified suitable sites and studied the legal aspects of water use, land use and ownership. The following aspects for identifying a suitable site were considered:

- Commercially viable end-uses;
- Environmental benefits;
- Consistent water resources; and,
- Community involvement.

The potential schemes were also assessed on criteria such as: geographical and topographical conditions; diesel to hydro substitution; remoteness to grid connection; legal features; existing structures; community organization and structure; and, the economics of development and installation.

Twenty sites were identified and then filtered using the criteria above to highlight two schemes worthy of a detailed feasibility study. The study included a socio-economic survey to assess demand scenarios and the potential load factor of the proposed schemes. After further consideration based on refined criteria, one site was selected. The site is near Mbuiru village at Jiameceu Falls on Tungu river, about 200 km North of Nairobi.

Community involvem

Community mobilization activities included involvement in construction, mainly by providing both skilled and semi-skilled labour. This was taken into account in the design and construction of the weir, canal, powerhouse and penstock.

The result of this process was the formation of the community-based Tungu-Kabiri project management committee. The scheme will be operated on a commercial basis through share holding. The project is working with and receiving support from the local committee, together with the regional water and social services departments.

Although the communities will own and manage the project, the project team and the local development committee will require technical and commercial support, particularly in setting tariff structures and operating and maintaining plant components.

The community has contributed in the following ways during the construction of the scheme:

• Identification and provision of local artisans and resources.

• Labour for construction, moving materials, and diverting flow. (One day per week is a community working day, and this contribution of labour is included in the costs.)

• Land provided by the Government for building the powerhouse and canal; storage space for construction materials and equipment; lighting for night work; materials for river diversion.

• Providing finances to pay for legal registration and Government licences for the project.

• Maintenance of the canal(prior to filling).

Commercial end-uses

A demand was identified for combined mechanical and electricity generation. Mechanical or shaft power will be used for productive end-uses including grain milling, oil seed-processing and domestic water pumping. Electricity will be used for battery charging and tobacco curing. Combining both electricity and shaft driven processes is an appropriate use of the natural resource and adds value to the project in general. For example, during the day when demand for electricity is low, the hydropower is used to pump water for community use or to drive a directly coupled end-use processor like a mill or oil press. At night when the community requires electricity for lighting, the turbine drives the electric generator for charging batteries and tobacco curing.

At present, maize is ground using a diesel powered mill. The new hydro plant will reduce milling costs, thus increasing revenue for the village. Tobacco curing will be possible by using the waste heat from the ballast load during periods of low load.

Power from the scheme will be made available at a centralized utility building, where small enterprises will be set up. It is planned to run educational and workshop facilities from this centre, including welding, metalwork and woodwork.. There are no current plans for distribution to individual homes for electric lighting, hence battery charging is another commercial activity that will increase.

The scheme will contribute significantly in uplifting the levels of income and improving the livelihoods of the Tungu-Kabiri river communites. The technology will help alleviate problems of pollution and deforestation which are associated with biomass fuels for the curing of tobacco, diesel for milling of grains and kerosene for lighting.

Technical data for the pilot scheme

The scheme produces 17.8 KW of shaft power from a crossflow turbine, operating under a 13.5 m head with a discharge of 200 l/s. The scheme includes a desilting basin and forebay tank, with a lined power canal and a 20 m-long mild-steel penstock.

Impacts already achieved

The community members have organized themselves into a commercial development group, which has initiated a project fund for new ventures related to the hydro scheme. They have acquired, from the Government, an area of land to build the small enterprises power centre. The work has attracted the attention of the NGOs, government ministries, private agencies, individuals and donors. As an example, two new schemes are now planned for installation in the district of Kirinyaga.

Funding has been obtained for related activities, such as training in turbine manufacture. The scheme has become a centre for education on energy and environmental issues for local schools.

Lessons and recommendations

In a country where there is no micro hydro infrastructure, the following were found to be important factors:

- The existing level of involvement in micro hydropower development in the country needs to be improved.
- The hydro potential for the country needs to be assessed, to identify possible sites for development.
- The legislation for encouragement of micro hydro development needs to be put in place and clearly understood at the community level.
- The power sector policy aspects governing micro hydro in Kenya need to be explained to implementing agencies and communities.
- A lobbying process is necessary to increase awareness about the role of micro hydro in development.
- Logical, consistent and unbiased criteria for site selection.
- A pilot scheme to demonstrate that the technology is important in the initial phases of the process.
- A mechanism to create the capacity for manufacturing components such as turbines and electronic load controllers needs to be established, to achieve the economically feasible and sustainable dissemination of micro hydropower on a large scale. Training of potential manufacturers of micro hydro parts is therefore an important objective. This issue was highlighted by the problems involved in obtaining a suitable turbine. The machine used was eventually obtained from Ethiopia, but only after causing significant delays to the project.

The future of micro hydro in Kenya

This project is an important first step in establishing a micro hydro programme in the country. Interest is already growing with two more proposed schemes.

It is anticipated that this tangible demonstration of the significant benefits of micro hydro, through this first pilot scheme, will lead to many more successful schemes being built and operated.

D.P.R.Korea

D. P. R. Korea consists of the Korean Peninsular and the nearby 3000 islands9 with an land area of about 123. 2 thousand square kilometers. Geographically speaking, three quarters of the whole landscape in D. P. R. Korea is mountainous region and plateau. The rainfall is plentiful in the area and its annual precipitation is more than 1000 mm. As a result, most rivers in D. P. R. Korea are small but the current is swift and rich in hydropower resources. Since D. P.R. Korea has abundant coal resources, the SHP resources are never got a good utilization and exploitation. By the end of 1990, about 1000 medium and small sized hydropower stations have been erected with a total installed capacity of 169 MW, among which about 800 are under the jurisdiction of the local government with a total capacity of 38 MW.

In recent years, because the whole world has attached great importance to SHP, D. P. R. Korea also begins to exploit and utilize the SHP resources in the country, and takes seriously the important functions that SHP makes in rural development. Power Ministry of D. P. R. Korea also joins the Asia-Pacific Regional Network on SHP and has set up several

demonstrative SHP stations. The installed capacity of two SHP stations in the first group of pilot exploitation are 450 and 1400 kW respectively and its innvestment per kW is about 1600 US dollars. Besides, the feasibility researches towards 8 power stations have been carried out, and except specific stations , the unit cost of construction is similar to that of those pilot projects. It shows that the development of SHP is quite favourable in D. P. R. Korea, a country rich in large hydro and coal resources.

In D. P. R. Korea, power plants that have more than 1 MW installed capacity and 50 thousand Korean won's investment are under the state's plan. The designing task is assigned to the hydropower designing offices by the state.

Its design and budget have to been approved by the State Construction Commission. The construction of whole project is undertaken by the state-assigned professional groups and under the management of the Medium and Small Hydropower Bureau.

As for those hydropower stations under 1 MW with an investment lower than 50 thousand Korean won, these stations are placed into the local program by the local provincial commissions. The State Planning Commission and local provincial government are responsible for assigning construction targets. The design, budget as well as the construction of these projects are approved by the local governments.

The medium and small hydropower stations in D. P. R. Korea are managed at different levels. The power stations connected to the state power grids, after the investment and construction by the state, are submitted to the administration of Medium and Small Hydropower Bureau of the Power Industry Commission. But there are power plants that connect with the state grids while are controlled by the local government. The construction plan of the isolated power plants is conducted by the local government and under its management after the accomplishment. In the year 1979, the state set a policy that the electric output generated by those isolated power plants will not be brought into the state electric distribution quota, but can be allowed to be assigned inside the province for local demand. The measure stimulates local governments and people to develop SHP. Counties, towns, factories, even schools have built & lot of SHP stations, and the electricity generated by these SHP stations is used for warming and cooking, which is not limited by state allocation of electricity. Under the positive policy, such as , there are 4 counties, Darhomden country of Yanggang-Do (Province) , Yongun county, Seengun county and Dezane county of Hangyong-Namdo (Province) , to have resolved the problems of insufficient supply in electricity through constructing their own SHP stations.

In developing medium and small hydropower, D. P. R. Korea takes two ways. One of them is at the existing multi-purpose water-conservancy projects to construct hydropower staations. The other is to develop run-of-river power station with low-dam to avoid the inundation of a great tract of farmlands. Besides mini and micro hydropower stations mainly use the flow of brooks and mountain springs.

At the power stations in the multipurpose water-conservancy projects, the flow generating electricity is limited by the water consumption downstream, such as agricultural irrigation etc. AII the generation can be connected to the power grids without firm output. Such power stations account for 40N of the total SHP capacity in D. P. R. Korea, and has a comparatively larger installed capacity. The Yangfeng Lake Hydropower station in p'yongan-Budo province is a distinctive example in this group.

D. P. R. Korea also has a lot of mini hydropower stations, for instance, the whole drop on the 2 kilometers river course in Duyi village of Sinpyon county reaches 100 meters where 11 cascade mint hydropower stations with installed capacity from 6. 5 to 100 kW have been set up.

AII medium and small power stations in D. P. R. Korea are under the supervision of Medium and small Hydropower Bureau of Power Industry Commission for trade administration. Medium and small hydropower corporations are set up in local provinces.

And in places where have little hydropower resources, there are instructors in stead of the set-up of corporations. The large hydropower corporations are in charge of the technical supervision of stations connected to the state grids and the approval of the maintenance programs for those stations. Local mini hydropower stations are managed by the local government, with the advice from Medium and Small Hydropower Bureau. Also the Bureau regularly make an examination and trade assessment of the performance of those hydropower stations, its main indexes includes output value, energy generation, retrieval of scrap iron and all-round development etc. The power supply from these stations are controlled by Power Distribution Bureau of Power Industry Commission. D. P. R. Korea has attached great importance to the management of the medium and small hydropower, which might be seen in the following items.

Management of the economic plan
The generation plan of stations managed by the state is assigned monthly to each station by the Medium and Small Hydropower Bureau after the State Planning Commission delivers its quarterly generation plan to the power Industry Commission. As for stations under local management , its generation plan is assigned by the local planning commission. The energy generation from these stations constructed by the local governments will not be brought into the state electric distribution quota. After connecting with the state grids 9 for the areas supplied with electricity by them, the electricity can be supplemented by the state grids. This is a preferential policy for helping medium and small hydropower to develop, i.

e. for these areas covered by local grids, the targets of using electricity are the targets assigned by the state plus the generation from local SHP stations themselves, it is called the "self-generating" and the "self-consumption" for SHP.

Management of productive technology
The technical rules are issued by the State Power Industry Commission , which include manipulating rules, operation rules and safety rules as well as relevant directions in light of the local conditions.

Technical training
The State Power Industry Commission has set up various technical schools in many provinces to give courses on electric generation, electric transmission and turbine etc. Apart from it, the schools also organize students to practice in some operating stations. Each operator in power stations has to receive a strict training in these schools before he takes his position formally.

The maintenance of the equipment
According to the technical rules made by the State Power Industry Commission, in order to keep the sets in good conditions , all the equipment need a regular overhaul check. Major repair is practiced every five years during which the generating sets are dissembled. The key parts of sets

will be serviced every 2 or 3 years, and minor repair will be carried out two or three times each year. Those stations with large capacity may shorten their overhaul period in accordance to their own conditions.

Labor management
D. P. R. Korea has no unified labor quotas for medium and small hydropower stations, each station makes their own arranggement in the numbers of operators. Generally, in D. P. R. Korea there are not many staff members in SHP station. This may result from the management system for SHP stations. In D. P. R. Korea, SHP stations do not works as a independent accounting unit, but only as a "workship" attached to the local hydropower corporations.

Financial management
The income of state-managed power stations be long to the state in the form of plan targets, only taking the output value of generation as an indicatrix of examination. Its expenditure also has to be made down to it as a financial quota in the state plan. This kind of stations which have surpassed the production quota will be rewarded , and the extra electric output is still brought into the state power distribution plan.

The D. P. R. Korean government emphasizes the hydropower development. On October 28, 1996, after an inspection of the new complete Yuefei Mount Hydropower Station , D. P. R. Korean leader, Kim Jong Il said that D. P. R. Korea should fully utilize its rich hydropower resources and strengthen the construction of large, medium and small hydropower stations nationwide so as to meet the demand for electricity.

During his inspection, Kim saw about the generating sets in the station and carefully inquired of the equipment installation and electric production of the station. He called for a high-standard normal operation of the power station and gave a concrete instruction on the station's operation and management.

The Yuefei Mount Hydropower station is located in the Kimggong mountain areas, Kangwon Do. The construction plan for this protect was proposed by the former Chairman Kim Il Sung.

The power station was built by the Korean People's Army (KPA). Kim Jong Il said in his inspection that all D. P. R. Korean people should learn from the KPA for their spirit of doing pioneering work with painstaking efforts. He praised that the station is an amazing wonder created by those KPA soldiers and is another precious wealth of the Korean people.

KOREA

The Republic of Korea (South Korea) covers an area of 99 475 km3, and has a population of 45.6 million.

Water resources

The average annual precipitation is 1274 mm. About two-thirds of precipitation occurs in the flood season(June to September), and most discharges directly into the sea. Total mean annual runoff is 69.7 km3. The total water storage at all dams in the country is 12.7 km3.

The national authority responsible for water resources development is the Ministry of Construction and Transportation (MOCT, and that in charge of water quality is the Ministry of the Environment (MOE). Korea Water Resources Corporation (KOWACO) is a public owned corporation founded for the principal purpose of improving public welfare through water supply and water quality improvements, by effective water resources development and management.

Korea has about 800 dams in operation. The largest dams under construction are:

Namgang (refurbishment): CFRD, 34 m high, reservoir capacity 309×106 m3, 14 MW hydro scheduled for completion in 1998.

Yongdam: CFRD. 70 m high, 815×106 m3 reservoir capacity, 24.4 MW hydro plant, 2000.

Hoeng Song : rockfill 48.5 m high, 86.9×106 m3 reservoir capacity. 1.4 MW hydro plant,1999.

Milyang: CFRD, 89 m high,73.6×1O6 m3 reservoir capacity,0.12MW hydro plant, 1999.

Boryung: 50 m high, 116.9×106 m3 reservoir capacity, 0.6 MW hydro plant, 1998.

Tam Jin: CFRD, 54 m high, 183×106 m3 reservoir capacity, 0.6 MW hydro plant, 2001.

Yongwol: rockfill with concrete core, 98 m high, 698.1×106 m3 reservoir capacity, 19.6 MW hydro plant, 2001.

Per capita domestic water consumption in urban areas is 44 9 litres/person/day. While in rural areas it is 270 litres/person/day.

The main domestic design consumption for dams and hydro projects are: DoHwa, Saman, Yooshin, Korea and Hankuk engineering Consultants Co.Ltd, and the main civil contractors Hyundai Engineering & Construction Co.Ltd, Samsung Corp, Dong-Ah Construction Industrial Co.Ltd, Daelim Industrial Co.Ltd, and Ssangyong Engineering & Construction Co.Ltd.

Energy and power sectors

The sources of primary energy in South Korea in 1996 were petroleum (66.4 per cent), coal (16.7 per cent), nuclear power (9.3 per cent), LNG (6.3 per cent), hydropower (0.6 per cent) and others (0.7 per cent). The total primary energy consumption was 165 209 kTOE.

Installed capacity in 1996 was 35.715 MW. The sources of electricity were: pure hydro (4.2 per cent). pumped-storage plants (4.5 per cent), petroleum (20.6 per cent), LNG (21.9 per cent), coal (21.9 per cent) and nuclear (26.9 per cent). About 69.4 per cent of power was generated using imported fuels.

Total electricity consumption in 1996 was 182 470 GWh, about 4000 kWh/person._

Energy consumption is expected to increase by an average of 4.5 per cent/year between 2000 and 2015 and by 3.7 per cent/year between 2005 and 2010.

Electricity demand is expected to rise by 3.3 per cent this year, by 6.6 per cent in 1999, and then by about 6 per cent on average between 2000 and 2005, with a general decrease in growth rate.

The Ministry of Trade, Industry and Energy is in charge of energy, through national and regional energy/power authorities. Korea Electric Power Corporation (KEPCO) is the national power authority. KEPCO owns and operates 96.5 per cent of powerplant capacity, while 3.5 per cent is private.

Per capita electricity consumption is 1469 kWh/year (domestic) and 3640 kWh/year(total).

Hydropower development

The gross theoretical hydropower potential of South Korea is 51 777 GWh/year. The technically feasible potential is 26 389 GWh/year and the economically feasible potential is 18 603 GWh/year. About 11 per cent of the technically feasible capacity has been developed.

The installed capacity at powerplant of all types is about 35 715 MW, of which 1494 MW is hydro capacity (3094 MW including pumped-storage capacity).

A further 61.3 MW of hydro capacity is under construction. The generation from pure hydro plants in 1996 was 2424 GWh,1.3 per cent of national power production. Hydro including pumped-storage plants contributes 2.9 per cent of power production.

South Korea has 1600 MW of pumped-storage capacity in operation, a further 2300 MW under construction, and 800 MW planned. The generation by pumped-storage plants in 1996 was 2777 GWh.

Small hydro

There are 21 hydro plants of less than 10 MW in operation, with a total capacity of 41.8 MW (97.6 GWh/year}. A further three plants (7.6 MW) are under construction.

Future outlook

Water demand is continuing to increase in South Korea as a result of industrialization, urbanization and rapid population growth. As in many parts of the world, Korea faces a water deficit crisis in the 21st Century.

The country has suffered from water shortages as a result of the decreasing amount of dam construction, rising compensation costs, water quality deterioration, and so on. Water conservation is thus the most important issue facing the country.

KOWACO is making considerable efforts to provide a clean and reliable water supply by optimal management of water resources. The Government is planning to construct 28small or medium-scale multipurpose dams to help alleviate water shortage by 2011.

LAOS

Laos has an area of 236 800 km2 and a population of about 4.8 million.

Water resources

The Ministry of Agriculture and Forestry. and its Department of Irrigation and Micro Hydropower, is responsible for water resources. A new Water and Water Resources Law was enacted in 1996.

Laos has two large dams in operation, and five dams in total, providing a total storage capacity of 7.2 km3.

A 76.5 m-high CFRD is under construction on the Houay river for the 150 MW Houay-Ho hydro project. It will have a gross storage capacity of 596×106 m3. Project completion is scheduled for 1999.

A CFRD is also under construction for the Nam Leuk hydro project, also scheduled for completion in 1999. The reservoir capacity will be 185×106 m3.

Several other large dams are planned in the future., all for hydro projects:

Nam Ngum 3, a CFRD with a height of approximately 220 m;

Nam NguM 2, an arch dam, 169 m height and,

Xepian-Xenamnoy, a rocfill dam 78 m high.

Energy and power sectors

The Ministry of Industry and Handicraft (MIH) is responsible for energy. Electricite du Laos (EdL), is the state-owned national power utility responsible for power generation, transmission and distribution.

The Department of Electricity (DOE) has been established recently within the MIH as an institutional step in the process of electricity sector restructuring. The Hydropower Office within the DOE has been created as the planning, management and administration for the IPP programme, allowing Edl to concentrate more on its prime responsibility of domestic electricity generation, transmission and distribution.

A Committee for Investment and Foreign Economic Co-operation has been established within the Prime Ministry's office to administer and co-ordinate all foreign investment in Laos.

As part of an overall market-oriented restructuring of the Lao economy, changes have recently been made to create an investment climate more favourable to an IPP mode of development, in line with the objective of the Government of Laos(GOL). The GOL has reformed the commercial sector to encourage and regulate foreign capital and, in parallel, it has restructured and commercialized the power sector to enhance regulatory capacity and operating efficiency.

A programme of legislative reform is being undertaken to establish a proper legal and regulatory framework to manage the emerging market economy, to promote regional co-operation and to protect third Parties and environment from potentially adverse effects of private investment. Various new laws have been introduced since 1988, the most recent being a new Water and Water Resources Law (1996) and Electricity Law (1997).

The Electricity Law has introduced a licensing system which IPPs seeking a sole mandate to develop a power project must apply for a license. Regulations under the recent laws are now being drafted and will define many of the concession conditions for licenses and provide the necessary mechanisms for implementing the licensing system.

A number of measures have been taken to commercialize EdL. Tariffs for domestic consumption were increased by 70 per cent in October 1997. EdL became a public company under a charter approved by MIH on 29 December 1997, and signed a Performance Contract with the Ministry of Finance and MIH on January 1998. The utility has also been reorganized into profit centres, and has engaged a Financial Management Adviser to help introduce formal cost accounting and internal transfer pricing for each profit centre. Finally, EdL has established a Loss Reduction Unit, which is identifying major sources of technical and commercial losses and is making appropriate investments to reduce them.

The electricity market currently involves power purchase agreements. Currently about half of the country's hydro plant capacity is privately owned. Deregulation of the energy/power sector is envisaged in 2010, and will involve the separation of generation, transmission and distribution.

The main source of energy is fuelwood (90 per cent), the balance being supplied by electricity (5 per cent oil-based and 5 per cent hydro).

The sources of electricity in 1996 were: hydro(97 per cent)and imported oil (3 per cent).

The total electricity consumption in 1996 was 380 GWh, representing per capita consumption of 80 kW/year, one of the lowest rates in South-East Asia. At present, only 16 per cent of households, mainly in Vientiane, have access to electricity.

Most of the electricity generated in Laos is exported to Thailand. During 1996, 792.4 GWh was exported, and 87.5 GWh was imported.

Both energy consumption and electricity demand are expected to increase by about 9 per cent/year during the next decade.

Hydropower development

Laos has a very large hydropower potential, with a gross potential of 26 500 MW (232 564 GWh/year), of which the technically feasible potential is estimated to be about 18 000 MW (about two-thirds in the country's interior and the remainder on the Mekong river adjoining Thailand and Cambodia. Only about 2.3 per cent of the technically feasible potential has been developed so far.

The total installed capacity in Laos is now 427 MM of which 423 MW is hydro capacity.

The average annual generation of the hydro plant now in operation is 2814 GWh/year. Hydro will continue to supply about 97.5 per cent of power produced.

The 210 MW Theun - Hinboun project has recently been completed, nearly doubling the country's installed capacity.

The Nam Song Diversion Project has also recently increased the average annual output from the 150 MW Nam Ngum scheme from 860 GWh/year to about 1000 GWh/year.

A further 210 MW of hydro capacity is under construction, at an average cost of US$ 1500/kW, and 3717 MW more is planned for completion by 2007. Studies are also under way or pending for another 2669 MW of hydro capacity.

Nam Leuk, a Government project under construction, will add 60 MW (245 GWh/year) to the Vientiane grid. The plant's two units will operate under a gross head of 191.6 m; completion is scheduled for 1999.

Houay-Ho, the first major privately funded hydro project in Laos, is on schedule. It will have a capacity of 150 MW (617GWh/year) from two units, and is expected to start generating power in 1999. It is being built on a BOT basis.

The existing hydro plants could be uprated by an estimated MW.

BOT hydro projects to be developed soon are as follows:

Nam Ngum 3 (460 MW) and Nam Ngum 2 (615 MW), both scheduled for completion in 2003. Memoranda of Understanding (MoU) on power purchase agreements (PPAs) have been signed.

Nam Theun 2 (681 MW) is to be developed privately as a BOOT scheme.

Xepian and Xenamnoy (438 MW), to be completed in 2006; a PPA is under negotiation.

Xekaman I (468 MW), 2006: a PPA is under negotiation.

Nam Theun I (400 MW), 2007; a feasibility study has been submitted.

Feasibility studies are to be conducted soon for the following non-BOT projects: Xeset 2 (30 MW), to be completed in 2003; Tat Ko (30 MW), 2004; Xekong 4(470 MW), 2004, and, Nam Ngum 4 (45 MW), 2005. A feasibility study has already been carried out for Nam Mang 3 (50 MW), to be completed in 2006.

Feasibility studies have been submitted for the following BOT projects: Nam Theun 3 (236 MW); Nam Khan 2 (145 MW); Xetalam I(44 MW): Xetatam 2 (46 MW), Nam Ou (513 MW); and Nam Lik 1/2 (80 MW). Feasibility studies are under way for Nam Ngiep 2 (495 MW) and Nam Tha I (263 MW).

Studies are also pending for: Nam Cha 1 (115 MW); Nam Cha 3 (70 MW); Nam Ngiep 2 (495 MW); Nam Ngiep 3 (70 MW); and Nam Seuang (192 MW).

Small hydro
Laos has nine small, mini or micro hydro plants in operation, with a total capacity of 10 MW. An 80 kW plant is under construction, and two more are planned, with a total capacity of 2.7 MW. A number of small hydro projects are also under construction jointly by Thailand and Laos.

Further development is planned to serve the needs of remote areas, mostly financed by donor countries.

Future outlook
The hydro potential of Laos is far in excess of domestic requirements, and the GOL intends to facilitate development of hydro projects for power export, to make a very significant contribution to the country's economy. The Government is hoping to develop other energy markets, apart from Thailand, in particular in Vietnam and Cambodia.

A major programme of studies for large and medium-scale hydro projects is under way. Government policy on future power development divides project into two types:

Domestic Generation Projects will be principally for meeting increasing domestic demand; they can be brought on-line early earn export revenue. They will mostly be from 5 to 60 MW in capacity and will continue to be built by the GOL.

Export Generation Projects will be implemented in joint venture arrangements with IPPs, specifically to meet export commitments, but they may also supply local demand near the project. Initially, IPPs will build projects needed to satisfy obligations under MoUs with Thailand and Vietnam. An inventory of additional projects is being developed to provide back-up and to meet additional export demand anticipated in the medium to long-term.

The GOL will favour power projects which will have: limited detrimental social and environmental impacts; provide associated infrastural and social development; GOL equity in IPP projects to enhance returns to the country; and, timely implementation.

Transmission planning is at all Important juncture, with several important issues under consideration, including: establishment of a Lao National Grid Company: implementation of a 500 kV line for taking power from the Nam Ngum basis: finalization of interconnection

Arrangements for other IPP projects; planning of a 500 kV line in southern Lao to export power to Vietnam; and, planning for an HVDC line to connect the Jinghong project in Yunnan province, China, through Laos to Thailand.

The process of institution, commercial and regulatory reform will continue It will clarify issues relating to the rights of developers and lenders seeking to invest in Laos, and will include further commercialization of EdL.

Rural electrification remains a high priority. A number of isolated mini and micro hydro projects are at various stages of planning and implementation, and other forms of renewable off-grid supplies are being investigated. Such projects will usually be funded by bilateral arrangements with donor countries and supported by other international organizations. A trial installation of photo-voltaic power supply is planned and, if feasible, could open the way for other such investments.

Latvia

The Republic of Latvia covers an area of 64 600km21 and has a population of 2.6 million.

Water resources

The average annual precipitation is 600 mm. The total mean precipitation volume is 46 km3 of mean annual runoff.

The ministry of Environmental protection and Regional Development (MEPRD) is responsible for water resources development.and there are four so-called committees of Environmental protection in charge of water at regional level.

There are four large dams in operation.

It is planned to improve dam safety by refurbishing the three largest dams; plavinas (43 m high), Kegums (17 m) and Riga (21 m).These planned works will be completed by 2000.The total volume of water stored by all reservoirs in the country is 4.9km3

Per capita water consumption is 250 litter /person/day.

Environmental impact assessments are the responsibility of the State EIA Board. Which is affiliated to the MEPRD. The Ministry is responsible for all development projects of nation-al or international significance. At the regional and local levels, its responsibility is delegated to a series of Regional Environmental protection committees operating in conjunction with the municipal and other regional authorities.

Energy and power sectors

The main sources of primary energy consumption in 1996 were; natural gas (8 per cent), heat energy (32 per cent), electricity (11 per cent), heavy fuel oil (3 per cent), firewood (14 per cent), coal (3 per cent), peat (1 per cent), diesel (14 per cent) and gasoline (14 per cent). Total primary energy consumption was 162.7 PJ.

The main sources of electricity in 1996 were: hydro (62 per cent), heavy oil (17 per cent), natural gas (18 per cent) and peat 9 3 per cent). Total electricity consumption was 4690 GWh, representing per capita consumption of 463 kWh/year. The estimated annual increase in electrcity demand is expected to be 6 to 7 per cent/year during the next decade.

During 1996, 3438 GWh of electricity was imported, and 211 GWh was exported.

The Ministry of Economy is in charge of the country's energy through its Department of Energy. The joint stock company Latvenergo is the national power authority, with branches acting as regional power authorities.

During 1996, the Latvian Cabinet of Ministry took a decision to begin deregulation of the electricity sector. New rules for the privatization process and the future structure of the electricity market are now being worked out. Deregulation is envisaged sometime during 1998. The deregulated market will be vertically integrated with separated generation, transmission and distribution. The Cabinet is now elaboration the rules. The market is currently based on power purchase agreement.

The state owns all large powerplants. They are operated by Latvenergo, which owns 97 per cent of the total powerplant capacity. Approximately 3.2 per cent of powerplant capacity is privately owned; tis mainly comprises small thermal and small hydro plants, and 0.17 per cent of hydro capacity.

Hydropower development

The total hydropower potential of Latvia has been evaluated recently, but figures for this region from the former Soviet Union gave the gross potential as 7200 GWh/year, technically feasible potential as 4000 GWh/year and the economically feasible potenital as 3900 GWh/year. However, it is now estimated that 87 per cent of the technically feasible hydro potential has been developed, in the Daugava river basin.

There is 1507 MW of hydro capacity in operation, of a total powerplant capacity of 2102 MW. A further 0.3 MW of hydro capacity is under construction.

The average annual generation of the hydro plants is 2750 GWh/year, but generation in 1996 was only 1861.5 GWh/year. On average, the hydro plants supply 70 per cent of national power production and about half the total power requirements, taking into account the large electricity imports.

The three largest hydro plant a;; supply peak power and are on the Dagava river: Plaavinas(850 MW, 10 units); Kegums I and II (260 MW, seven units); and, Riga (402 MW, six units). However, many of the units are in need of repair and modernization.

It is estimated that an additional 50 MW could be installed through unrating existing plants.

Small and micro hydro

There is a long tradition of using small hydro plants and mills. There are now 15 small plants in operation, with a total capacity of 2.6 MW; they generated 2.52 GWh year during 1996. Another five are construction (with a total capacity of 0.6 MW).

Future outlook

Development of the electricity sector in Latvia determined by Government energy policy and the Latvian National Energy Program. At present, a specific Law on Energy is being worked out to define the role of enegy within the national economy in compliance with the European Agreement signed on 12 June 1995, and requirements for all types of property and entrepreneurial activities in energy by the new Law.

During 1998, it is planned to design begin upgrading four units at the Kegums schems, to be completed in 1999. Then in 1999, the upgrading of two units in the Plavinas plant will take place.

It is planned to refurbish approximately five small hydro plants each year. The reconstruction of these plants is being encouraged by the higher electricity prices set by the government. The setate will purchase electricity generated by small hydro plants at this higher tariff during the first eight years of opeartion.

Lebanon

Lebanon covers an area of 10 452 km2, and has a population of about 3.7 million.

Water resources
The average annual precipitation is 830 mm, but it is mainly concentrated during four months of the year.

The Ministry of Hydraulic and Electric Resources (MHER) is the national authority in charge of water resources

There are six dams, only one of which is a large dam according to ICOLD's definition.

Total per capita water consumption is 70 m3/year. However, it is predicted that by the year 2000, the water demand will be 280×106 m3 for domestic consumption, 1600×106 m3 agriculture, and 400 ×106 m3 for industry.

Energy and power sectors
The Ministry of Industry and Petroleum (MOIP) is the national energy authority with responsible for the petroleum and gas sectors, with the Directorate of Petroleum being the executing agency, also responsible for import activities.

The Ministry of Hydraulic and Electric Resources (MHER) is in charge of electrical power. Electricite du Liban (EDL), an autonomous state-owned entity under the MHER, has the monopoly in production, transportation and distribution of electricity. There are proposals to privatize EDL, to provide clear incentives to improve generation efficiency, and to minimize theft and other distribution losses. Privatization also implies a commitment to full cost recovery pricing.

About 98 per cent of energy resources consumed in Lebanon are imported, mainly oil products. The principal sources of primary energy imported in 1996 were: petroleum (32 per cent), fuel-oil (33.5 per cent), gas-oil (21 per cent), coal (2.6 per cent), GPL (3 per cent), imported electricity (0.6 per cent) and others (3.9 per cent). The remaining 2 per cent is renewable energy, comprising mostly hydropower (1.5 per cent), traditional sources, such as timber and a very small amount of solar power. Consumption of primary energy in 1996 was 4647 kTOE.

Total power consumption in 1996 was 7648 GWh (including 683 GWh imported from Syria), of which 798 GWh was produced at hydro plants, that is, 11.3 per cent of production. The other 6176 GWh was from thermal plants, the vast majority owned by EDL. Per capita electricity consumption was 1865 kWh/person.

Despite rehabilitation in the power sector following war damage. Electricity demand still exceeds production, and several additional powerplants are planned. The main priority for

future development is the installation of two combined cycle powerplants. Gas turbine plants may follow.

Hydropower development
The hydropower potential of Lebanon is not known, but nearly all of the potential has been exploited already. The total installed powerplant capacity is 1361 MW, of which 1121 MW is at thermal plants and 240.1 MW at hydro plants. However the effective capacity of the hydro plants is 227.4 MW, while that of thermal plants is 1131 MW.

Of the hydro production in]996, the 190 MW Litani scheme produced 570.8 GWh, 32.3 MW Nahr Ibrahim scheme producсd 87.7 GWh, the Nahr Bared scheme produced 48.2 GWh, the Kadisha plant produed 69.4 GWh and other EDL plants produced 2 I .9 GWh.

It is estimated that the existing hydro plants could be uprated by up to 270 MW.

Small hydro

Lebanon has 10 small, mini and micro hydro plants in operation with a total capacity of 80 MW), defined as follows: small, less than 15 MW; mini, less than 5 MW; and, micro, less than 50 kW plants. No further development of small hydro is planned at present.

LESOTHO

Lesotho has an area of 30 400 km2 and a Population of about 2 million.

Water resources

Phase 1A of the Lesotho Highlands Water Project (LHWP) has recently been inaugurated. With official celebrations taking place on 22 January, 1998. Water is now flowing through the 85 km-long tunnel network from the Katse reservoir to South Africa.

Phase 1 B of the LHWP, involving the construction of a second major dam at Mohale (145 m high), a transfer tunnel from Mohale to Katse(31. Km)and the Matsoku diversion weir and

diversion tunnel to Katse (6 km), is now under way. It will increase the potential water delivery rate to South Africa to 28 m3/s. Phase 1B is scheduled for commissioning by 1 January 2003.

South Africa's requirement for further water supplies to augment its Vaal river catchment could lead to implementation of Phase II of the LHWP, but other options are also being studied.

Energy and power sectors

The Lesotho Electricity Corporation (LEC) is the power authority in Lesotho. The LHWP is being developed by the Lesotho Highlands Development Authority (LHDA) under the Government.

Lesotho has only about 5 MW of installed capacity, 3.25 MW of which is hydro capacity at four small and mini plants, the rest is from diesel sets.

In the year to March 1997, Lesotho Generated 5.83 GWh from hydro and 6.3 GWh at its diesel plants. Hydro thus supplied 48 per cent of electricity production. However, Lesotho relies on power imported from South Africa, and imported 330 GWh in the year to March 1997.

Hydropower development

The 72 MW 'Muela hydro plant has been constructed in Lesotho as part of Phase 1 of the LHWP. The first 24 MW unit was scheduled to come on line during March 1998, with the final unit scheduled to be commissioned in September 1998. The production of hydroelectricity will transform the power situation in Lesotho.

The 'Muela plant could be expanded to 180 MW: this is envisaged as part of future phases of the LHWP.

LIBYA

Libya covers an area of 1 775 500 km2 in central north Africa. The country's population is 5.3 million, mostly concentrated near to the northern Mediterranean coast.

Water resources

Average annual precipitation ranges from 300 mm along the western coast and 500 mm in Jabal Al Akhdar to less than 10 mm in the central and southern parts of the country.

The total mean precipitation is 43 km3, and total runoff is estimated to be about 2 km3/year. The total water storage of all dams is 0.344 km3, with annual average storage at 0.06 km3.

There are 12 dams in operation higher than 15 m, and 17 dams more than 10 m high.

No new dams are under construction, but rehabilitation of the Wadi Ghattara main dam and reconstruction of the secondary dam have just started.

A number of new dams are planned, but construction has not yet begun because of financial restraints.

The General Water Authority is responsible for water resources management. A new executive authority for the construction and operation of dams and water storage facilities has just been established.

Per capita domestic water consumption is 220 litres/day in urban areas and 170 litres/day in rural areas.

There is no legal framework for environmental assessment or management of projects.

Most major projects are carried out by foreign contractors.

Energy and power sectors

The main source of energy is oil. Oil-fired power stations provide effectively all of the country's electricity, with total electricity consumption in 1995 of 11 760 GWh. The per capita electricity consumption in 1995 was 2673 kWh/person/year. There are also a few small solar-powered stations.

The national energy and power authority is the General Company for Electricity; there are no regional power authorities. Deregulation is not expected, and the Government continues to own and operate all powerplants.

The total powerplant capacity in operation in 1995 was 4204 MW. No hydro plants are planned.

Future outlook

Most of the country's financial resources devoted to the water resources sector are being invested in the Great Man Made River Project, now under construction.

It is therefore unlikely that there will be any major developments in the field of dams in the near future.

The project will provide 6.1×106 water per day, to enable Libya to be self-sufficient in agriculture and industry.

The main pipelines have now been completed, and Libya's major cities, Tripoli and Benghazi, now have new water supplies from the project. Further works are required to make use of the full discharge for domestic and irrigation purposes.

Lithuania

Lithuania is a low-lying country in the center of Europe, and has an area of 65 200 km2. It has a population of 3.88 million.

Water resources
The average annual precipitation is 748 mm. The total mean annual precipitation volume is 48.1 km3, of which 15.4 km3 is runoff and 32.7 km3 evaporates. The rivers do not have large flows and may be frozen for up to three months per year during the winter.

Lithuania has large dams in operation of more than 15 m, and a total of 429 dams of all sizes. The total water storage of all the dams is 1.14 km3.

The dike type dam at the upper basin of the Kuonis pumped-storage plant is currently being heightened to maximum of 41 m; its main section is 6666 m long, consisting of a sand base and a reinforced retaining wall at the downstream side. It will comprise 1.17×106 m3 of earthfill and 543 910 m3 of reinforced concrete. The dam's main purpose is hydropower, but in future it wil be used for irrigation. The upper basin will have a storage capacity of 46.5×106 m3 .

Dams that are planned are mostly related to hydropower projects on the Nemunas and Neris rivers.

Per capita domestic water consumption is about 230 litres/person/day in urban areas and 160 litres/person/day in rural areas.

The national authority in charge of water resources is the ministry of Environmental Protection; and there are eight regional agencies. There is no co-ordinated policy for water resources management. About 10 year ago, only limited water management functions was abolished, only limited water management functions were transferred to the new Ministry of Environmental Protection. Therefore, there are plans to establish a Water Resources Board, which will include representatives of relevant organizations for energy, agriculture, fisheries, navigation, municipalities, environment and safety.

The Lithuanian energy Institute, Lithuanian Water Management Institute and the Water Management faculty of the Lithuanian University of Agriculture also deal with issues relating to dams and hydropower schemes. The main hydraulic design company is Kauno Hidroprojktas.

An environmental impact assessment is required for hydropower projects of more than 10 MW capacity and reservoirs with a surface area greater than 0.5 km2. The Water Law of 1996 now hinders the construction of new dams and reservoirs.

The main domestic civil contractors for small dams and hydro plants is Lietuvos Melioraciju Asociacija.

Energy and power sectors
The main sources of primary energy in 1996 were: solid fuels (5.5 per cent); oil (32.3 per cent); nuclear power936.4 per cent); gas (21.7 per cent); coal (2.3 per cent); hydropower(0.3 per cent); and other indigenous resources (7 per cent). Total primary energy consumption was 9979 kTOE.

The main sources of electricity production in 1996 were: the Ignalina nuclear plant (82.3 per cent); oil and gas (12.5 per cent); and, hydro (5.2 per cent, including pumped-storage plants). All the electricity was generated using imported fuels, except that generated by hydro. Total power production was 16 789 GWh.

Total electricity consumption in 1996 was 6621 GWh, representing per capita consumption of 1782 kWh/year. It is estimated that total energy consumption will increase from 202 pJ in 1996 to 300 pJ by 2008.Electricity demand will increase from 7000 GWh/in 1996 to 11 000 GWh in 2008.

Energy now comes under the Ministry of Economy.

The Energy Agency was established in 1993 for implementing energy policy. There are several independent regulatory offices for energy: the Nuclear power Safety Inspectorate: the state Energy inspectorate; the state Commission for Energy pricing and Energy Activities Control: and , the Competition Board.

Considerable reforms are under way in the energy sector relating to management restructuring. In 1996, All power enterprises became joint-stock companies. Decentralization of the joint-stock company Lietuvos Energija has started, namely, transfer of the heating sector to the jurisdiction of municipalities.

At present, generation, transmission and distribution of electricity is a monopoly of the state-owned utilities .Electricity purchase agreements are strictly centralized.

Only 4.4 MW of hydro capacity is privately owned.

Hydropower development

The gross theoretical hydropower potential in Lithuania is 5129 GWh/year; the technically feasible potential is 3600 GWh/year; and ,the economically feasible potential is estimated to be 1500 GWh/year. About 11 per cent of the technically feasible hydro potential has so far been developed.

The installed capacity of powerplants of all types is 6331MW,of which 108 MW is hydro capacity. Kaunas (101 MW, 380 GWh/year) is the only major pure hydro plant. There are 17 plants at multipurpose projects .

The annual average generation from hydro is 380 GWh/year (about 2.5 per cent of national power production); however, actual production was 320 GWh in 1996.

A further 2 MW of hydro capacity is under construction. and 47 MW is planned, 2 MW up to 2000 and 45 MW between 2000 and 2010..There is uprating potential of 0.5 MW at small hydro plants.

The 600 MW Kruonis plant is in operation. It is designed to have an eventual capacity of 1600 MW from eight units. Construction of a fourth 200 MW unit at Kruonis is under way, and should be completed during 1998 .The dam is currently being heightened by about 7 m, which will allow the design head of 109.5 m to be used .Future development of the plant is not definite, but a further 800 MW of capacity is planned.

Kruonis plays an important role in the electrical system in view of the large reliance on nuclear generation. The plant generated 548 GWh during 1996 and consumed 771 GWh.

Permissibility studies have been carried out for hydro plants on the Nemunas River and its main tributary, the Nervis. Two options have been analyzed: 11 low-head projects (75.2 MW..514 GWh/year); or, six low and medium-head projects (82.6 MW,557 GWh/year);.Dams would be required, which would be earthfill structures with concrete overflow sections, power-houses and fish ladders .

However, the future of the whole Neris cascade is not certain. The most probable project being considered is at Jonava. Near a large chemical works belonging to Achema, the possible investor.

The Nemunas river between Kaunas and Klaipeda (Curonian bay) is part of the network of European inland waterways of international importance. Navigation to the east is blocked by the Kaunas hydro plant, which has neither a ship lock nor fish ladder. Recent studies have been carried out with EU funding to modernize the waterway and build a new one on the Neris river up to Jonava. The study has suggested improvement of the waterways through the construction of hydropower dam projects, which would incorporate locks for navigation.

Small hydro

There are 14 small, mini and micro hydro plants in operation, with a total capacity of about 6 MW (25 GWh/year). A another five plants are under construction (1.2 MW) and 40 are planned (16 MW) by 2010. The mean cost per kW of the new small low head plants under construction at existing reservoirs is USS 1200 to 1600/kw.

Two phases for the future development of small hydro are foreseen. The first is refurbishment of existing ,obsolete plants and construction of new ones at existing reservoirs designed for irrigation. Construction of new plants at existing reservoirs will require about 66 per cent of the total investment The second phase is the development of new projects on small and medi-um-sized rivers (an approximate economically feasible potential of 500 GWh/year exists).

Future outlook

Lithuania has very limited energy resources, with indigenous supplies representing only 7 per cent of total domestic demand .One of the main goals of energy policy is to develop hydro ,the contribution of which could reach 15 to 20 per cent rather than the current 2 per cent.

It is hoped that the environmental standards can be brought in line with those of debeloped countries. If the Ignalina nuclear plant had to be shut down earlier than expected, the country would face increased emissions of SO2, Nox and Co2,Renewable energy resources, especially hydro, could be stimulated as alternatives for electricity generation.

Lithuania is reconsidering its National Energy Strategy (which currently only addresses the development of small hydro at existing reservoirs) and is going to decide soon on whether to develop its largest rivers ,the Nemunas and Nervis. Therefore, an international committee of technical and environmental experts will be established in the near future.

The Lithuanian Hydropower Association has recently been established to promote hdropower development. It is undertaking studies on : environmental flows, legislation and authorization, large scale and small scale resources, environmental aspects, and so on.

Recently a draft Hydropower Act was prepared on behalf of the department of Energy development by the LHA. The Act introduces, for the first time., the concept of IPPS. It will now become compulsory for utilities to purchase electricity generated by private developers. To datae, there is no legal framework for the development of renewable resources.

Luxembourg

Luxembourg has an area of 2586 km2 and a population of 404 000.

Water resources
The average annual precipitation is 755 mm and the total mean annual precipitation volume is 1.95 km3.

The Government is in charge of the country's water resources.

There are three large dams in operation. The total storage capacity of all dams is 0.06 km3.

Per capita domestic water consumption is 175 litres/person/day.

The energy and power sectors
The Government is responsible for energy and power. The country has no fossil fuel resources, so its main energy resources is water. The total primary energy consumption in 1996 was 3.39 MTOE, a figure which is not expected to increase during the next decade.

The main sources of electricity in 1996 were: hydro(69 per cent including pumped-storage plants); blast-furnace gas(14 per cent); natural gas(14 per cent); waste (2 per cent); and, oil (1 per cent). About 15 per cent of electricity was produced using imported fuel. Most of the hydro genergation is from pumped-storage plants. Pure hydro plants contribute about 5 per cent of national power production on average.

Total electricity consumption was 5014 GWh., representing per capita consumption of 12 082 kWh/year. Electricity demand is expected to increase by 1.8 per cent/year during the next decade. During 19965, 5710 GWh of electricity was imported and 809 GWh was exported.

The Government owns two hydro plants and the private company Societe Electrique de l'Our(SEO). Only 1.5 per cent of hydro plant capacity is publicly owned (6.8 per cent in terms of generation), while only 1.4 per cent of all powerplant capacity is publicly owned.

Deregulation of the power sector will take place in line with the ECO directive on liberalizaion of the electricity market. The format of the deregulated market has not yet been decided.

Hydropower development
Luxembourg has a gross theoretical hydropower potential of only 125 Gwh/year. Its technically feasible potential is 120 GWh/year and, its economically feasible potential is 97 GWh/year. Most of the potential has already been developed.

The installed capacity of all the powerpalnts in operation is 1129 MW,of which 33 MW is hydro capacity. Of the hydro capacity, 12 MW is at multipurpose developments.

The pure hydro plants generated 89 GWh/year on average, while the total generation in 1996 was only 64 GWh(873 GWh including pumped storage).

Luxembourg has a major pumped-storage station: the 1096 MW Vianden plant, which generates on average 582 Gwh/year. It generated 809 GWh in 1996, and consumed 1140 GWh.

Small hydro
There are 13 small, mini and micro hydro plants in operation, with a total capacity 22 MW(90 GWh/year).

The Agence de l'Engerie has studied the refurbishment of older run-of-river plants; uprating there could provide an additional 3 MW.

Future outlook
No new hydro projects are definitely planned for implementation in Luxembourg as a result of opposition from the environmental movement.

The main priority of the Government in the energy and power sectors is to increase the reliability of energy supply and to reduce the environmental impact of energy production from all sources.

The authorities have taken a decision to built a 350 MW combined-cycle plant, schedueld for commissioning in 2010.

MADAGASCAR

Madagascar has an area of 587 000 km2 and has a population of about 13.9 million.

Water resources

Annual average precipitation varies from 3600 mm/year to 350 mm/year in different regions.

The national authority in charge of water resources is the state company JIRAMA.

There are two large dams in operation. The total water storage capacity of all dams is 210 km3. Per capita water consumption is 634 m3/year total and 471 m3/year for domestic Consumption.

Energy and power sectors

The main sources of energy in 1995 were: firewood (77 per cent); charcoal (9 per cent); petroleum (12 per cent); and, electricity (2 per cent).

The Ministry of Energy and Mines is responsible for energy, while JIRAMA is the national power authority. The powerplants are owned by JIRAMA.

Per capita electricity consumption is 2180 kWh/year total and 880 kWh/year for domestic consumption.

Hydropower development

The gross theoretical hydro potential of Madagascar is 321 000 GWh/year. The technically feasible potential is 180 000 GWh/year and the economically feasible potential is 49 000 GWh/year. These figures were evaluated in 1981. Only 0.2 per cent of the technically feasible potential has been developed.

Madagascar has 225 MW of installed capacity, of which 105 MW is hydro capacity. Hydro plants generated 411 GWh in 1995. A further 30 MW of hydro capacity is planned.

Small hydro

In Madagascar, small hydro is defined as plants of up to 20 MW capacity; mini hydro is up to 10 MW and, micro hydro is up to 1 MW. According to these definitions, there are 11 hydro plants in operation, with a capacity of 106 MW.

MALAWI

The Republic of Malawi has an area of 119 140 km2 and a population of 10.2 million.

Water resources
Irrigation and Water Development is in charge of Malawi's water resources; and there are three regional water authorities. Deregulation of the water sector is envisaged soon. Average annual precipitation is 750 to 1600 mm.

Identified hydro projects/sites in Malawi

Project/site Capacity(MW) Output(GWh/year)

Manolo 60 to 130 360 to 590

Henga Valley 20 to 40 155 to 185

Rumphi 3 to 13 22 to 60

Chizuma 25 to 50 110 to 170

Chasombo 25 to 50 175 to 215

Malenga 30 to 60 200 to 240

Mbongozi 25 to 50 200 to 240

Kholombidzo 140 to 280 11 00 to 1795

Mpatamanga 135 to 300 985 to 1470

Low Fufu 75 to 140 420 to 610

Low Fufu and Tran 90 to 180 575 to 835

High Fufu 90 to 175 625 to 800

Chimgonda 20 to 50 155 to 280

Zoa Falls 20 to 45 120to 200

There are three large dams in operation, built for hydropower generation. A 26 m-high earthfill dam is under construction for the Kapichira hydro projects.

Per capita water consumption is 9.8 m3/person/year total and 3.7 m3/person/year for domestic consumption (based on 1986 estimates).

The main domestic civil contractors for dams and hydro plants are Fargo, Cilcon, Terrastine and Lusitania.

Energy and power sectors
The Ministry of Energy and Mining is in charge of energy. The Electricity Supply Commission of Malawi (ESCOM) is the national power authority, controlling, generation, transmission and distribution; there are no regional power authorities.

The main sources of primary energy in 1996 were: fossil fuels (4 per cent); biomass (92 per cent); electricity (3.5 per cent): and, others (0.5 per cent).

The main sources of electricity in 1996 were: hydro (99 per cent); gas turbines (0.2 per cent); thermal (0. 15 per cent): and a very small amount of solar power generation. Total electricity consumption was 888 GWh, representing per capita consumption of 350 kWh/year. About 2.5 GWh of electricity was exported during 1996.

It is estimated that electricity demand will increase by 4.3 per cent/year during the next decade.

The state corporation ESCOM owns almost all powerplant capacity, although a few small plants are owned by private developers. The possibility of introducing privatization is being consider, and deregulation is envisaged for around June 1998. The deregulated market will probably involve distribution and billing initially.

Hydropower development

The hydropower resources of Malawi have not been precisely evaluated, but the potential of a number of major rivers and sites have been identified. A figure of 6000 GWh/year of technically feasible potential has been cited in the past.

There is 218.5 MW of hydro capacity in operation, of a total powerplant capacity of 242 MW. Hydro plants generated 858 GWh in the year to March 1996; average hydro generation is about 800 GWh/year.

A further 128 MW of hydro capacity is under construction at the Kapichira project, which is to be built in two phases: completion of the first 64 MW is scheduled for the end of 1999, and the other 64 MW in 2003. Phase I includes almost all of the civil works costs.

A further 365 MW of hydro capacity is planned. This includes the Lower Fufu hydropower project (90 MW), on the South Rukuru/North Rumphi rivers in the north of the country.

Small hydro

There is one small hydro plant in operation, the 4.5 MW Wovwe mini plant, and also the 600 kW Zomba micro plant. They generate about 8.7 GWh/year on average. No further developments are planned at present.

Future outlook

Apart from the 4.5 MW mini hydro scheme on the Wovme river in northern Malawi, all the hydro schemes so far developed are concentrated on the Shire river in the south. The hydro stations have recently experienced the effects of droughts and decreased lake levels. There is a need to provide security of Veneration by focusing on potential sites other that those oil the Shire river.

Malaysia

Malaysia has an area of 329 749 km2 and a population of about 22 million. It compriess 11 states in Peninsular Malaysia and the States of Sabah and Sarawak on the island of Borneo.

The Government's Drainage and Irrigation Department is in charge of water resources.

There are 52 large dams in operation in Peninsular Malaysia, with a total water storage capacity of 24.05 km3. Many dams are multipurpose.

The Chendorah dam in Peninsular in Peninsular Malaysia is currently being refurbished. It is a hollow gravity structure, 32 m high, incorporating a 40 MW hydro plant. The project should be completed in 2000.

Construction of the Bakun hydro project, which involved a 205 m-high CFRD, has been deferred, as part of a series of austerity measures by the Government. Further work may take place in the future.

The Kuala Yong dam, part of the Pergau hydro project, was completed during 1997.

The Ulu Terengganu and Liwagu dams are at the design/feasibility study stage.

EIA studies must be carried out as a condition for project approval for dams more than 15 m high and for ancillary structures covering a total area of more than 400 ha.

Energy and power sectors
The Ministry of Energy, Telecom and Post is responsible for the energy sector, with the Government's Electricity Supply Department in charge of the power sector. The electricity market currently involves power purchase agreements.

Privatization of the industry is on-going. Immediately after privatization there will be a number of vertically integrated entitites which may eventually be divided into separate generation, transmission and distribution companies.

The electricity supply industry is now regulated by the Department of Electricity and Gas Supply. The backbone of the regulatory framework is the 1990 Electricity Supply Act. Other components are: the 1994 Electricity Regulations made under the Act; the terms and conditions of licences; the Malaysia Grid Code which, among other things, sets the merit order and procedures for dispatching generation plants; and, the PPAs which IPPs enter into with utilities.

The task of forecasting, planning and approving new generation plants and planning the development of industry, previously under the jurisdiction of the utilities, is now co-ordinated by an Inter-Agency Planning Group (IAPG), formed in 1993.

There are three major electrical utilities in Malaysia, namely Tenaga Nasional Berhad (TNB) in Peninsular Malaysia, the Sabah Electricity Board (SEB) in Sabah, and the Sarawak Electricity Supply Corp (SESCO) in Sarawak. TNB and SESCO are publicly listed companies, in which the Government holds 70 per cent and 50 per cent equity, respectively, while SEB is a statutory body which will be privatized soon.

Tenaga Nasional Generation Sdn.Bhd, a subsidiary of TNB, is the major generator of power, with a generation capacity of 7600 MW. Besides that, there are a number of IPPs, who supply power to the utilities through PPAs. The iPPs are in the form of locally led consortia with foreign participation.

To date, 15 IPPs have been licensed, with a total capacity of 8200 MW, of which 4200 MW are in operation. They are: YTL Power Generation, Segari Energy Ventures, Genting Sanyen Power, Port

Dickson Power, Powertek. ARL, Serudong Power, Powertron, Stratavest, Bakun Hydro-Electric Corp., Nur Generation, Teknologi Tenaga Perlis Consortium, Teknologi Tenaga Perlis Overseas Consortium, Projass Engineering and Inter Hydro Corp. The last two have been licensed to operate a number of mini hydro plants, with total capacities of 17 MW and 43 MW respectively.

Energy and power sectors

The main sources of electricity in Malaysia in 1996 were: gas (58 per cent); oil (23.2 per cent); hydro (10.2 per cent); coal (8.2 per cent); and, others (0.4 per cent). Total electricity consumption was 41 656 GWh, and 1960 kWh/person. Both energy consumption and electricity demand are expected to increase by 8 to 10 per cent/year during the next decade.

Hydropower development

In view of the geographical separation of Peninsular Malaysia from Sabah and Sarawak, hydro potential data are given separately. Most of the economic hydro potential in Peninsula Malaysia has been developed, whereas there is a vast amount in Sabah and Sarawak yet to be exploited.

The gross theoretical hydropower potential of Peninsular Malaysia was calculated in 1980 to be 83 500 GWh/year. However, the gross potentials of Sabah and Sarawak are much higher.

The technically feasible potential of Malaysia is 123 000 GWh/year (29 GW), of which only 16 000 GWh/year (4 GW) is in Peninsular Malaysia (evaluated in 1980), while 87 000 GWh/year (20 GW) is in Sarawak and 20 000 GWh/year (5 GW) is in Sabah, Sarawak and Sabah thus account for 86 per cent of the technically feasible hydropower resources of the country. So far, only 4.9 per cent of the total has been developed, although more than 25 per cent has been developed in Peninsular Malaysia.

Malaysia has 1419 MW of hydro capacity in operation, of which 1239 MW is in Peninsular Malaysia, 110 MW in Sarawak and 70 MW in Sabah. A further 655 MW of hydro capacity is under construction and about 3000 MW is planned.

The generating units at the 600 MW Pergau project recently began operation, and were in the phase of hand-over to the owner, TNB, at the end of 1997.

The Chendorah project Includes a 40 MW hydro plant.

The total generation at hydro plants in 1996 was 5150 GWh, representing 10.2 per cent of power production. However, in 1995, hydro supplied 16 per cent (14.6 per cent of TNB's production, 29.6 per cent of SESCO's and 27.5 per cent of SEB's). In 1996, 140 GWh electricity was exported.

Construction of the 2400 MW Bakun hydropower project in Sarawak, one of the largest privately funded projects ever undertaken, has been deferred.

Expansion of the 400 MW Kenyin hydro plant through the construction of an additional 300 MW plant adjacent to the existing station is planned soon.

Small hydro

There are 46 hydro plants in operation in Malaysia (capacities of 1.6 MW or less), with a total capacity of 23.3 MW. Sarawak has six hydro plants of 1 MW or less, and Sabah has five such plants.

Future outlook

The hydropower resources of Malaysia will be developed for electricity production. However, most of the untapped potential is in the states of Sabah and Sarawak whereas the load is mainly in Peninsular Malaysia.

Up to 2020, nearly 30 GW of powerplant capacity should be installed, requiring almost US$ 40 billion of capital expenditure. Through privatization, the Government aims to spread the investment burden.

MALI

Mali covers an area of 1 241 000 km2 and has a population of about 9.4 million.

Water resources

The average annual precipitation is 600 to 800 mm. The total mean annual precipitation volume is 74.5 to 99.3 km3, with 24.9 km3 of runoff. Per capita water consumption is on average 46 litres/day in urban areas and 20 litres/day in rural areas.

The national authority in charge of water resources and energy is DNHE (Direction Nationale de l'Hydraulique et de l'Energie), and there are also regional authorities in all administrative regions. DNHE is soon to be divided into two sections, one for water and the other for energy.

There are two large dams in operation. The 25 m-high Seingue dam on the Sankarani river, a tributary of the Upper Niger has a 44 MW hydro plant which can produce 200 GWh/year. It also provides for the irrigation of 20 km2 of land and regulates 150 m3/s of the Niger river flow. Lahmeyer has been carrying out engineering services for rehabilitation of the dam and overhaul of the mechanical and electrical equipment.

The 66 m-high Manantali dam recently completed at the Senegal/Mauritania near Mali, is part of a tri-national multipurpose project which will include a 200 MW powerplant

Two other large dam projects are planned. They are: the Tossaye dam on the Niger river (25 m high) in file north: and, the Kenie dam, also on the Niger (15 m), about 30 km downstream of Bamako.

Energy and power sectors

The main sources of primary energy in Mali in 1996 were: biomass (98 per cent), fossil fuels (11 per cent) and hydropower (1 per cent). Total primary energy consumption was 2.8 million TOE.

The main sources of electricity were: hydro (54 per cent) and thermal from imported fuels (46 per cent). Total electricity consumption was 333 GWh, representing per capita consumption of only 32 kWh/year. Electricity demand is expected to increase by 6.7 per cent/year during the next decade.

A new entity created by the splitting up of DNHE will soon be responsible for energy. The national power authority is EDM. There are also regional power authorities covering all administrative regions.

All hydro plants are owned by the state, while 70 MW of 174 MW total powerplant capacity is privately owned (68 GWh/year out of 404 GWh/year).

Of the total electricity consumption of 333 GWh, EDM accounted for 265 GWh, while industrial users accounted for 68 GWh.

The Society for Realization of the Manantali Plant (SOGEM) has recently been created, and a Society for the Exploitation of the Manantali Plant (SEM).

Hydropower development

The technically feasible hydropower potential of Mali is, 1050 MW (5000 GWh/year), estimated in 1992.

The installed capacity of all Mali's powerplants is 174 MW, of which 50.2 MW is hydro capacity. The 44 MW Selingue plant is soon to be refurbished, but in view of the importance of the plant, only one unit can be overhauled each year. The overhaul of all four units will take until 2001. The 5.4 MW Sotuba plant, originally completed in 1966, has recently been rehabilitated.

Construction of the 200 MW Manantali plant (800 GWh/year), as part of the Senegal River Project, was scheduled to begin at the end of 1997. It will generate 800 GWh/year. The cost is estimated at US$ 1500 to 2000/kW.

The hydro plants in operation generate on average 246 GWh/year, representing 60 per cent of national power production. Hydro plants generated 216 GWh in 1996. A further 800 MW of hydro capacity is planned. There is about 52.3 MW of potential capacity that could be installed through upgrading the existing hydro plants: 5.7 MW (43 GWh/year) at Sotuba plant; 46 MW (200 GWh/year) at Selingue; and, 0.6 MW (3 GWh/year) at Felou.

Two hydro projects that are planned are: Tossaye (20 MW, 80 GWh/year) and Kenie (30 MW).

Small hydro

Two small hydro plants are in operation with a total capacity of 6 MW (46 GWh/year): Sotuba, on the Niger river, and Felou, on the Senegal river. Construction of nine small hydro plants is planned, as well as eight other plants, with a total capacity of 18 MW. They include: Markata (2 MW); Talo (2.8 MW); and DjennE (7 MW).

Future outlook

The main priorities for future development are to exploit the country's indigenous energy resources, with particular emphasis on hydropower and solar power. In the medium term, the Sotuba, Manatali, Tossaye and Kenie hydro plants will be commissioned.

Other priorities include: reducing the impact of energy production and consumption on the environment; improving the efficiency of Mali's energy system by the implementation of an integrated energy policy for the various regions; and interconnection of the country's grid with the systems of cote d'Ivoire, Senegal and Mauritania, and eventually also Guinea.

In the field of water, the aim is to ensure that the whole population will have a drinking water supply by the year 2000.

MAURITIUS

Mauritius covers an area of 1865 km2 and has a population of 1.13 million.

Water resources

The average annual precipitation is 2110 mm. The total mean annual precipitation volume is 3.95 k m3, of which 2.04 km3 is runoff.

The Central Water Authority is responsible for the country's water resources. Per capita water consumption is 73 m3//year.

Midland dam, with a reservoir capacity of 20×106 m3, is at the planning stage. Its main purposes will be water supply for domestic use and irrigation for the northern area of the island.

Energy and power sectors

The Ministry of Energy is in charge of energy, and the Central Electricity Board (CEB) is the national power authority. The main energy sources are: petroleum and coal (90 per cent), biomass (bagasse); and, hydropower.

The sources of electricity are: diesel (about 71 per cent), hydro (12.8 per cent), bagasse and coal (13 per cent) and kerosene (4 per cent).

Powerplants are owned either by the CEB or by sugar estates. Mauritius has a total installed capacity of 364.6MW, which includes 52.2 MW of independent thermal capacity at sugar estates.

Per capita electricity consumption is 750 kWh/year.

Hydropower development

About 90 per cent of the technically feasible hydropower potential has been developed so far.

There is 59.4 MW of hydro capacity in operation (54.2 MW available capacity). Hydro plants generated 134 GWh in 1995, of 1047.4 GWh total production.

Besides three hydro plants larger than 10 MW, there is 834 MW of capacity at five small and mini plants.

Future outlook

The main priorities for future development include: enhancement of power from biomass; and, consideration of a combined as turbine plant.

Mexico

Mexico has an area of 967 183 km2 and a population of about 94 million.

Water resources

Average annual precipitation is 777 mm. The total mean annual precipitation on volume is 1521 km3, of which about 27 per cent is renewable surface water.

Per capita total water consumption is 2166 m3/year(1994), with 838 m3/year for domestic consumption.

The national authority in charge of water resources is the Comision Nacional del agua Directorates of Management Areas: Northwest, North, Northeast, Lerma-Balsas Basins, Valley of Mexico and southeast. There are also basin councils (representation of states and user organizations in the river basins) for the Lerma and Bravo rivers.

There are about 540 large dams in operation.

Energy and power sectors

The main sources of energy in Mexico are: fossil fuels (82.9 per cent), electricity (7.5 per cent), biaomass (5.9 per cent)and geothermal(4.9 per cent).

The national energy authority is the Secretaria de Energia (Ministry of Energy). The national power authority is the Comision federal de Electricidad (CFE), the Federal Electricity Commission. CEF's Regional Directorates are regional power authority, as well as Compania de Luz y Fuerza del Centro (CLFC), the Central Light & Power Company, which is a public organization.

All powerplants are publicly owned by CFE(97.5 per cent) and CLFC (2.5 per cent).

Per capita electrical consumption in Mexico is 1557.8 kWh/year(1996 estimate).

Hydropower development

The gross theoretical hydro potential of Mexico is 154 726 GWh/year: the technically feasible potential was estimated in 1996 to be 45 000 GWh/year, and the economically feasible potential is about 35 000 GWh/year. About 58.3 per cent of the technically feasible potential has been developed.

The installed capacity of all powerplants is about 44 000 MW, of which hydro capacity accounts for 10 034 MW. Hydro plants generated 31 442 GWh in 1996, about 21 per ent to national electricity production in 1996.

Hydro plants that are planned were listed in the 1996 World Atlas. The San Rafael project(23.12 MW), with a head of 14 m and two units, and the El Cajon project(640 MW, head 156 m, two units)should begin operation in 2005.

There are no pumped-storage plants in operation or under construction, but approximately 1000 MW is planned.

The estimated potential for uprating existing capacity at hydro plants is 144.4 MW of firm capacity.

Small hydro

There are 27 small hydro plants in operation (less than 5 MW), with a total capacity of 51.34 MW. These are no mini or micro plants (less than 2 MW).

Some identified projects are: Portezuelo I (4.75 MW), Portezuelo II (1.91 MW), Itzicuaro (1.79 MW), Texolo (4.38 MW) and Platanal (6 MW).

Mongolia

In the world Mongolia is the second large landlocked country, having 2.2 million people with a territorial area of 1.56 million square km. There is a rare precipitation of about 200 mm annually in Mongolia. It is investigated that Mongolia holds more than 4000 small rivers with a total length of over 6000 km. These small rivers reserve a potential hydropower of about 5800 MW with a theoretical energy generation of 56. Billion kWh per year. If 50% of reserve is exploitable, about 3000 MW hydropower capacity could be installed and an annual energy generation of 20 billion kwh could be got. An estimation of hydropower potential in the country made by the Institute of Water Policy of Mongolia in 1994 through the programme named Hydropower of Mongolia have identified 81 possibl sites of hydropower stations (HPS), 64 HPS of them are with large dam and 17 HPSs are diversion type. All these SHS are medium and small hydropower stations.

The capabilities of Medium and Small Hydropower in Mongolia

To date, in August 1999, there are 4 existing SHP stations in opeation with a total installed capacity of 3128 kW in Mongolia. These SHP stations operate in summer only, three of them have the equipment imported from China. The first SHP station in Mongolia was the 528 kW Harkhorin SHP station assisted by China 1960. In 1987, the second mini HPS 200 kW was built in Uvs province. In the end of 1997 two mini HPS have been built in Dzavkhan and Gobi-Altai provinces respectively. Setting off a upsurage to develop medium and small hydropower.

Mountainous regions, highlands and the Gobi desert cover the great majority of Mongolian territory, therefore, it is difficulty for Mongolia to develop hydropower. Specially with poor transport facilities and the weather situation all rivers will be iced in the winter, the cost of construction a HPS is quite high and the efficiency of generating power is so low because of a short time operation seasonally in a year, making Mongolia hydropower resources be not utilized. Also, cities and villages of Mongolia have long distance between them therefore to connect them to central energy system is very difficult as well as impossible. However, Mongolia government has worked out a plan accomplishing the electrification throughout the country by 2000, and for solving the problem of power storage, Mongolia has alreadly started to construct small and medium HPSs.

The medium Egiin river SHPs are under planning now. in recently years Elgin river prokect has made by Swiss, Italy and Mongolian companies sponsored by loan from Asian Development Bank. For constructing these HPSs an investment of 285 million US$ will be needed> a joint venture contract had been signed by Mongolian and Czech for the HPS. According to the contract Egiin HPSs will be built from 1999 to 2004. The capacity of SHPs is 220 MW.

According to an investigation made into the physical inventory for hydropower potential in Mongolia the capacity of medium and small hydropower are as follows:

9 HPSs with a capacity more than 50 MW

39 HPSs with a capacity 5-50 MW

47 HPSs with a capacity 0.1-5 MW

15 HPSs with a capacity less than 0.1MW

the basic data of 110 HPSs above were approximately evaluated in recent years, it is the first scientific survey of hydropower potential over Mongolia. Up to mow also in Mongolia have made one Feasibility Study for 21 MW HPS, one Detail Design for 12 MW, two projects are in Feasibility Study for 18 and 23 MW. These HPSs are planned for provincial capitals. Because 50% of provincial capitals have use diesel engine for electric energy and average demand of one province centre is 2-3 MW.

In Mongolia there are about 300 rural village, most of them use diesel power to get electricity, the demands on electricity for per village is about 200-400 kW at present. For rural electrification and development, Mongolia government is planning to develop medium and small hydropower. Table 2 gives the list of 4 identified SHP stations, which are in the actual schedule to be constructed in the near future. These future SHP stations have a total installed capacity of 49400 KW with loans offered by Kuwait, China and Russia. Table 3 gives the identified SHP stations under study numbering 13 stations with a total installed capacity of 193.7 MW, which had been formally registered to be constructed by the authorities concerned of Mongolia.

MOROCCO

Morocco covers an area of 710 950 km2 in northwest Africa and has a population of about 29.2 million.

Water resources
Annual average precipitation ranges from 29 mm to 1000 mm. The total mean annual precipitation volume is 150 km3, with a total annual mean runoff 30 km3. The total water storage provided by dams is 14.5 km3.

Per capita domestic water consumption is 80 litres/person/day in urban areas and 30 litres/person/day in rural areas.

Morocco now has 99 large dams in operation, according to ICOLD's definition.

The Direction de la Recherche et de la Planification de l'Eau is in charge of water resources, and there are regional water authority: Directions des Regions Hydrauliques par Bassin Versant (DRH).

A law adopted in October 1995 provides effective legal instruments relating to the control and use of water resources. It includes an evaluation of water resources and gives responsibility to agencies in each river basin to ensure rational planning, optimal exploitation and construction.

The largest dams under construction are:

El Ghrass (93 m high arch, 345 m long, 210 000 m3 dam volume, 275 x 103 m3 storage, scheduled for completion in July 1999).
Chakoukane (CFRD), 63 m high, 420 m long, 1.8 x 106 m3 50 x 106 m storage scheduled for completion in 1998
D'Char El Oued(CFRD, 101 m high ,in the Oum Er Rbia river, 2.03 x 106 m3 dam volume 740 x 106 m3 storage, for domestic water supply, irrigation and hydro). Its 82 MW hydro plant is been built between 1997 and 2000).
Asfalou (arch dam, 110 m high, in the Ouergha basin upstream of Al Wahda dam, for irrigation and hydro).
Other large dams planned include:

Heightening of the Sidi Mohamed Ben Abdellah zoned earthfill dam from 98 m-hi-h to 111 m; and,
M'Dez (rockfill, 100 m high);
Energy and power sectors
The source of energy in Morocco are: thermal (75 per cent) and hydro (25 per cent). The main sources of electricity are: thermal plants (using petroleum fuels and coal), hydro (from storage schemes) and gas turbines.

The Ministry of Energy and Mines is in charge of energy resources. Powerplants are owned and operated by the Office Nationale d'Electricit6 (ONE), the national power authority. Regional power authorities are ONE and the Regies Autonome de Distribution.

Hydropower development
Morocco's gross theoretical hydropower potential has not been evaluated. The technically feasible potential is 4700 GWh/year and the economically feasible potential is 4000 GWh/year; these figures were evaluated in 1991.

There is 1175 MW of hydro capacity at large dams in Morocco, representing 32 per cent of the total installed capacity. A 333 MW pumped-storage plant has been studied.

MOZAMBIQUE

Mozambique covers an area of 802 000 km2 and has a population of about 18.1 million. There are eight large dams in operation.

Energy and power sectors

The major power utility is Electricidade de Mozambique (EdM). The country's major powerplant, Cahora Bassa, is operated by Hidroclectrica de Cahora Bassa (HCB).

In 1996, there was 509.5 MW of hydro capacity in operation, out of a total powerplant capacity of 634.9 MW. However, at that time, only 415 MW of the maximum 2075 MW at Cahora Bassa was in operation.

Hydropower supplied 579 GWh in 1996, of 610 GWh total electricity production, representing 95 per cent. Mozambique also imported 599 GWh (almost all from Eskom in South Africa, with a small amount from ZESCO of Zambia).

Mozambique (EdM) is a member of the Southern African Power Pool (SAPP).

EdM (Mozambique) and Eskom (South Africa) recently completed reconstruction of the DC transmission line between Cahora Bassa and South Africa, and the station will now deliver 950 MW of base load to South Africa. A new line between Mozambique and Zimbabwe is under construction.

EdM and Eskom are studying Mepanda Uncua, a 1600 to 2200 MW hydro project below Cahora Bassa on the Zambezi river in Mozambique. Studies are also under way for new high voltage interconnections between South Africa and Maputo, the capital.

Hydropower development

Cahora Bassa, on the south side of the Zambezi river, had been operating at only 415 MW in recent years, but operation at higher capacities has now resumed, following restoration of the transmission link to South Africa.

Other large hydro plants in Mozambique have continued to operate at less than full capacity, such as: Mavuzi (44.5 MW effective capacity out of 52 MW nominal capacity); Chicamba (34 MW of 38.4 MW); AND Corumana (14 of 16.6 MW).

There is potential for an additional 1200 MW capacity at Cahora Bassa, on the north bank of the Zambezi.

Several new hydro projects are proposed for the Zambezi river, downstream of Cahora Bassa; Mepanda Uncua (1600 MW); Baroma (444 MW); and, Lupata (654 MW). These may be carried out following power purchase agreements with neighboring countries.

NAMIBIA

The Republic of Namibia, located in southwestern Africa, has an area of 824 000 km2 and a population of about 1.8 million.

Water resources

The Department of Water Affairs is in charge of water resources, under the Ministry of Agriculture, Water and Rural Development. NamWater is the main utility.

The average annual precipitation is 350 mm. The total mean annual precipitation volume is 288.4 km3 of which total mean runoff is 14.4 km3. Most precipitation occurs between October and April. About 80 km2 of land is under irrigation.

Per capita domestic water consumption is 150 litres/person/day in urban areas and 60 litres/person/day in rural areas. The national average is 120 litres/person/day.

The country's major agricultural product are cattle and maize.

There are 13 large dams in operation. All Namibia's dams which are mainly for water supply or are multipurpose, provide a total storage capacity of 0.7 km3.

Energy and power sectors

Namibia's power utility is NamPower. The country has one major hydro plant (Ruacana, 240 MW, one large thermal plant (Van Eck, 120 MW) and two diesel plants (24 and 3 MW), giving a total capacity of 387 MW.

During 1997, Namibia experienced water shortages as a result of low flows in the Kunene river, forcing it to rely on power imports from South Africa for around 90 per cent of its requirements at certain times. Ruacana was reported to be operating at only 33 MW, with flows of only 29 m3 /s instead of the 220 m3 /s required to operate the three 80 MW units effectively.

During the year to June 1996, 854 GWh was generated at Ruacana by hydro, while only 19.3 GWh was generated at thermal plants. Namibia imported 1090 GWh (mostly from South Africa) and exported 29.5 GWh.

Construction of the Kudu and Epupa projects are seen is tile long-term solution to the country's water and power shortages, although water could be pumped to the countries drier central areas from perennial sources such as the Okavango river. Another solution would be desalination of sea water. However both the pumping and desalination options would both require large amounts of additional power, which could only be supplied by Epupa.

However, the Epupa project, which has been under investigation for some time, would require financial aid, and the project may only be feasible if South Africa agrees to purchase power. A recent bilateral agreement to develop off-shore gas fields has made this development less likely.

Severe droughts in northern Namibia and southern Angola could affect the operating capability of Epupa.

Hydropower development

Namibia has a gross theoretical hydropower potential of about 9000 GWh/year, evaluated in 1992. Its technically and economically feasible potential is 8645 GWh/year, evaluated in 1991.

The 240 MW Ruacana station generates 97.8 per cent of Namibia's power production.

The Epupa hydro project is still under investigation , and would provide between 200 and 360 MW of capacity, although up to 650 MW could be installed. A feasibility report, funded by NORAD and SIDA, was completed during 1997.

Nepal

Nepal has an area of 147 181 km2 and population of about 22 million.

Water resources

The Ministry of Water Resources is in charge of water management. There is one large dam in operation, he 114-m high dam built for the 92 MW Kulekhani hydro project.

Average annual precipitation is about 1500 mm/year. The total mean annual precipitation is 220.8 km3, of which 174.2 km3 is runoff.

Construction of the Kali Gandaki A hydro project involoves a 44 m-high dam, while the West Seti hydro project will include a 189 m-high CFRD.

Nepal and India Have signed an agreement to implement the 6000 MW Pancheshwar high dam project on the border river Mahakali. This project would have a 315 m-high rockfill dam.

Energy and power sectors

The main sources of electricity in Nepal in 1994/1995 were: hydro (85.67 per cent), diesel (14.29 per cent) and solar power (0.04 per cent).

The Energy Commission Secretariat (WECS) is in charge of energy, while the Nepal Electricity Authority is the national power authority.

At present, 2.5 per cent of powerplant capacity Is private capita electricity consumption is 60 kWh/person/year.

Hydropower development

The gross theoretical hydropower potential is 83 290 MW (727 TWh/year). The technically feasible potential has recently been re-evaluated, and stands at 43 442 MW (179 TW/year).

The economically feasible potential is estimated to be 14 742 MW (43 TWh/year). So far, only 0.6 per cent of the technically feasible potential has been developed.

The total installed capacity of powerplants in Nepal is 296.73 kW of which 254.2 MW is hydro capacity. The average annual generation of hydro plants is 1116GWh/year.

Construction of the 144 MW Kali Gandaki A hydro project is under way, for which NEA has secured a loan from the ADB. It is scheduled for construction in 2001.

Meanwhile, SMEC of Austratia is starting development of the West Seti hydro project in western Nepal, which will supply almost of its power to India. It is being developed on a BOO basis under a 36 year licence.

The 60 MW Khimti project is being develeped as a BOO project by a private company with Norwegian majority participation. Commissioning is scheduled for 2001.

Nepal and India are also considering large joint hydro projects. Of these, the most important is the 6000 MW Pahcheshwar high dam project; Nepal's 50 per cent share of power would be exported to India. Both Government have signed an agreement to go ahead with the construction of this project.

Several other medium-sized hydro projects are planned for projects.

small hydro

There are six small (1 to 10 MW), 31 mini (100 kW to 1 MW) and 320 micro hydro plants in operation (total 2 I .3 MW). Data are not available for plants under construction or planned under private ownership.

Future outlook

There are good prospects for hydropower and multipurpose projects in Nepal. Small, mini and micro hydro are the only realistic options for power supply for rural electriciation. The development of large projects at an accelerated pace will probably depend on export contracts with India State Electricity Boards.

The national priority is further hydro development, since only indigenous resource for power sector development in the country. The major constraint is funding.

Netherlands

The Netherlands covers an area of 37 290 km2, and has a population of 15.45 million.

Water resources
The average annual precipitation is 760 mm/year. Per capita total water consumption is 55 litres/person/day(1995).

The national water authority is Rijkswaterstaat, and there are about 30 regional water authorities.

There are 10 dams in The Netherlands, three on the Rhine river and seven on the Mecuse. Polders have been built for flood control and for reclaiming land.

Energy and power sectors
The main sources of energy are : coal(40 per cent), natural gas(50 per cent) and others (10 per cent).

The main sources of electricity in 1996 were: gas (46.8 per cent), coal (44.8 per cent), nuclear (7 per cent), wind (1 per cent), oil (0.4 per cent) and hydro (0.1 per cent).

Total electricity consumption was 75 350 GWh, representing per capita consumption of 4710 kwh/year.

Energy consumption and electricity demand are expected to increase by about 2 per cent/year during the next decade.

The Dutch Electricity Generating Board, Samenwerkende Elektriciteits-Produktiebedrijven(SEP), is effectively in charge of the power sector. It owns and operates the national grid.

Large scale generation of electricity (plants more than 25 MW) are operated by four regional generating companies: UNA, EZH, EPH and EPON, which work in close cooperation with SEP. However, these four power produces are in the process of uniting into one company.

The purchase, transmission (in part) and distribution of electricity, as well as decentralized electricity generation, are managed by 27 of the 41 energy distribution companies, which also mamge the suply of gas and heat. Each has its own individual corporate strategy, although, in a number of fields, they have combined their interests within the sector umbrella organization, energiNed. These companies are in the process of merging. EnergieNed's task is to reinforce the position o the energy distribution sector, from which each individual company may benefit.

About 23 per cent of powerplant capacity is privately owned, with all of the hydropower plants are publicly owned.

Hydropower development
The gross theoretical hydropower potential of The Netherlands is only 700 GWh/year, the technically feasible potential is 200 GWh/year and the economically feasible potenital is 130 GWh/year. All these data were re-evaluated in 1995.

So far less than half of the technically feasible potential hs been put into operation (60 GWh/year). Hydro capacity is only 30 MW, of the toal powerplant capacity of 18 650 MW (14 447 MW under SEP and 4200 MW belonging to auto-producers) and total generation of about 78 000 GWh/YEAR.

Alternatives for the development of up to 2000 mw pumped-storage capacity are being considered.

Small hydro

The hydro capacity in operation in the Netherlands is supplied by four mini hydro stations (up to 10 MW0 and approximately 10 micro hydro plants(less than 1 MW). They were all built in or next to existing weirs.

Future outlook

A further three 5 MW small plants are planned, all mini plants next to existing weirs on the Meuse river.

Surtaxes and voluntary levies (for renewable) on electricity prices are the main reason that has led the plants for the three new small hydropower stations mentioned above.

New Zealand

New Zealand has area of 270 534 km2 and a population of 3.62 million.

Water resources
Precipitation varies considerably according to region, from more than 6000 mm/year to less than 4000 mm/year.

The Ministry for the Environment is responsible for water resources development. There are nine regional authorities in North Island and seven in South Island(see 1995 World Atlas for details}.

There are 67 large dams in operation according to ICOLD's definition. The total storage volume of all reservoirs in operation is about 13 km3.

Per capita water consumption is estimated to be approximately 570 m3/year.

The Watabina dam is currently undergoing seismic strengthening. No further large dams are under construction or planned.

There is a framework in New Zealand for environmental impact assessment and management; all sizeable projects must comply with the Resource Management Act.

The energy and power sectors
The main sources of primary energy in New Zealand in 1996 were coal (6.5 per cent), imported oil products (26.2 per cent), indigenous oil (5.9 per cent), gas (29.1 per cent), hydro (13.3 per cent), geothermal (13.6 per cent) and wood, waste, biogas and other renewable (5.4 per cent). Much of the gas, oil and solid fuel is used to generate electricity. Total primary energy consumption was 422.6 PJ.

The main sources of electricity production in 1996 were: hydro (79 per cent), geothermal (6 per cent), coal (1 per cent), gas (12 per cent), and wind, biomass and others (2 per cent). Total electricity consumption in 1996 was about 30 600 GWh (110 PJ), with per capita electricity consumption 8453 kWh/person. .

Energy consumption is expected to rise by 1.5 per cent/year and electricity demand by 1.7 per cent/year during the next decade.

The Ministry of Commerce is responsible for energy.

The power sector has recently undergone deregulation, with transition to private power companies and separated generation, transmission and distribution. The electricity market involves pool bidding: generators offer electricity to the marketplace for dispatch and transmission through the national grid operated by Transpower, a state-owned enterprise. Companies buy electricity from the pool for supply to retail customers. This physical spot market is supplemented by the trading of a range of forward contracts.

A competitive wholesale power market was launched on 1 October 1996. The former state power authority, ECNZ (Electricity Corporation of New Zealand), now competes with Contact Energy Ltd, a newly formed state-owned enterprise which took over eight power stations (including the 432 MW Clyde and 320 MW Roxburgh hydro plants). By 2000, it is predicted that ECNZ will have a 41 per cent market share of New Zealand's electricity generation business, compared with 84 per cent in 1995. This is in line with the intent of the Memorandum of Understanding signed between ECNZ and the Government in 1995.

During 1997, Electricity Market Company Ltd (EMCO) was also introduced, and the Mangahao hydro plant (30 MW) was transferred from state to private ownership.

About 9 per cent of all powerplants, in terms of total generation (2750 GWh/year), is non-Government owned, of which 1530 GWh/year is from hydro plants (5 per cent of total generation).

About 200 MW of new generating capacity was commissioned by ECNZ and is competitors in the North Island during 1997, and 800 MW more is expected to be commissioned in 1998.

Hydropower development

The gross theoretical hydropower potential of New Zealand is 152 000 GWh/year, and the technically feasible potential is 77 000 GWh/year (estimated in 1990). The economically feasible potential was reevaluated in 1993 and found to be 40 000 GWh/year. So far, about 30 per cent of the technically feasible potential has been developed. Three hydro plants are parts of multipurpose development.

The installed capacity of all powerplants in New Zealand is 7900 MW, of which about 5200 MW is hydro capacity. Hydro plants generated about 24 100 GWh in 1996. It is estimated that existing hydro plant capacity could be upgraded by about 5 per cent.

Manapouri, New Zealand's largest hydro plants is currently being upgraded, by the construction of a new 10 km-long tailrace tunnel. The plants capacity will be increased from 585 MW to 760 GWh/year increase).

New turbine runner are currently being fitted al the 220 MM Aviemore hydro plant.

Approximately 1500 MW of additional hydro capacity has been investigated, including the 350 MW Tuapeka hydro project (1620 GWh/year)

Small hydro

There are about 45 small, mini and micro hydro plant in operation, with a total capacity of 115.5 MW.

Future outlook

Present Government policies favour a market-controlled power sector and assume that private generaton will meet the power demand. Environment approvals for hydro are difficult to obtain New power stations planned are combined cycle. No major new hydro projects are likely to go ahead in the near future, although investigations are continuing.

Fur state-owned hydro station with a total capacity of 220 MW, are soon to be sold.

Nicaragua

Nicaragua has an area of about 13 000 km2 and population of about 4.2 million. There are four large dams in operation.

Energy and power sectors

The only commercial energy resources are hydropower and some geothermal potential. Power is currently generated by hydro, geothermal and thermal units.

Hydropower development

The gross theoretical hydro potential is 32 938 GWh/year. The technically feasible potential is 9541 GWh/year and the

Economically feasible potential is 6552 GWh/year These data were evaluated in 1980.

In 1995 Nicaragua had about 106 MW of hydro capacity in operation (340 GWh/year),of a total powerplant capacity of about 457 MW. The hydro plants generated 375 GWh in 1996, 25 per cent of total power production

A further 477 Mw hydro was planned (2087 GWh/year) There was 5.2 MW of mini and micro hydro, of which 114 kw was privately owned

The 56 MW Carlos Fonseca hydro plant is currently being upgraded The plant owner is Empresa Nicaraguans

NIGERIA

Nigeria has an area of 923 800 km2, and a population of about 108 million.

Water resources

The average annual precipitation is 1080 mm, giving a total mean annual precipitation volume of about 998 km3, of which the total runoff is estimated to be 230 km3.

Per capita domestic water consumption is 30 litres/day, (about 11 m3/year).

There are 63 large dams in operation.

The national authority in charge of water resources is the Federal Ministry of Water Resources and Rural Development. There are also 12 river basin development authorities, state water boards/corporations/utilities which cover the country's 30 states and tile capital, Abuja.

Energy and power sectors

The main energy sources are: petroleum and gas; coal and lignite; hydropower; biomass; and, solar power.

The main sources of electricity in 1995 were: thermal-fired stations (60 per cent) and hydro (40 per cent).

The national energy and power authority is the National Electric Power Authority (NEPA); there are no regional authorities. NEPA owns and operates all powerplants.

Hydropower development

The technically feasible hydropower potential of Nigeria is 30 690 GWh/year, which was evaluated in 1980.

There is about 6000 MW of capacity installed at powerplants of all types, of which 2341 MW is hydro capacity. Hydro plants generated 6000 GWh in 1996.

It is scheduled that 1210 MW of new hydro will come on-line before the year 2000 from the Zungeru and Katsina-Ala hydro plants. About 4200 MW of further hydro capacity is planned.

Small hydro

There are 41 small plants (less than 5 MW) in operation, with a total capacity of 32 MW. A programme of small hydro construction is planned, which will include 702 MW of small hydro capacity from 236 sites and 400 MW from mini hydro plants.

Norway

Norway covers an area of 324 300 km2 and has population of 4.33 million.

Water resources

The average annual precipitation is 1380 mm, ranging from 2000 mm in the west (with up to 5000 mm on the glaciers) to less than 750 mm in the east of the country(with some regions having only 280 mm). The total mean annual precipitation volume is 447 km3 of which 371 km3 is runoff. Per capita water consumption is 180 m3/year.

The Ministry of Industry and Energy is principally responsible for water resources. It manages water in conjunction with the Norwegian water Resources and Energy Administration (NVE), which has five regional offices.

Norway has 330 large dams in operation, almost bum for hydropower, and about 2500 dams more than 4 m high. The total storage volume of all the country's dams is about 40 km3.

The storglomvatn dam (125 m high, with a volume of 5.27 106 m3) was completed during 1997, as part of the Svartisen hydro project in the north of the country. It is a rochfill structure with a central asphaltic core.

There is a legal framework for environmental impact assessment and management. At the planning stage of a project, a detailed report with an assessment of consequences is drawn up. Then at the approval stage, the environmental impact is evaluated and must be approved by NVE.

Energy and power sector

The Ministry of Industry and Energy is the national energy and power authority. There are about 25 regional power authorities.

The main sources of primary energy in 1996 were: fossil fuels (46 per cent), electricity (48 per cent) and biamass (6 per cent). The total primary energy consumption was 722 PJ.

Hydropower contributed 99.2 per cent of national power production in 1996, with the remainder being from coal and oil. Total electricity consumption was 113 786 GWh. Per capita consumption was 8396 kwh/year in 1995. During 1996, 13 262 GWh of electricity was imported, and 4215 GWh was exported.

Powerplants are owned and operated by Statkraft or municipal authorities, or are privately owned.

About 85 per cent of powerplants are publicly owned. Norwegian energy Corporation (Statkraft) owns 29.9 per cent, and 55.1 per cent are owned by municipalities. The remaining 15 per cent are privately owned.

Per capita electricity consumption in Norway is 26 000 kWh/person/year, the highest in the world.

Hydropower development

Norway has a gross theoretical hydropower potential of 550 TWh/year, calculated in 1965. The economically feasible potential is 178.4 TWh/year, of which 65.7 TWh/year(37 per cent) remains to be developed.

The installed capacity of hydro is about 26 000 MW, representing 112 676 GWh/year. Hydro plants generated 112.7 TWh in 1996. Less than 5 per cent of hydro plants are parts of multipurpose schemes.

Hydro plants with an average annual generation of 1.7 TWh/year are under construction or planned, although no major projects are currently under construction.

Norway also has about 1290 MW of capacity at dumped-storage powerplants.

Future outlook

Enviornmental concerns will make the development of major new hydropower projects fifficult. However, the Government is willing to develop new renewable resources, including hydrpower.

A shortage of preciptation in 1995 resulted in increased electricity prices and an increase interest in small hydropower plants.

PAKISTAR

Pakistan covers an area of 796 095 km2 and has a population of about 132 million.

Water resources
The Ministry of Water and Power is in charge of water resources. There are also Irrigation Department in each of the four provinces. Deregulation of the water sector is envisaged.

There are 71 large dams in operation, according to ICOLD's definition. The largest dams under construction were described in the 1997 World Atlas. The total storage volume of all is 19.3 km3.

There is a legal framework for environmental impact assessment, applicable to all projects.

The main domestic civil contractor for dam and hydro projects are the National Construction Company. Frontier Works Organization and HAKAS.PEL Pakistan.

Energy and power sectors
The main sources of energy in 1995 were: hydropower, coal, natural gas, oil and biomass.

The main sources of electricity production in 1996 were: thermal plants using fossil fuels (56.6 per cent), hydro (43.4 per cent). Total electricity consumption was 42 66_3 GWh, representing per capita consumption of 311 kWh/year. During the next 10 years, an additional 22 081 of generating capacity is expected to be required.

Energy comes under the Ministry of Water, Ministry of Petroleum and Natural Resources and the Ministry of Planning (Energy Wing). There are two major regional power authorities: WAPDA (covering most of the country)and the Karachi Electric Supply Corp. The electricity market involves power purchase agreements.

Deregulation is expected to take place in June 1998, leading to separated generation, transmission and distribution. New organizations have recently been formed in view of this, including the Private Power and Infrastructure Board (PPIB)and the National Electric Power Regulatory Authority(NEPRA). The PPIB is responsible for co-ordination with private investors, evaluating their technical/financial proposals, signing implementation agreement, and so on. In addition, it formulates the policy framework for private investors in the fields of thermal and hydro generation, and transmission.

NERA is responsible for the regulatory framework for tariffs, private powerplants, and the generation, transmission, distribution and dispatch entities within the electrical sector after privatization and the corporatization of WAPDA.

Hydropower development
The gross theoretical hydropower potential of Pakistan was estimated in 1982-1984 to be equivalent to about 30 GW of capacity (263 TWh/year), and the technically feasible potential as estimated to be about 24 GW. So far about 20 per cent of the feasible potential has been developed.

There is 4826 MW of hydro capacity in operation. Hydro plants generated 25.653 GWh in 1996.

A further 1634 MW of hydro capacity is under construction, and 13 313 MW is planned. A further 960 MW could be installed at the Tarbela scheme after construction of the planned Kalabagh dam, enabling the two reservoirs to be operated in conjunction.

The two hydro plants under construction are: Chashma (184 MW, head 10 m, eight units, for commissioning in 1998); and, Ghazi Barotha (1450 MW, 69 m, five units, due for commisioning in early 2001).

The hydro plants planned include several very plants:

Kalabagh *2400 MW), which is awaiting the go-ahead after more than 10 years of delays;

Basha (3360 MW), which is awaiting funds for feasibility investigations;

Neelunl Jhelum (969 MW) and Golan Gol (16 MW), for which feasibility studies have been completed; and,

Kohala (1000 MW) and Jinnah(44 MW), for which feasibility studies are now being finalized.

Small hydro

There are nine small hydro plants in operation, with a total capacity of 108 MW. Another two under construction (10 MW) and 18 are planned (180 MW).

Future outlook

Pakistan has a vast hydro potential in the north. However, as a result of delays in exploiting this potential the hydro:thermal ratio is decreasing. During the past two years, a high priority has been given to the construction of new thermal plants through the private sector. However, the future priority is for hydro plants within the private sector.

PANAMA

The Republic of Panama covers an area of 75 517 km2, and ha a population of 2.7 million

Water resources
Average annual precipitation is 2700 mm

There are four organizations responsible for water resources development: Instituto de Recursos Naturales Renovables; Instituto de Acueductos y Alcantarillados Nacionales: Instituto de Recursos Hidraulicos y Electrification; and Mini8sterio de Salud

There are two large dams in operation both for hydropower production;l no other dams are planned at present

The following dams are under construction:

Diversion dam on Chiriqui river (RCC, 40 m high to be completed in 2001);

Guasquitas (CFRD. 45 m high. 98.4 MW hydro 2001) and,

Canjilones (RCC, 30 m high, 36.6 MW, 2001).

Panama's per capita water consumption is about 200 litres/person/day in urban areas and 150 litres/ person/ day in rural areas

Energy and power sectors
The main sources of primary energy in 1996 were: petroleum (69 per cent); hydro (13.5 per cent)

In 1997 ,72 per cent of national electricity production was from hydropower , the remaining 28 per cent being from imported diesel and bunker fuels

Total electricity consumption in 1996 was 3302 GWh, givi8ng per capita consumption of 1215 kwh/person The annual increase in electricity demand is expected to be on average 5.5 per cent/year during the next decade

During 1996, 64 GWh electricity was imported and 101 GWh was exported

At present, 10 per cent of the country's hydro capacity is privately owned, and 11.4 per cent of its total powerplant capacity, In August 1998, the state's hydropower plants will be offered for sale in open international bidding

The comjision Nacional de Energia is responsible for energy development, and the national power authority is Instituto de Recursos hidraulicos y Electrificacion (IRHE). IRHE owns and operates most of the country's powerplants It is soon to offer all of its assets in open international bidding, and be divided into eight new companies: one transmission/dispatch company, three distribution companies and four generating companies. With the exception of the transmission company. Which will remain a public entity for five years, all the companies will be sold off

The Comision de Politica Energetica has been created and put in charge of the formulation of policies and strategies for developing the energy sector Also by law, the Enter Regulador has been created to regulate the electricity market, with power purchase agreements and competence established by the operating efficiency of the participating companies

Deregulation is not envisaged in the near future

According to the new privatization law, the transmission company's Expansion Generating Plan will be valid by law for five years and the new Energy planning Commission will have an indicative Generation plan, to evaluate the energy offer from the private sector by comparison

Hydropower development

The gross theoretical hydro potential was estimated in 1985 to be 26 147 Gwh/year, of which 11 577 GWh/year is considered to be technically and economically feasible for development.

At present, hydro capacity is 551 MW of the total installed capacity of 922 MW. The average annual generation from hydro plants is 2775 GWh (based on 1995 to 1997). Generation in 1996 was 2902.5 GWh.

A further 135 MW of hydro is under construction, at the guasquitas and Canjilones dam projects. The mean cost per kw for the hydro plants under construction is UC$ 1400/kW.

The 126 MW Esti projects are included in the expansion generation plan (their capacity are given, together with their years for proposed connection to the National Integrated system):

Gualaca(28 MW, 2004),

LOS Aniles (35 MW, 2005),

El Corro(54 MW, 2005), and,

Baru(150 MW, 2007).

No potential for upgrading existing hydro plants has been identified.

Small hydro

There are eight mini and micro plants in operation, with a total capacity of 11 MW. No further small schemes are planned at present.

Papua New Guinea

Papua New guinea has an area of 464 840 km2 and a population of 4.3 million.

Water resources

The total mean annual precipitation volume is 672 km2. The national authority in charge of water resources is the Bureau of Water Resources, Policy district Interim Commission is in charge of the region. There are two large dams in operation.

Energy and power sector

The main sources of electricity in PNG in 1995 were: hydro(75 per cent)and diesel oil (25 per cent). The major priorities for the future are to use the country's hydro, natural gas and oil resources.

Per capita electricity consumption is 138 kwh/year total, and 28 kWh/year for domestic consumption.

Only 4 Gwh was privately produced in 1995, of 514 GWh of total power production of 689 GWh, 514 Gwh of which was hydro.

Hydropower development

The gross theoretical hydropower potential of PNG is 175 000 GWh/year(20 000 MW); the technically feasible potential is 122 640 GWh/year(14 000 MW); and the economically feasible hydro potential is 36 800 GWh/year (4200 MW). All these data were re-evaluation in 1994. So far, only about 1 per cent of the technically feasible potential has been developed, and 4.3 per cent of the economic potential.

There is 162.4 MW of hydro capacity in operation. Of 262.4 MW total powerplant capacity. Hydro plants generated 514 GWh in 1995.

A further 16 MW of hydro capacity is planned, at the toe of Yonki dam.

There are 10 small, mini and macro hydro plants(of less than 2 MW) in operation, with a total capacity of 19.8 MW. No further small hydro development is planned.

Paraguay

The Republic of Paraguay is a landlocked country in central South America, surrounded by Boliva to the northeast, Brazil to the northeast and east, and Argentina to the south and west. it covers 406 752 km2 and has a population of 5.3 million, 51 per cent of whom live in urban areas. The population is growing at a rate of 2.7 per cent/year. The GDP was US$ 9.6 billion in 1996.

The Paraguay river divides the country into two regions: western (known as the Chaco) and eastern. The eastern part of the country has 95 cent of the population and most of the industrial and agricultural activity.

The highest mountain peak is Cerro Pero (el 835 m). The Chaco is mainly flat, with a slight slope upwards towards the west. Land near the Paraguay river frequently floods. The eastern part of eastern Paraguay, which resembles a plain, is the western extension of the Parana plateau of brazil. The Parana plateau is composed principally of ancient lava flows.

Paraguay has a semi-tropical climate, with considerable heat and humidity in spring, summer and autumn. Winters are generally warm, but are interrupted by occasional cold period.

The degree of seisnmicity is very low.

Water resources

Paraguay's major river are the Paraguay, Pileomayo and Parana, which belong to the La Plata basin. The Pilcomayo and Parana form the country's borders with Argentina, while the Paraguay river flows southwards through the central part of the country, joining the Parana river at the southern border.

The annual average precipitation is about 1100 mm, with about 800 mm in the Chaco region and about 1500 mm in the eastern region. The total mean precipitation volume is 450 km.

There are four large dams in operation, Itaipu, Yacyreta and Acaray are all part of hydro schemes; the other is the Yguazu river dam. The total water storage volume of all country's dams is very large, at 58.7 km3.

Per capita domestic water construction is 220 litres/person/day in urban areas and 60 to 130 /litres day in rural areas, giving an average of 150 litres/day.

The main agricultural products are cattle, soya beans and cotton. The Vice-Ministry of Mines and Energy is in charge of water resources.

Energy and power sectors

The main sources of primary energy in 1996 were: fuelwood (40 per cent), oil (30 per cent), electricity (9 per cent), and others, mostly charcoal and vegetable residues (21 per cent). Total primary energy consumption was 138 million GJ in 1995.

The sources of electricity in 1996 was 3630 GW, giving per capita consumption of 723 kWh/person/year. The breakdown capita consumption is : domestic (42 per cent), industrial (21.5 per cent), commercial (18.4 per cent)and other (18.1 per cent).

Energy consumption forecasts are not available. Historical average annual rates of increase during 1985 to 1995 were as following: fuelwood (1.9 per cent/year), oil (9 per cent/year), electricity (13.2 per cent/year) and others(7.8 per cent/year).

Electricity demand is expected to increase by 9.5 per cent/year during the next 10 years.

The main electricity-consumption industries are the cement construction, and grain and agriculture-related industries.

The Vice-Ministry of Mines and Energy is in charge of energy and electricity in Paraguay. ANDE is the Government's vertically integrated electricity utility. There are no regional authorities.

There is a national grid system.

Paraguay has one state –owned powerplant, and shares the major Itaipi and Yacyreta binational hydro plants with Brazil and Argentina, respectively. Its 50 per cent shares of these plants are completely administered by the Government. All powerplants in the country are thus publicly owned.

There is a preliminary proposal for deregulation of the electricity sector, but it has not been approved yet. It is not yet predicted when deregulation might take place, it at all. The initial proposal considers separated generation, transmission and distribution and a separate retial market.

Power purchase are based on annual contracts which can be renegotiated every three months, however, it is very likely in the near future that there will be a pool bidding system similar to, or even part of, the one already implemented in Argentina.

Hydropower development

Paraguay has a large potential for hydropower, in view of the Parana river and its tributaries. The gross theoretical hydro potential has been calculated to be 111 TWh/year, of which 85 TWh/year is economically exploitable and 68 TWh/year is economically feasible.

The installed hydro capacity in operation is currently 7400 MW, with a further 650 MW installed but not yet in operation at Yacyreta; a further 56 MW is under construction and 200 MW is planned, as well as another major binational hydro project, Corpus, on the Parana river.

The average annual generation of the hydro capacity in operation is 54 250 GWh/year, more than its electricity requirements. Paraguay exported 36 998 GWh in 1996.

Paraguay owns half of the 12 600 MW capacity of the Itaipu project, the world's large hydro plant, which it shares with Brazil. It sells most of the Electricity to which it is entitled to brazil.

Paraguay shares the 3100 MW Yacyreta project with Argentina. The 20th and final 155 MW unit (10 of which belong to Paraguay), was scheduled to begin service by the end of March 1998. However, all the units are currently operating will be flooded when the reservoir reaches its final operating level. The units are currently operating at about 90 MW capacity. However, despite owning 10 units. Paraguay is currently using only about 70 MW of capacity, less than the capacity of a single unit.

Paraguay wholly owns the 200 MW Acaray hydro plant, where the four 50 MW nits are now being uprating to 64 MW.

Two additional 700 MW units will be installed at Itaipu in further, one of which will belong to Paraguay.

There is a plan to install two 100 MW units at the existing Yguazu dam. ANDE is currently receiving bids for the project.

Corpus, a third major hydro plant is planned on the the Parana river, nut at present the future of the project is uncertain. It would have a capacity of between 3000 and 6000 MW, and would be jointly owned by Paraguay and Argentina.

There are no small or mini hydro plants in operation or definitely planned.

Future outlook

Paraguay has abundant hydropower potential which far surpasses its electricity requirements. Surplus capacity is currently sold to Brazil and Argentina. However, a steady increase in domestic energy consumption is expected, particularly resulting from the electrification of new areas and new industries,. For this purpose, special rates have been approved for large industrial consumption as an incentive for foreign investors.

The Corpus hydro plant is a major project planned for the Parana river between Itapu and Yacyreta.

Peru

Peru covers an area of 1 285 215 km2 in the northwest of south America and has a population of 24.1 million.

Water resources

Annual average precipitation in Peru is 1500 mm. The total mean precipitation volume is 1900 km3, with total mean runoff being 1050 km3. About 94 per cent of precipitation falls within the catchment of the Atlantic tributaries.

The Ministry of Agriculture is responsible for Peru's water resources.

There are 47 large dams on operation, according to ICOLD's definition. The total water storage capacity of all reservoirs is about 5 km3. There is no significant construction of new dams under way. It is expected that the Government will construct the Angostura dam, a 100 m-high concrete dam with a 0.6 km3 capacity reservoir, as part of its Majes irrigation project in the south of the country.

Two water supply projects are under way to increase the water supply to Lima by 5 m3/s from Atlantic river and to supply Ayacucho city.

Energy and power

Per capita electricity consumption is 700 kWh/year total, with about 250 kWh/year of domestic consumption.

The Ministry of Energy and Mines is responsible for the country's energy.

An important recent development is further integration of the national grid system, through private investment in construction and operation of the Mantaro-

Socabaya transmission line, integrating the two existing main system. Through this interconnection, the Government expects to achieve better utilization of the Camisea gas resources and greater competition between generation companies.

Another aspect that has advanced significantly in recent years is an increase in the national electrification coefficient from 0.55 to 0.7, achieved mainly through extension of the interconnected system to isolated areas.

The main priorities for the future are to conclude privatization of the power sector, now under way, to install gas turbine, to develop the country's natural gas resources, and to develop more hydro plants which are particularly economic.

Privatization of the ten regional power distributors, created through the splitting up of Electroperu, is now under way. However, at present the privatization programme is proceeding slowly, and discussion is under way to change the concession.

Electrical generation capacity has increased in the past few years through the installation of 650 MW of gas turbines, which in a first stage are operation with diesel oil. In the future, they will operate with natural gas from Camisea project, when it is available. Two other natural gas projects (230 MW), several fuel oil diesel groups (100 MW) and small and medium hydro plants (90 MW) have also been added, as well as reconditioning of existing plants (100 MW). Completion of the Camisea project (300 MW), probably in 2003, will facilitate the fuel change of main thermal plants (650 MW) and the introduction of combined cycle operation. This is expected to lead to tariff reductions.

Other expected development in the south of the country include a 300 MW coal-fired powerplant to supply the county's principal copper mine. Two hydro plants (with a total capacity of 250 MW) are also planned.

Hydropower development

Peru has a gross theoretical hydro potential of 1811. 5 TWh/year, and a technically feasible potential of 305 395 118 GWh/year. Both these figures were evaluated in 1979. So far, only 4 per cent of the technically feasible hydro potential has been developed.

There is about 2550 MW of hydro capacity in operation, of a total powerplant capacity of about 4700 MW. The average annual generation of the hydro plants in operation is 15 300 GWh/year. Hydro plants represented 83 per cent of national power production in 1995.

The 12 MW Curumuy and 34 MW Gallito Ciego hydro projects were completed during 1997.

Construction of the Gaban hydro plant (110 MW, two units), is due to be completed in 2001. This project was held on standby recently until investors associated with privatized companies decided to construct the 40 MW Yanango and 11 MW Chimay hydro projects. Construction of Yanango went ahead during 1997, and Chimay is expected to go ahead in May 1998. These projects are being developed by Peruna de Energia (PERENE) in association with EDEGEL, the principal company privatized by the state, which has more than 800 MW of generating capacity.

It is estimated that the existing hydro capacity could be uprated by about 15 per cent, that is 350 MW; however, not all of this extra capacity may be economic.

Other hydro plants are planned. It is hoped that the following plants will be implemented in the short-term: Huanchor (15 MW) and Yunean (126 MW), in the centre of country on rivers in the Amazonian watershed; and, Lluclla 2 (90 MW first stage), in the south. Other medium-scale projects are expected to be developed in the future in the north and south.

Refurbishment of the Machu Picchu plant (110 MW) is necessary, as the powerhouse and switchyard were submerged by a landslide in February 1998, which impouned the Vilcanota river to a height of 70 m. It was the worst accident at a hydro plant in recent decade and reemedial measures are under investigation.

Private companies, such as mining companies, are likely to develop other projects, including some large ones.

Small hydro

Power supply based on non-grid system using mini hydro plants is considered to be an important element in improving Peru's rural infrastructure. There are several mini hydro programme under way, both governmental and involving international co-operation.

Future outlook

There is now a resurgence of interest in developing the hydropower resources of Peru, following a period during the 190s and mid-1990s when an economic crisis, coupled with energy policy and legislation, lead to priority being given to oil and gas-fired plants. Private investment has helped to accelerate a new programme of medium-scale hydro development.

Future hydro development will probably be concentrated in the Amazonian catchment area, which is not well developed, but has appropriate hydrological conditions. However, competition with natural gas be strong; therefore, only the most economically favourable projects with limited risks are likely to be developed.

Philippines

The Republic of The Philippines covers an area of about 300 000 km2 and has a population of 73.3 million.

water resources

The average annual precipitation is 2583 mm in Luzon. 1933 mm in Visayas, and 1974 mm in Mindanao. The national authority in charge of water is the National Water Resources Board(NWRB).

There are 15 large dams in operation. The country's dams have a total water storage volume of about 30 km3.

The San Roque dam, which is under construction, will be a 200m-high gravel fill structure. This multipurpose structure should be commissioned in 2005. Toher dams under construction are: Bakun AC (11 m high, concrete gravity, 1999); and, Casecnan (25 m high, overflow weir, 2000).

Per capita domestic water consumption is 21 .9 m3/year in rural areas and 40.1 m3/year in urban areas.

The Philippine Environmental Impact Statement (EIS) System required all Government agencies, government-owned or controlled corporations and private companies tp prepare an EIA for any project or activity that affects the environment. These assessments, which are essential in obtaining an environmental Compliance certificate (ECC) are issued by the department of Environment and Natural Resources (DENR). The ECC is needed to obtain project-related permits and approval, and in many cases, bank loans.

Projects of 10 MW or more require an EIS, while projects of less than 10 MW need an Initial Environment Examination.

Energy and power sectors

The main sources of electricity in 1996 were: oil (51.5 per cent), hydropower (21 .9 per cent), including pumped-storage plants), geothermal (12.4 per cent), coal (14.1 per cent) and biomass (0.1 per cent). About 55 per cent of electricity was generated using imported fuels. Total electricity consumption of 473 kWh/year. No electricity is imported or exported.

Total energy consumption is expected to increase by 5.25 per cent/year during the nect decade, while electricity demand is likely to increased by 6.1 per cent/year.

The national energy authority is the Department of Energy (DOE) and the national power authority is the National Power Corporation (NPC).

At present, 98.72 per cent of hydro plant capacity is publicly owned, and 76 per cent of all powerplant capacity is publiclly owned.

The Government is now encouraging the private sector to participate in the development of power utilities through BOT schemes. Proposed organization changes aim to liberalize and deregulate the power industry to promote competition.

Under the plan, the transmission function of the Government owned NPC will be separted from electricity generation. In the privatied environment, tarifs will be determined by market forces and charged by the generating companies. However, transmission and retail wheeling charges, as well as tariffs which distribution can charge customers, will be regulated.

Hydropower development

The gross theoretical hydropower potential of the Philippines is 47 459 GWh/year and the technically feasible potential is 20 334 GWh/year. The economically feasible potential is 18 184

GWh/year. About 21 per cent of the technically feasible potential has been developed.

The privatization of the energy sectors is now beginning. So far only a few hydropower which are not connected to the grid are privately owned.

The main priority in the energy sector is further hydropower development.

Small hydro

A total of 69 small hydro plants (with a total capacity of 32 MW) were built between 1940 and 1978. Interest in small scale plants then declined and most of these these plants decommissioned, leaving only five in operation (with a total capacity of 13.87 MW), all in the mountainous Badahsan Independence region of Pamir.

Four new small plants were under construction in 1996: Ziddi (500 kW); Tearv(360 kW); Anderoag(230 kW); and Pasthuff (500 kW). Two others are planned: Sirkent 2 (100 kW) and Yazgulem(2 MW).

A plan for further development of small hydro plants, envisaging the construction of 179 plants, has been drawn up: 51 in the range of 100 to 500 kW; and, 67 in the range of 500 to 1000 kW; 55 in the range of 1 to 3 MW; six of more than 3 MW. It is proposed that all these plants can be constructed using standardized equipment, involving four types of Pelton turbines and three types of reaction turbine.

Future outlook

The basic priority further hydropower development arises from: the large unexploited hydro resources and lack of fossil fuel resources; and, the increase demand for electricity.

A fundamental criterion for developing the country's water resources will be the adoption of a complementary approach involving hydropower and irrigation, and the aim will be to exploit the rivers fully.

These considerations determine that future water projects will involve: large hydropower dams providing for energy production as well as irrigation; large and medium-sized hydro plants which will operate as part of a common system and convert the energy potenital of the rivers into useful power in the most beneficial way; and, small and medium-sized hydro plants on the smaller rivers to meet the needs of individual consumers.

Poland

Poland has an area of 312 km2 and a population of 38.8 million.

Water resources

The Ministry of Environmental Protection, Natural Resources and Forestry is in charge of water resources. There are seven regional water Management Boards.

The total mean annual precipitation volume is 190 km3, of which 59 km3 is runoff.

Per capita domestic water consumption is 145 litres/person/day in urban areas 58 litres/person/day in rural areas.

There are 36 dams higher than 15 m in operation in Poland and 61 higher than 5 m and with storage capacities greater than 3×106m3; these have a total water storage volume of 3.6 km3. There are 100 dams with storage capacities greater than 1×106 m3.

The 60 m-high dam for the Czorsztyn-Niedzica pumped-storage project was completed during 1997, just prior to the extreme floods of July 1997. The reservoir proved to be effective in reducing 60 per cent of the maximum flow.

The Swinna Poreba and Wiory projects, which involved the construction of earth dams for water supply are expected to be commissioned after 2000.

There are no other definite projects, but it is planned to created some large reservoirs for flood control, especially in the upper Vistula and Odra catchment area.

A new version of the country's Water Code is being prepared at present. An EIA is necessary for all new dams, reservoirs and hydropower plants.

The main domestic civil contractors in the field of dams and hydro plants include Hydrobudowa(of Warsaw or of Poznan) and Hydrotrest(of Krakow).

Energy and power sectors

The Ministry of Economy is the national energy authority.

The main sources of primary energy in 1996 were: coal (60 per cent); oil (13 per cent); lignite (13 per cent); gad (10 per cent); peat and wood (3 per cent); hydropower(0.5 per cent); and others (0.5 per cent). Total primary energy consumption was 4515 million GJ.

The main sources of electricity in 1996 were: coal (63 per cent); lignite (36 per cent); hydro(1 per cent); and others (less than 1 per cent). Total electricity consumption was 122 016 GWh, representing per capita consumption of 3160 kWh/year.

During 1996, 5438 GWh of electricity was imported and 7925 GWh was exported.

About 5 per cent of hydro plant capacity is privately owned, compared with about 3 per cent private ownership for the total powerplant capacity.

In according with the new Energy Code, deregulation is on course, aimed at the introduction of a pool system. However, a system based on power purchase agreement is also being discussed.

Hydropower development

The gross theoretical hydropower potential is 25 00 GWh/year, and the technically feasible potential is 12 000 GWh/year (these were evaluated in 1975). The economically feasible hydro potential is now 7000 GWh/year. So far, 13 per cent of the technically feasible potential has been developed.

There is 535 MW of hydro capacity in operation, of a total powerplant capacity of 33 392 MW. Hydro plants generated 1700 GWh on average. About 80 per cent of the hydro capacity is multipurpose schemes.

There is further 30 MW of hydro capacity under construction. powerplants in the lower Vistula basin are still under discussion.

There is 1657 MW of pumped-storage capacity in operation. Pumped-storage plants generated bout 2150 GWh of electricity during 1996 and consumption 2745 GWH. Pure hydro and pumped-storage together supply about 3 per cent of power production.

The 92 MW Czorsztyn-Niedzica pumed-storage projects was commissioned during 1997.

Small hydro

There are about 250 small, mini and micro hydropower plants in operation in poland (defined as plants of up to 5 MW), with a total installed capacity of about 120 MW. Further development is planted in connection with the rehabilitation of small water storage facilities.

Future outlook

In view if the extreme of July 1997, future projects will probably be focused on creating some large flood control reservoirs in the upper catchment areas of the Odra and Vistula rivers.

The future development of cascade hydro plants on the Lower Vistula river and also the Mloty pumped-storage plant depend on financial and ecological circumstances.

Priority will continue to be given to further improving the water quality in rivers and lakes.

Portugal

Portugal has an area of 99 790 km2 and a (mainland population of 10.56 million.

Water resources
The total mean annual precipitation volume is about 80 km3, of which about 57 km3 is runoff.

There are 40 large dams in operation associated with hydro plants, with a total storage volume of about 4 km3.

The largest dam under construction is Alqueva, on the Guaduana river, which is a concrete arch structure 96 m high, being built for irrigation water supply, hydropower and to provide downstream minimum flows. It will have a reservoirs volume of 4.1 km3, and is due to be commissioned in 2002.

The Instituto da Agua (INAG)is responsible for national water resources, while the direccao Regional do Ambiente is in charge of water regionally.

The Quinta das Laranjeiras dam is planned for construction on the Sabor river, a tributary of the Douro. It will be 115 m high, and will have a reservoir volume Of 1.07 km3. It is part of a pumped-storage projects, planned or commissioning in 2007.

Another dam which is under review is Fridao on the Tamega river, also a tributary of the Douro. It would be 86 m high and have a reservoir volume of 0.16 km3. There would be an associated hydropower plant.

Energy and power sectors
The Derccao Geral de Energia (DGE) is the national authority for energy and power, while the direccao regional da Industria is in charge of regional power. A regulating entity, ERSE, created fir the power sector in 1996, has been regulating the sector. DGE is responsible for planning, and will now assume the role of sector's regulation.

The electricity market currently involved power purchase agreements in the regulated market between power generators and the national grid. The market is being deregulated and will involve separate accounts.

The main sources of primary energy in 1996 were (provision al data): fossil fuels (86 per cent), electricity (7 per cent) and others (7 per cent). Total primary energy consumption was 18 980 kTOE.

The main sources of electricity production in 1996 were: coal (37.2 per cent); hydro (43.6 per cent); oil (19.2 per cent); and , wind (0.03 per cent). About 56 per cent of electricity was 29 890 GWh, representing per capita consumption of 3010 kWh/year.

During 1996, 4166 GWh of electricity was imported and 3005 GWh was exported.

It is estimated that energy demand will increase by between 2 and 3 per cent/year during the next 10 year, and electricity demand will increase by 3.4 per cent/year.

At present, 96 per cent of hydro plant capacity and 85 per cent of total powerplant capacity are publicly owned.

Per capita electricity consumption is 2780 kWh/person/year total, and 780 kwh/person/year.

Hydropower development
The gross theoretical hydropower potential of Portugal is 32 500 GWh/year; the technically feasible hydropower potential is 24 500 GWh/year. So far, 50.7 per cent of the technically

potential has been developed.

The total installed capacity of all powerplants is 8935 MW, of which 4125 MW is hydro capacity in operation (including 562 MW at four mixed pumped-storage plants). Hydro plants generate on average 12 415 GWh/year(37 per cent of total electricity production), although generation was 14 680 GWh in 1996.

A further 420 MW of hydro capacity is under construction and 266 MW is planned. Of the hydro in operation, 441 MW is at multipurpose developments, as well be all the hydro capacity under construction and planned.

The Alqueva project will have 240 MW of capacity from reversible units, and is scheduled for commissioning in 2002. The Vila Nova ll hydro plant is a new plant at the existing Venda Nova dam on the Rabagao river. It will have a capacity of 180 MW(reversible) and should be commissioned in 2003.

The planned Quinta dad Laraneiras project will provide 164 MW o reversible capacity. It is scheduled to be commissioned in 2007.

The Fridao project on the Tamega river is planned to have a capacity of 130 MW, although no definite schedule has been established.

At present, uprating of some existing plants with the installation of reversible units is foreseen.

The installed capacity at mixed pumped-storage plants is 562 MW. A further 420 MW of capacity is under construction at the Alqueva and Vila Nova I mixed pumped-storage projects, and, 138 MW is planned at the 164 MW Quinta das Laranjeiras mixed pumped-storage plant. Pumped-storage plants generated 100 GWh during 1996 and consumed 137 GWh.

Environmental impact assessments are mandatory for hydropower projects that have the following minimum characteristics: an installed capacity of 20 MW; a dam height of 15 m; a reservoir capacity of 100 000 m3; a reservoir area of 50 000 m2; or a dam crest length of 500 m.

Small hydro

There is about 230 MW of hydro capacity in operation at 74 small, mini and micro hydro plants, generating about 640 GWh/year. Details of plants under construction or planned are not available.

Future outlook

Prioroties for the future are multipurpose schemes. Environmental constrains are becoming more important and string. Hydropower development in the future will have to be carried out within the framework of a regulated electricity market.

Romania

Romania has an area of 238 391 km2 and has a population of 23.2 million.

Water resources

The total mean annual precipitation volume is 151.8 km3. Runoff comprises 37.8 km3 of surface and 5.6 km3 of underground water.

The Ministry of Water, Forestry and the Environment is in charge of water resources, operation through the Romanian Water Authority. No changes are envisaged in the short term in this sector.

There are 144 large dams in operation, of which 78 are for hydropower, 40 are multipurpose, with hydro as one of the their functions, and 26 have other users. A further 36 large dams are under construction (25 for hydro, 7 multipurpose including hydro, and 4 with other functions). There are 204 dams of all sizes in operation, and 38 under construction. the total water storage volume of all the dams in operation is 206 km3, of which 117 km3 is at the large dams.

The largest dams under construction include: Gura Apelor (168 m high, rockfil); Poiana Marului (125 m high, rochfill); and, Rastolita (105 m high, rockfill).

Per capita water consumption is 433-m3/year total, and 87.8 m3/year for domestic consumption.

There is a legal framework for environment impact assessment and management. The Law on Environment, issued after 1990, specifies the obligations of all water users, including hydro plant owners.

The main civil contractor in the field of dams and hydro plant is Hidroconstructia SA Bucharest.

Energy and power sectors

The main sources of primary energy in 1996 were: natural gas (35 per cent); oil (25 per cent); coal (30 per cent0; hydro (9 per cent); and, other (1 per cent).

The main sources of electricity production in 1996 were: coal (34.6 per cent); fuel oil (10.5 per cent); natural gas (26.4 per cent); hydro (26.2 per cent); and, nuclear (2.3 per cent). The total electricity consumption was 62 158 GW, representing 2726 kWh/year per capita consumption. During 1996, 809 GWh was imported though short-term exchanges with neighboring countries.

Energy consumption is expected to increase by 2500 to 3000 GWh/year annual during the next decade, while electricity demand will increase by 800 to 1000 GWh/year annually.

The Ministry of Industry is in charge of energy, while RENEL (the National Electricity Authority) is the national power authority. It has various regional subsidiaries for production and distribution.

Deregulation of the energy/energy sector is beginning during 1998, with the objective of co-ordination the power system and energy transportation. RENEL will be transformed into a National voltage power grid, and the system operator (the existing National Power Dispatcher). The energy producer and distribution centers (RENEL subsidiaries at present) will become independent energy producers, that is independent commercial companies. Some of these will be totally or partially privately owned, possibly with foreign participation.

An Energy Law will be issued to specify the conditions for implementation of the new energy market. This will include: implementation of a new electricity tariff system; and, a framework for the contractual relationships between energy partners (generating companies, the network operator, distribution companies and consumers).

The deregulated market will involve separated generation, transmission and distribution, and probably power purchase agreement.

RENEL currently owns 97 per cent of powerplant capacity (with the remaining 3 per cent having private or other public owners) and 98 per cent of hydro plant capacity.

In the future, additional environmental and safety requirements for hydro projects can be expected.

Hydropower development

The gross theoretical and technically feasible hydropower potential is 70 000 GWh/year, evaluated in 1986. The technically feasible hydro potential is 36 000 GWh/year, corresponding to 11 500 MW of capacity. The economic transition to a market economy means that it is difficult to assess the economically feasible potential, but it is approximately 28 000 to 32 000 GWh/year(9100 to 10 300 MW). So far, about 42 per cent of the technically feasible hydro potential has been developed.

The installed capacity of all powerplants in operation is 18 653 MW, which is less than in previous years as a result of some old thermal units being disconnected. The installed capacity of hydro plants is 5912 MW, which generate 16 700 GWh/year on average (25 per cent of production). In 1996, hydro plants generated 15 684 GWh.

A further 992 MW of hydro capacity is under construction, and 921 MW is planned. The projects under construction include some which were temporarily abandoned after 1990 in review of the difficult economic situation. It is hoped that the involvement of foreign investors or multipurpose water users may provide an opportunity to complete some of these schemes. The mean cost per kWh for the hydro plants under construction is US¢ 6 to 14/kWh (overall lifetime costs). More accurate evaluations are still being carried out by domestic of foreign consulting companies.

The planned projects were designed before 1990, but insufficient funds are available to begin construction. they include development o the Tisa river through a joint Romanian Ukainian projects(30 MW, 200 GWh/year).

There is significant uprating potential at existing hydro plants: 370 MW through rehabilitation of about 30 hydro units which have low reliability or generating limitations as a result of deficiencies. At present this capacity is considered permanently unavailable, although it is included in the 5912 MW hydro capacity given above. There is an additional potential of 206 MW through the uprating o 14 hydro units, including the Iron Gates plant.

A 1000 MW pumped-storage plant is planned, Tarnita Lapustesti, which will have four 250 MW units. Romaniia's first nuclear power unit (700 MW) requires a large base load, and a pumped-storage plant was planned to operation in conjunction with it before 1990. However, the start of construction was delayed, again because of lack of funds. Construction of the plant is now planned with the help of an international loan, and Government guarantees.

Small hydro

There are 256 small, mini or micro hydro plants in operation(up to 10 MW), with a total capacity of 332 MW. A further 28 are under construction(70 MW), and 46 are planned (223 MW).

There is likely to be an increase in interest in small hydro when public/private ownership becomes more important.

Future outlook

The national strategy concerning the electricity energy sectors is mainly related to the transition now under way to a market-oriented economy and the new relationship to be established between power producers and consumers. The main objectives are a reorganization of RENEL from a state-owned organization towards public and private ownership, and implementation of the energy market based on a modern Energy Law.

Th main priorities for future hydropower development remain:

Completion of civil works and commissioning of unfinished projects which are considered efficient after economic and financial analysis:

Retrofitting and upgrading works, to bring the power units operational parameters in line with European UCPTE standards;

Increasing the efficiency of plant operation by computerized means, based on least-cost criteria;

Implementation of modern diagnostic and predictive maintenance methods; and,

Modernization of powerplant control using computer technology.

Russian

The Russian Federation covers an area of 17 075 400 km2 and has a population of about 150 million.

Water resources
Average annual precipitation is 600 to 800. The total mean annual precipitation volume is 9348 km3 and total mean annual runoff is 4262 km3.

Per capita domestic water consumption is 373 litres/day .Russia currently has 91 large dams in operation. The total water storage capacity of all dams is 9349 km3.

The largest dams under construction and planned are listed with their associated hydro plants below.

There is a system of laws which help provide environmental protection is in place.

Energy and power sectors
The national energy and electricity authority in Russia is Russian Joint Energy Inc (Russian JES). There are currently 70 regional power authorities. Russian JES now owns only 33 per cent of hydro plants; shareholding companies of the separate power grids own 65 per cent, and non-incorporated owners own 2 per cent.

There is a regulated energy/electricity market, controlled by the state.

The main sources of primary energy in 1996 included (in MTOE): oil (440), gas (710), nuclear (40), hydro (20), of the total 1380 MOTE.

The main sources of electricity production in Russia in 1996 were: thermal plants (68.8 per cent); hydro (18.3 per cent): and, nuclear (12.8 per cent); the total was 846.4 TWh. About 19.7 TWh electricity was exported during 1996, mostly to other CIS countries.

Per capita electricity consumption is 5600 kWh/person/year.

Electricity demand is expected to increase to about 1080 to 1270 TWh/year during the next 10 years.

Hydropower development
Russia has a gross theoretical hydropower potential of 2400 TWh/year and an estimated technically feasible potential of 1670 TWh/year. The economic potential is estimated to be

850 TWh/year. These figures have been updated recently. Only about 10 per cent of the technically feasible hydropower potential has so far been developed.

The installed capacity at powerplants in Russia is currently 196 700 MW, of which 44 100 MW is hydro capacity. Hydro plants generated 155 TWh in 1996.

It is estimated that Russia's hydro plants could be upgraded by 3 to 5 per cent in terms of capacity, and 5 to 8 per cent in terms of power output.

The mean cost per kW of Russia's hydroplants is US$ 2700 for low head plants, US$ 2000 for medium head pants and US$ 1300 for high head plants.

Russia's main domestic civil contractors for dams and hydro plants include: Bratskgesstroy, Krasnoyarskgesstroy, Sevkavgidroenergostroy and Chirkeygesstroy.

A further 9600 MW of hydro capacity is under construction, and 5595 MW is planned.

The largest hydro schemes under construction (more than 300 MW) are:

Boguchany, on the Angara river in Siberia (4000 MW, 90 h-high gravity and 79 m-high rockfill dam);
Bureya, on the Avarskoe Koisu in the Caucasus (800 MW, 111 m-high earthfill dam);
Iragnai, on the Avarskoe Koisu in the caucasus (800 MW, 111 m-high earthfill dam);
Ust-Srednekansk, on the Kolyma river in Siberia (550 MW, 66 m-high earthfill dam);
Vilyui 3 (360 MW, 50 m-high earthfill dam);
Zaramag, on the Ardon river in the Caucasus (342 MW, 39–high earthfill dam);
Zelenchuk, on the Upper Kuban rivers in the southwest (328 MW, 40 m-high gravity dam); and,
Telman, on the Mamakan river in Siberia (450 MW, 140-high rockfill dam).
The largest hydro projects planned (more than 300 MW) are:

Katun, on the Katun river in Altai (920 MW, 179 m-high gravity dam);
Chmal, on the Katum river in ALTAI (#)) MW, 65 m-high earthfill dam);
Mochskaya, on the Vitim river in altai (1200 MW, 114 m-high gravity dam), which will operate in conjunction with Katun, providing regulation;
Agvaliysk, part of a cascade on the Andiyskoe Koisy (400 MW, 215 m-high earthfill dam with face);
Zagorsk pumped-storage project(800 MW);
Nizne-Niman on the Niman river in the Far East (600 MW, 142 m-high rockfill dam); and,
Gilui (525 MW, 103.5 m-high gravity dam).
Russia now has 1000 MW of pumped-storage capacity in operation and 200 MW under construction. A further 840 MW is palled, most at the 800 MW Zagorsk plant. Pumped-storage plants generated 1015.8 GWh in 1996 and consumed 1380 GWh.
Small hydro
There are currently 29 small and micro plants (less than 30 MW) in opeation, with a total capacity of 52.8 MW. Four plants (33 MW) are under construction.

RWANDA

Rwanda has an area of 28 300 km2 and has a population of about 8.5 million.

water resources

Average precipitation varies between 800 mm/year in the eastern plains to 2000 mm in the northwest.

The construction of power and transmission projects are under the auspices of the Ministry of public works, Energy and Water. The Ministry hands over completed schemes to Electrogaz, the organization responsible for generation, transmission and distribution of power throughout the country.

Hydropower development

Rwanda has a total potential of about 100 MW, nearly a third of which has been developed at four small hydro plants, and a number of independent micro plants.

There is about 34 MW of total generating capacity, of which 28 MW is at the four hydro plants and one diesel plant. Electricity is also received from the tri-national Ruzizi I,II and III plants (shared with Burundi and Dem. Rep. of the Congo), and imports from Zaire. Electrogaz currently has about 57 MW of capacity.

A potential project on the Sebeya river Keya, has been studied; this could provide between 0.8 and 1.8 MW of additional capacity.

Only about 4 to 5 per cent of Rwanda's population has access to the grid. Per capita power consumption for those connected to the grid is about 720 kWh/person/year.

Future outlook

Rwanda needs to implement new hydropower projects to meet increasing demand and to Continue to avoid the need to import oil. Before tile outbreak of war in the region, if was planned to develop a masterplan for development, starting with an assessment of small and medium-scale sites.

The tributaries within the upper Kagera river catchment offer particularly good prospects for hydro development, especially the Mukugwa, Nayabarongo, Rukaraya and Akanayaru rivers in the west.

Further projects could be built on the Ruzizi river, where a head of about 664m is available over a relatively short distance along the East Africa Rift. However, international agreement would be nessary.

There are plants to connect Rwanda's grid to those of Uganda and Tanzania.

Saudi Arabia

The Kingdom of Saudi Arabia covers 2 250 000 km2 on the Arabian Peninsula, and has a population of 18.7 million.

Water resources

The distribution of rainfall is extremely variable, ranging from 25 mm/year in the south and northwest up to 600 mm/year in the southwest mountains of Asir.

The Ministry of Agriculture and Waster is in charge of the kingdom's water resources.

There are 184 dams in operation, with a total storage capacity of 482.25×106 m3; 38 are large dams. The main purpose of supply. The largest dam under construction is the 113 m-high King Fahad dam at Bisha. It is a concrete gravity structure which will have a capacity of 325×106 m3. A large number of new dams are planned for the future.

Energy and power sectors

Most energy is consumed in the form of electricity. The Ministry of Industry and Electricity is the national energy authority, and the Saudi Consolidated Electricity Corporation (SCECO) is the national power authority. The Saudi Arabian Basic Industrial Corporation is the largest consumer of power.

The per capita electricity consumption is 4377 kWh/year in total, with domestic consumption of 3250 kWh/year.

SENEGAL

Senegal has an area of 197 000 km2 and a population of 9 million.

Water resources

The principal rivers in the region are the Senegal and the Gambia, which are under the auspices of the Organization de Mise en Valeur de fleuve senegal (OMVS), and the Organization de Misc en Valeur de fleuve Gambie(OMVG), respectively. The OMVS involves Senegal, Mail and Mauritania, while OMVG involves Senegal, the Gambia, Guinea and Guinea-Bissau. Two large dams are in operation.

The population of the Senegal river valley is about 1.5 million, 50 per cent of whom live in Senegal, 20 per cent in Mauritania and 30, per cent in Mali.

The Senegal River project, being implemented at present, includes:

The 66-m high Manatail dam (now complete), on the Bafoulabe tributary of the Senegal river, at the Senegal/Mauritania border, which impounds a reservoir coving about 500 km2 ;

A 200 MW (800 GWh/year) powerplant, near the Manatail dam, now under construction.

The Diama dam, impounding a 400 to 500 km2 reservoir in Senegal near the mouth of the Senegal river;

Construction of various ports along the river and dredging of the riverbed; and;

Irrigation of some 2500 km2 .

Hydropower development

The technically feasible hydropower potential of Senegal is 4250 GWh/year, and the economically feasible potential is GWh/year. These data were evaluated in 1986.

Construction of the 200 MW Manantali plant (800 GWh/year), as part of the Senegal River project scheduled to begin after September 1997 and to be completed in 2001; some components, including the dam , are already in peace.

SIERRA LEONE

Sierra Leone has an area of 73 326 km2 and a population of 4.8 million.

The country has been in a state of civil war during the past year, and so very little development work has been carried out.

Water resources

The average annual precipitation is 3000 mm, varying from 1862 mm in the extreme north to 5000 mm along the coast. The total average precipitation is 220 km3 , of which it is estimated that 20 to 40 per cent is runoff.

Per capita water consumption is 3.65 m3/year in rural areas.

Sierra Leone now has two large dams in operation: the 68 m-high Guma dam in the Freetown peninsula mountains, which supplies water to Freetown and the 90 m-high Bumbuna Falls dam, completed recently as part of a hydro project which is not yet commissioned.

The authorities in charge of water management are: the Ministry of Energy and Power – Rural Water Supply; Guma Valley Co (Freetown); and, the Ministry of Agriculture, Land and Water Development Division (for Agriculture).

Energy and power sectors

The National Power Authority (former Sierra Leone Electricity Corporation) is the national energy/power authority. The country's main energy source is imported crude oil. All powerplants are owned and operated by the government.

Per capita electricity consumption was at least 185 kWh/year in 1991.

Hydropower development

There are two small hydro plants in operation: a 2.4 MW plant at Guma dam, and the 2 MW Dodo plant, both in Eastern Province. A further 70 MW of hydro capacity is under construction at the Bumbuna Falls project, on the Rokel river.

Future outlook

There is significant potential for hydropower development. However, there are few suitable sites for reservoir construction in the interior plains, and the distance between suitable sites and load centres is generally large.

The recent civil war means that development of new projects is not going ahead at present.

Slovakia

The Slovak Republic covers an area of 49 014 and has a population of 5.43 million.

Water resources
Average annual precipitation is 743 mm/year. The total average precipitation is 36.4 km3, of which 12.6 km3 is runoff however, the runoff in Slovak rivers also includes 105 km3 (3328 m3/s) of runoff from neighboring states.

Per capita water consumption in 1995 was 88.6 m3/person/year, of which 42 m3/person/year was for domestic consumption.

The national authorities in charge of water resources are the Ministry of Land Economy; Ministry of the Environment; Water Research Institute; and, Water engineering Constructions.

There are four organizations for river basin administration(in Bratisava, Piestany, Banska Bystrica and Kosice) and five water and sewerage works (two in Bratislava, and one each in Zilina, Banska Bystrica and Kosice).

There are 50 large dams in operation according to ICOLD's definition, of a total of about 300 dams. The Zilina earhtfill dam, 15 m high, is under constructiom as part of a 62 MW hydro project, to be completed during 1998.

Two earth dams are planned: Tichy Potok (60 m high, reservoir capacity 22×106 m3, for water supply); and Sered (20 m high, reservoir capacity 27×106m3, for hydro , navigation, irrigation and recreation).

Development of the Vah river between Bratislava and Wolfsthal will involive a 35 m-high earth dam, with a reservoir capacity 120×106 m3.

There is a law (Act 127/1994) which provides a legal framework for environment impact assessment.

The main domestic civil contractors for dams and civil works include Voahostav a.a. Zilina and Hydrostav bratislava.

Energy and power sectors
The main sources of energy in 1996 were: soild fuels (30.2 per cent), liquid fuels (18.9 per cent), gas (30.8 cent), hydropower (3.8 per cent) and nuclear power (16.3 per cent). Total primary energy consumption was 754.2 PJ.

The main sources of electricity in 1996 were: nuclear (44.6 per cent), thermal (37.8 per cent)and hydro (17.6 per cent).

Total electricity consumption of 5396 kWh/year. During 1996, 3592 GWh of electricity was imported.

The Ministry of Economy is responsible for energy. The national energy and power authority became a shareholding company during 1994, called Slovenske elektrarne (SE). It produces about 85 per cent of electricity).

The electricity market involves purchase agreements. No deregulation is envisaged.

About 13.6 MW, that is 0.6 per cent, of hydro capacity is privately owned.

Hydropower development
The total potential of Slovakia is about 10 000 GWh/year. The technically feasible potential is

7361 GWh/year(evaluated in 1982) and the economically feasible potential is about 6000 GWh/year. So far56 per cent of the technically feasible potential has been developed, and it is planned that 65 per cent will be developed by 2005.

The installed capacity of powerplant of all types is 7130 MW, of which 2400 MW is at hydro plants. The average annual generation of all the hydro plants in operation is 4100 GWh/year, and generation in 1996 was 4463 GWh.

The Cunovo scheme (24.2 MW, 7.1 m high, 171 GWh/year) was completed during 1997, as part of a multipurpose development involving a hydro project and auxiliary lock, within the framework of the Gabcikovo scheme.

A further 90 MW of hydro capacity is under construction and about 200 MW more is planned up to 2010.

The largest hydro project under construction is Zilina (62 MW, 24 m head, 173 GWh/year), which is scheduled to be completed in 1998.

The mean cost per kW for the low-head hydro under construction is US$ 2000 to 3000/kw.

Hydro projects planned included: the sered multipurpose project (61 MW, 170 GWh/year, 20 m head, 2002 to 2005); and Strecno (22 MW, 9 m head, 72 GWh/year, 2001, 2005).

There is a 915 MW of pumped-storage capacity in Slovakia, and a further 600 MW planned for commissioning between 2005 and 2010. Pumped-storage plants generated 214 Gwh in 1996 and consumed 300 GWh.

There is an estimated uprating potential of 15 MW (50 GWh/year) at existing hydro plants up to 2005.

Small hydro

There are 154 small, mini or micro plants in operation, with a total capacity of 52 MW (16 GWh/year). Another six are under construction (4 MW) and 60 planned up to 2005 (90 MW0.

Up to 2030, a further 1200 GWh/year of small hydro generating capacity is planned.

Small hydro is developed by private investors. The authorities approving construction are decentralized.

Somalia

Somalia has a land area of about 640,000 square kilometers and a population of 9.3 million (1989). Of this population 29 per cent are rural, 44 per cent nomadic and 27 per cent urban. Livestock and crop production are the main economic activities, contributing 37 per cent ad 24 er cent receptively to GDP and sizably to export earnings. Manufacturing was insignificant at 5 per cent.

Energy

Commercial energy consumption is very limited. Fuelwood and agricultural residues account for 87 per cent of all energy consumed, petroleum for only 11.8 cent electricity for a mere. Energy consumption by sector for the major types of energy is shown below.

Somalia: Energy consumption by sector

Sector	Fuelwood %	Petroleum %	Electricity %
Residential	97.2	8.5	16.7
Industry	2.4	12.7	25
Commercial&government	0.4	9.3	58.3
Transport	-	60.2	-
agriculture	-	9.3	-
	100	100	100

Diesel is the main source of electricity, except for 4.6 MW of hydro at Fanole and 15 MW of thermal at Jesira. The diesel plants are very poorly maintained, and are utilized at a low capacity. This is accentuated by the uncertainties of diesel importation duo to foreign exchange difficulties. Currency devaluation occurs by the day. The price of electricity also skyrocketed from 2 Somalia shilling in 1982 to 120 in 1989. Even then costs were much higher than tariffs, and defaults leading to stoppage of electric supply were frequent. An electricity supply extended to sonsumers in the Balad district by a textile factory which had generation and the municipality, which acquired one, was not successful either, and the supply was discontinued.

Recent intensification of civil strife in Somalia, which has resulted in the researcher losing contact with the network, underlines the fact that organized electricity supply requires a minimum standard of administration in terms of reliable output, collection of revenues, and macro-economic administrative continuity. Since the major source of electricity supply is imported diesel, tariffs take a severe beating when there is continuous and galloping devaluation.

SOUTH AFRICA

The Republic of South Africa covers an area of 1 220 000 km2 and has a population of about 45 million.

Water resources

The average annual precipitation is 497 mm, giving a total mean annual precipitation volume of about 600 km3, of which only 53.5 km3 is runoff (it is only considered practicable to exploit 33 km3 /year). Surface runoff is the dominant source of water.

The Department of Water Affairs and Forestry is responsible for water resources. Water management at regional level is being restructured, under the major cities implemented since the elections in 1994.

Existing major dams in South Africa have a capacity equivalent to 50 per cent of the total mean annual runoff. These control nearly all the runoff from tile interior plateau.

As of 31 March 1994 there were 3239 dams registered, of which 130 are classed as large, being more than 30 m high; another 762 are between 12 and 30 m high. Paris and Greater Ceres dams, 72 m and 61 m high, are under construction.

Phase IA of the Lesotho Highlands Water Project (LHWP) has recently been commissioned, and water transfer front Lesotho to Gauteng Province, South Africa, has begun. Phase IB is now under way and will provide a greater flow rate.

Another large water transfer scheme (about 35 m3 /s) will be needed following the completion of phase I. This could be Phase II of the LHWP, but other options exist.

The Department of Water Affairs and Forestry is well advanced with feasibility studies for further augmentation of water supply to the Vaal river catchment and replanning of the Orange river basin. Both plans could involve hydro plants.

Energy and power sectors

The main sources of energy in South Africa are: coal and coke (31 per cent), liquid fuels (30 per cent), electricity, (26 per cent) and biomass (14 per cent).

The main sources of electricity are: thermal (coal), 92.4 per cent; nuclear, 5.7 per cent and, hydro, including pumpedstorage, 1.9 per cent.

Eskom owns and operates most powerplants, although a small number are owned by municipal or private power producers. Per capita electricity consumption is about 4500 kWh/year. Eskom currently has 20 power stations, with a nominal capacity of 38 497 MW, which generated 184 500 GWh in 1996, about 98 per cent of the electricity requirements of the country. (Eskom is the fifth largest utility in the world in terms of its size and sales, and provides more than half of the electricity generated in Africa.) . It sells about 42 per cent of its electricity to local authorities, which resell it to end-users.

The Department of Mineral and Energy Affairs is in charge of resources, while the National Electricity Regulator is in charge of power. Regional bodies are being reorganized.

South Africa is a net exporter of power, exporting 5554 GWh in 1996 and importing just 29 GWh.

As part of the Reconstruction and Development Plan of the Government, Eskom has launched a drive to bring electricity to the whole population, including those in the rural areas.

The Southern African Power Pool (SAPP) has been established among southern Africa countries.

Eskom and EdM (of Mozambique) have recently completed reconstruction of the DC transmission line between the Cahora Bassa hydro plant in Mozambique and South Africa. The Cahora Bssa hydro station will soon provide 950 MW of base load capacity for South Africa. Eskom has ceded it's right to a futher to 500MW to ZESA of Zimbabwe until 2003, and for this purpose a new transmission line between Mozambique and Zimbabwe is being constructed.

Hydropower development
The hydropower potential of South Africa has not been comprehensive evaluated.

The total nominal capacity of all powerplants in South Africa is about 40 GW, which includes 667 MW of hydro capacity (including 61 MW of hydro capacity not owned by Eskom).

The generation from Eskom's hydro plants in 1996 was 491 GWh, of the total generation of 184 500 GWh. Hydro thus represented only 0.3 per cent of power production.

There is 1400 MW of pumped-storage generating capacity at two Eskom pumped-storage stations, Drakensberg (1000 MW) and Palmiet (400 MW).

Eskom and EdM may soon proceed the final feasibility study for Mepanda Uncua,, a 1600 to 2200 MW hydro project below Cahora Bassa on the Zambezi river in Mozambique. Studies are also already under way for new high voltage interconnections between South Africa and Maputo, the capital of Mozambique.

Small hydro
A number of decommissioned small hydro plants exist in South Africa and there is scope for upgrading these plants. However, there is no commitment to do so at present.

Future outlook
South Africa is continuing to undergo a major transformation process, following the elections in 1994. The whole of the country's administration is being restructured.

In view of the establishment of the SAPP, Eskom is starting to look more intensely at regional options for power projects.

Spain

Spain covers an area of 504 717 km2 and has a population of 39.4 million.

Water resources
The average annual precipitation is 670 mm. The total mean annual precipitation volume is 331 km3, of which 114 km3 is runoff. The regulated resources have a volume 45.5 km3.

Per capita domestic water consumption is 400 litres/person/day in urban areas and 270 litres/person/day in rural areas.

Spain has 1096 large dams in operation, and the total storage volume of all dams is 54.6 km3.

There are 10 dams more than 60 m high currently under construction, the largest of which are: Rialb (99 m high); Llosa del Cavalle (122.3 m); La Aguzadera (104.5 m); Itoiz (128 m); Rules (130 m high); and, Enciso (103.5 m).

Many more dams are planned, several of which would be more than 100 m high.

M.Lorenzo Pardo (157.7 m), for irrigation and hydro;

Brena (125 m), for irigation and hydro;

Torio (105.8 m), for irrigation and hydro; and,

Esera (100.5 m), for irrigation.

The Yesa dam (116.7 m), for irrigation, hydro and water supply, is to be refurbished.

The Ministerio de Medio Ambiente (Ministry of the Environment) is in charge of water resources. There are also basin authorities in charge of the water resources of each major river basin.

National regulations concerning environmental impact assessments have been adopted by the Government aimed at complying with EC Directive 85/337/EEC. They are the Legislative Royal Decree 1302/1986 on EIA and the Royal Decree 1131/1988. EIAs are required for large dams and, in addition, 14 region have more specific legislation for EIAs which include small hydro projects.

The main domestic civil contractors for dams and hydro projects include Dragados and Ccion.

Energy and power sectors
The sources of primary energy consumption in 1996 were: coal (15.2 per cent), oil (55.4 per cent), natural gas (8.3 per cent), hydropower (3.5 per cent), other renewables (3.1 per cent), and nuclear (14.5 per cent). Total primary energy consumption was 101 415 kTOE.

The main sources of electricity in 1996 were: coal (32.1 per cent, 3.4 per cent being imported), nuclear (34.5 per cent), hydro (23.1 per cent). Imported oil and gas (1.3 per cent), IPPs using wind, combined heat and power (8.4 per cent) and imports (0.6 per cent). Total electricity production was 163 279 GWh, about 5 per cent of which was generated using imported fuels.

Total electricity consumption was 156 245 GWh, representing per capita consumption of 4318 kWh/year. During 1996, 6750 GWh of electricity was imported and 5691 GWh was exported.

During the next 10 years, energy consumption is expected to increase by 2.5 per cent/year and electricity demand by 2.3 per cent/year.

The Ministerio de Industria y Energia is the national energy authority. There are 17 regional governments, each with a limited responsibility for energy and powers.

The 14 most important electricity utilities own and operated about 95 per cent of Spain's poweerplant capacity. Some of them are publicly owned, and others privately owned. A major process is now under way, and all the utilities will soon be privately owned, although the state will keep a minority share of the stock in some of them.

The National Energy Plan (1991-2000) encourages the use of natural gas and independent production through cogeneration, while maintaining the use of domestic coal and hydropower.

In November 1997, the Spanish Parliament issued a new regulation for the electricity sector. The new law distinguished between regulated activities (transmission and distribution) and free market activities(generation and supply).

Hydropower development

The gross theoretical hydropower potential in Spain is 138 000 GWh/year; and the technically feasible potential is 70 000 GWh/year (both calculated in 1980. The economically feasible potential was evaluated in 1991 to be 41 000 GWh/year. So far about 46 per cent of the technically feasible potential has been developed.

The installed capacity at all of Spain's powerplants is 46 241 MW, of which 16 533 MW is hydro capacity. These plants have an average annual generation of about 32 000 GWh/year (about 19 per cent of national electricity production), but the generation varies significantly in view of variation in precipitation. In 1996, hydro generation was much higher than average, being 40 272 GWh, 23.1 per cent of power production.

A further 300 MW of hydro capacity is planned.

Spain now has 5000 MW of capacity in operation at pumped-storage powerplants, but no more under construction or planned. Pumped-storage plants generated 1066 GWh in 1996 and consumed 1523 GWh.

Small hydro

Spain has 982 small, mini or micro hydro plants in opeartion, with a total capacity of 1413.7 MW. A further 70 MW is under construction and 25 GWh/year is planned.

To accomplish the targets of National Energy Plan for 1991-2000. It would be necessary to build 440 MW of capacity at mini hydro plants (up to 5 MW) during this period.

Sri Lanka

Sri Lanka has an area of 65 610 km2 and a population of about 18.4 million.

Water resources

The Ministry of Irrigation and the Water Resources Board are in charge of water resources. The Irrigation Department and the National Water Supply & Drainage Board control watter at regional level.

The total mean annual precipitation volume is 120 km3, with total runoff being 56 km3.

Energy and power sectors

The main sources of energy in 1995 were: biomass (49.8 per cent); hydropower (14.82 per cent); petroleum (34.44 per cent);

And, liquid petroleum gas (0.94 per cent).

The Ministry of Irrigation, Power & Energy is in charge of energy, while the Ceylon Electricity Board (CEB) is the national power authority. Lanka Electricity Co. (Ptv) Ltd is responsible for electricity distribution in some urban. All powerplants are publicly by the CEB.

Per capita electricity consumption is 2612 kWh/person/year total and 68.24 kWh/person/year domestic consumption.

Hydropower development

The gross theoretical hydropower potential of Sri Lanka is about 11 400 GWh/year. The remaining technically feasible potential is 8000 GWh/year (about 2000 MW), and the economically feasible potential is 7460 GWh/year. These data were evaluated in 1987. About 56 per cent of the technical feasible potential has been developed.

The total installed (rated) capacity of all powerplants in operation is 1385 MW, with the available capacity being 1359 MW. Of this, 1137 MW is hydro capacity (including 20 MW of small hydro). In 1995, hydro plants generated 4514 GWh, of the total of 4800 GWh, representing 94 per cent of power produced.

The 70 MW Kukule Ganga hydro project is planned. It is a run-of-river projects, which will have two 35 MW units. It is scheduled for commissioning in 2002.

Small hdyro

There are 74 small , mini and micro hydro plants in operation, with a total capacity of 23.3 MW. Agreement are being reached with private investors to develop 20 mini and micro plants with a total capacity of 46.2 MW.

It is estimate that there is potential for about further 430 such plants (about 200 MW, 940 Gwh/year), 400 of which would be micro plants(up to 100 kW).

Future outlook

There is currently a greater emphasis on the development of hydropower. However, the Upper Kotmate project (150 MW, 532 Gwh/year) has been stalled by extensive environmental lobbying, even though extensive measures have been incorporated to mitigate unfavorable influences on the environment.

High priority is being given by the Government to the development of Uma Oya hydro project (150 MW), which will included trans-basin diversion to provide water for irrigation requirements in the dry southeastern zone.

SUDAN

Sudan has an area of 2 506 000 km2 and has a population of about 30 million.

Water resources
The Ministry of Irrigation and Water Resources in charge of water resource. Four large are in operation.

The two largest dams are the Roseires and Sennar dams on the Blue Nile, which are multipurpose structure. The height of Roseires dam has recently been increased by 10 m, to provide a large increase in total storage capacity, and to allow for an increase in hydro generation of up to 50 per cent. Two 194 km-long irrigation canals, to irrigate 36 000 km2, were include in this project.

Sennar dam has also recently been rehabilitated, as part of a programme to rehabilitate the Gezira irrigation scheme. Work included refurbishment of the sluiceways and installation of additional isolating gates. The two irrigation channels are soon to be refurbished.

Energy and power sectors
The Ministry of Energy and Mines is in charge of the energy sector.

There is about 240 MW of hydro capacity in operation, of a total powerplant capacity of about 630 MW, which includes an estimated 100 MW of privately owned generation capacity at small diesel units.

The National Electric Corporation (NEC) owns and operates 475 MW of the total capacity, including the 240 MW hydro capacity.

Hydropower supplies about 71 per cent of power production.

Hydropower development
The largest hydro plants are: Roseires (210 MW) and Sennar (15 MW), which are on the Blue Nile; and, Kashm el Girba (13 MW) on the Atbara river. Taking into account irrigation requirements and maintenance, the reliable capacity is about 87 per cent of the total.

The hydro plants generated 945 GWh in 1995, 71 per cent of total power production.

Various studies have confirmed the economic feasibility of upgrading the Roseires and Sennar plants (by about 40 MW and 30 MW respectively), and construction of the following run-of-river projects:

Malakal (one or two 10 MW plants); and,
Atbara Rumela (30 MW).
A major new project, Merowe, at the fourth cataract on the Nile, 20 km upstream from Merowe in Northern Dafur province, has been studied. It could provide a hydro capacity of 600 to 1240 MW.

Future outlook
Sudan needs to implement new hydro projects to overcome energy shortages and to reduce dependence on imported oil. Integrated Nile Basin development would allow for better use of the water resources of the Nile, increasing, electricity production.

An interconnected grid, involving hydro plants in the Upper Nile basin and the Egyptian grid could solve problems of instability and insufficient capacity.

SWAZILAND

The Kingdom of Swaziland covers an area of 17 360 km2 and has a population of about 966 000.

Water resources

Average annual precipitation is 1200 mm in the west and 400 mm in the east. Total mean annual precipitation is 14 km3, of which an estimated 12 per cent is runoff. There are six large dams in operation.

Per capita water consumption for domestic use is 75 m3/year in urban areas and 15 m3/year in rural areas.

The Ministry of Natural Resources and Energy is in charge of the country's water resources.

Energy and power sectors

The Ministry of Natural Resources and Energy is the national energy authority. The Swaziland Electricity Board (SEB) is the national power authority.

SEB owns almost all of the powerplants. There are also five private plants: three sugar mills and one pulp mill, which burn biomass, and a mine which burns coal.

The main sources of energy are biomass (63 per cent), petroleum (19 per cent), coal (16 per cent) and hydropower (3 per cent).

The main source of electricity is coal-based imports (57 per cent). However, hydro generation contributes almost all of SEB's power generation.

The country imported 599 GWh from Eskom in South Africa in the year to March 1996.

Per capita electricity consumption is about 1000 kWh/year.

Hydropower development

Swaziland has a gross theoretical hydropower potential of 3800 GWh/YEAR. The technically feasible potential is estimated to be 560 GWh/year, of which 300 GWh/year is economically feasible. These data were evaluated in 1992. About 33 per cent of the technically feasible potential has so far been exploited.

There is 122 MW of installed capacity at all of Swaziland's powerplants, of which 43 MW is hydro capacity.

The existing hydro plants can generate 135 GWh/year even during a prolonged dry period. Hydro generation in the year to March 1996 from SEB's 40.5 MW of hydro capacity was 196.8 GWh, 99.6 per cent of its electricity production.

Small hydro

There are five small mini or micro plants in operation, with a total capacity of 9.1 MW. A further 0.3 MW of hydro capacity is under construction, and a 15 MW plant is planned. This is the Maguga project, currently at the study stage, which would also be a river control and irrigation scheme.

Future outlook

Upstream abstractions and long-term drought conditions mean that hydro generation is now less favorable than in the 1970s, when the existing schemes were built or studied. There is, however, scope for additional dams to be built for river control and irrigation.

Deforestation and increasing land use pressure pose sedimentation risks to reservoirs.

Since the late 1970s the runoff has decrease significantly, and it is unlikely that any other hydro schemes will be studied until the regional hydrology has been reassessed.

Sweden

Sweden has an area of 449 964 km2 and a population of 8.82 million.

Water resources
The national authority in charge of water resources in Sweden is the SMHI.

There are 190 large dams in operation.

Per capita water consumption is 150 m3/person/year.

Energy and power sectors
The National board for Industrial and Technical Development (NUTEK) is Sweden's national energy authority.

The main sources of energy are: oil (42 per cent), coal (6 per cent), electricity (32 per cent), biofuels (17 per cent), and others (4 per cent).

Electricity production in 1996 was from: hydro (37.5 per cent), nuclear (52.5 per cent), thermal plants (9.9 per cent) and wind (0.1 per cent). About 4.3 per cent of the generation was from imported fuels.

The total electricity consumption in 1996 was 142 100 GWh, representing per capita consumption of 16 000 kWh/year. During 1996, 15900 GWH of electricity was imported and 9800 GWh was exported.

The state currently owns 50 per cent of powerplant capacity. Municipalities own 23 per cent; foreign organizations, 13 per cent; private owners, 7 per cent; and, other companies, 7 per cent.

Hydropower development
The gross theoretical hydropower potential of Sweden is 200 000 GWh/year (1995), of which 130 000 GWh/year is technically feasible and 90 000 GWh is economically feasible. About 50 per cent of the technically feasible potential has been developed so far.

Of the 34 133 MW of installed capacity at Sweden's powerplants, 16 178 MW is hydro capacity. Hydro plants generate on average about 63 000 GWh/year (47 per cent of national power production), although in 1996 they generated only 51 000 GWh.

There is 425 MW of pumped-storage capacity.

There are about 600 small hydro schemes (up to 1.5 MW capacity)in operation, with a total capacity of about 250 MW. A further 40 MW (200 GWh/year) is planned.

Future outlook
The development of new hydro plants has almost ceased for political and environmental reasons. The main activity in the coming years will be the refurbishment and modernization of existing plants.

Switzerland

Switzerland has an area of 41 293 km2 and a population of 7.08 million.

Water resources
The total mean annual precipitation volume is 60.1 km3, of which 53.5 km3 is runoff (40.4 km3 excluding water inflow from neighboring countries)

The Swiss Federal Office for Water Management is in charge of Switzerland's water resources.

There are 157 large dams in operation , according to ICOLD's definition. The total water storage capacity of all the reservoirs is 3.4 km3.

Per capita total water consumption is 155 m3/person/year.

The Luzzone arch dam has recently been heightened by 17 m to 225, Omcreasomg the reservoir caacotu frp, 87 to 108 106M3.The powerplant will be completed during 1998.

Energy and power sectors
The main sources of energy in 1996 were: oil (60.7 per cent); electricity (21.3 per cent); gas (12.5 per cent)/wood (2.2 per cent); and , coal (0.7 per cent)

The main sources of power were: hydro (53.9 per cent including pumped storage plants); nuclear (43 per cent); and, fossil fuels (3.1 per cent).

The national energy authority is the Swiss Federal Energy Office. It is also in charge of power, together with the Swiss Federal Office for Water Management.

Deregulation is envisaged, sometime after 1999. The establishment of a so-called Electricity Market Law is currently under public consultation It is envisaged that the deregulated market would involve regulated third party access.

About 25 per cent of hydro plants are privately owned in terms of generation.

Per capita total electricity consumption in 1995 was 7282 kWh/year.

Hydropower development
The gross theoretical hydropower potential of Switzerland is 144 000 GWh/year (evaluated in 1939). The technically feasible potential is 41.000 GWh/year and the economically feasible potential is 37 000 GWh/year (evaluated in 1987).

The installed capacity of powerplants of all types in Switzerland is 11 889 MW, of which 10 118 is hydro capacity. Hydro plants generate on average 32 209 GWh/year, and produced 29 698 GWh in 1996 (including pumped –storage).

A further 1339 MW of hydro capacity is under construction at: the 1200 MW Bieudron plant (1998); the 120 MW Amsteg plant (1998); and the Ruppoldingen run-of –river plant (19 MW, 2001).

Three run-of –river hydro plants are being upgraded: Birsfelden(from 85.2 to 97.4 MW by the installation of a nee turbine), for completion in 1999; Bannwil (24.2to 27 MW, by the installation of a new turbine). 2000; and, Goesgen (42 to 45 MW, through the construction of a new powerhouse), 2000.

The following hydro plants are planned: Hydro Rhone (166 MW at 10 run-of –river plants),Rheinfelden (116 MW),and Ritom (105 MW, including 40 MW of pumping capacity).

Three is 1771 MW of pumped-storage capacity in operation (1640 GWh/year on average),but none under construction

Two pumped storage plants are planned in addition to Ritom: Grimsel west (935 MwwwwW) and Brusio(139 MW).The Grimsel West project would include a 214 m-high arch dam.

Small hydro

It is estimated that there are about 1000 small, mini and micro hydro plants (up to 10 MW)in operation, with a total capacity of 737 MW. More are planned

Future outlook

Many power distribution companies are studying the influence of the liberalization of the European electricity market on their own structures. There is an oversupply of electrical energy at low prices in Europe at present, and so no decision can be taken in the short or medium term concerning future developments.

Tadjikistan

Tadjikistan covers 143 100 km2 and a population of about 6.2 million. The total average precipitation volume is 51.7 km3. There are 17 large dams in operation.

Energy and power sectors

The authorities in Tadjikistan responsible for power include the Scientific Research Institute on Hydrotechnics and Irrigation, the Institute for design of Water enterprises and Hdroenergoproyekt Design, Research and Scientific Institute.

The total electricity production is about 17 TWh/year (about 3000 kWh/year per capita). The main energy sources is hydro.

Hydropower development

The gross theoretical hydro potential is 527 000 GWh/year, representing about 60 200 MW of capacity. About half of this is economically feasible. The technically feasible hydro potential of the main river basins was given in the 1997 World Atlas.

The major hydropower plants in operation, under construction and planned were listed in a table in the 1997 world Atlas. There is 4054 MW of hydro of capacity in operation, about 4600 MW under construction, about 11 800 MW planned. Hydro plants generated 16 120 GWh in 1996, about 96 per cent of power production.

The owner of all powerplants in Tadjikistan, including substations, power lines and grids, is the Barki-Tadjik Stat Joint-Stock Power company.

The privatization of the energy sector is now beginning. So far only a few hydro plants which are not connected to the grid are privately owned.

The main priority in the energy sectors is further hydropower development.

Small hydro

A total of 69 small hydro plants (with a total capacity of 32 MW) were built between 1940 and 1978. Interest in small scale plants then declined and most of these plants decommissioned, leaving only five in operation(with a total capacity of 13.87 MW), all in the mountainous Badahsan Independence region of Pamir.

Four new small plants were under construction in 1996: Ziddi (500 kW); Teharv (360 kW); Anderoag (230 kW); and Pasthuff (500 kW). Two others are planned: Sirkent 2 (100 kW) and Yazgulem(2 MW).

A plan for further development of small hydro plants, envisaging the construction of 179 plants, has been drawn up: 51 in the range of 100 to 500 kW; 67 in the range of 500 to 1000 kW; 55 in the range of 1 to 3 MW; and, six of more than 3 Mw. It is proposed that all these plants can be constructed using standardized equipment, involving four types of Pelton turbines and three types of reaction turbines.

Future outlook

The basic priority of further hydropower development arises from: the large unexploded hydro resources and lack of fossil fuel resources; and, the increasing demand of electricity.

A fundamental criterion for developing the country's water resources will be the adoption of a complementary approach involving hydropower and irrigation, and the aim will be to exploit the rivers fully.

These considerations determine that future water projects will involve: large hydropower dams providing for energy production as well as irrigation; large and medium-sized hydro plants which will operate as part of a common system and convert the energy potential of the rivers into useful power in the most beneficial way; and, small and medium-sized hydro plants on the smaller rivers to meet the needs of individual consumers.

TANZANIA

Tanzania has an area of 945 234 km2 and a population of about 28.7 million.

Water resources
The National Urban Water Authority (NUWA) is in charge of water resources. There are plans to deregulate the sector within the next three years.

There are currently three large dams in operation, according to ICOLD's definition. A 25 m-high dam is under construction for the Kihansi hydro project.

Energy and power sectors
The main sources of primary energy in 1996 were: biomass (92 per cent), fossil fuels (7 per cent) and hydropower (1 per cent). The total primary energy consumption was 16 million TOF.

The main sources of electricity production were: hydro (90 per cent) and imported oil/gas (10 per cent). During 1996, 34 GWh of electricity was imported.

Total electricity consumption was 1820 GWh, representing per capita consumption of 65 kWh/year. Energy consumption is expected to increase by 4 per cent/year during the next decade, while electricity demand is expected to increase by 9 per cent/year.

The Ministry of Water, Energy and Minerals is in charge of energy, while TANESCO is the national power authority, which owns and operates all the country's hydro plants and 85 per cent of all powerplan capacity.

As part of deregulation, TANESCO is in tile process of being privatized within the next two years. The deregulated market will involve separated generation, transmission and distribution. The electricity market is based on a single buyer, where the main operator signs as PPA with the generators.

Total electricity production at TANESCO plants in 1996 was 2003.2 GWh, and 19 GWh was imported.

Two private organizations, SONGAS and Independent Power (T) Ltd, are to begin commercial operation during 1998.

All power projects are subject to an environmental impact assessment. The National Environmental Management Coucil is the main regulatory body.

Hydropower development
The gross theoretical hydropower potential of Tanzania is 190 000 GWh/year, and the technically feasible potential is 20 000 GWh/year (both evaluated in 1985).

The economically feasible potential is 1789 GWh/year, reevaluated in 1995, of which 85 per cent has been developed.

The total installed capacity of all powerplants in operation is 590 MW, of which hydropower capacity is 378 MW. One hydro plant (8 MW) is part of a multipurpose scheme. The generation from hydropower plants in 1996 was 1747 GWh.

A further 180 MW of hydro capacity is under construction at the Lower Kihansi project (three units), which is due for completion in 1999. It is a run-of-river plant with a small dam for daily regulation. It will cost US$ 250 million, representing US$ 1389/kW.

A number of other potential sites have been identified, although projects are not definitely planned: Rumakali (204 MW); Ruhudji (250 MW); Masigira (80 MW); Mpanga(160 MW); Stiglers Gorge

(1400 MW); Rusumo Falls (180 MW); and, Upper Kihansi (40 MW).

Small hydro
There are two small hydro plants in operation in Tanzania, with a total capacity of 8.74 MW. None is currently under construction or planned.1

Future outlook
Following the recent move by the Government of Tanzania to privatize public companies, including the electricity utility TANESCO, in an effort to increase efficiency, the role of power supply will mostly be in the hands of the private sector.

The higher initial investment costs of hydro projects and longer pay-back periods means that it is likely that hydropower projects will be less favorable than thermal projects.

Thailand

Thailand has an area of 513 115 km2 and a population of 60.3 million.

Water resources
The annual average precipitation is 1560 mm, and the total mean annual precipitation volume is 800 km3, of which 199 km3 is runoff.

There are 21 large dams in operation. The total water storage of all the country's reservoirs ois 51.5 km3.

Energy and power sectors
The main sources of electricity production in 1995 were: natural gas (34 per cnet), bunker oil (20 per cent), lingnite (18 per cent), hydro (8 per cent), diesel oil (3 per cent) and imorts (7 per cnet).

The department of Energy Development and Promotion (DEDP) is in charge of energy, while the Electricity generating Authority of Thailand (EGAT) is the national power authority. There are also power authority for metropolitan and provincial Electriicty Authority, respectively EGAT owns and operates all powerplants for the Government.

Hydropower development
The technically feasible hydropower potential of Thailand is 18 885 GWh/yeat, and the economically feasible potential is about 18 033 GWh/year.

The total installed capacity of all powerplants is about 1400 MW, of which 2909 MW is hydro capacity. The generation from hydro plants in 1996 was 7341 GWh.

The hydro capacity which is under construction and planned in Thailand is all at pumped-storage powerplants.

Thailand has 528 MW of pumped-storage capacity in operation, a further 1000 MW under construction, and 1460 MW planned. Pure hydro and pumped-storage together supply 20 per cent fo Thailand power production.

The pumped-storage plant under construction is Lam Ta Khong, with four 250 MW units which will be housed in an underground power cavern, and a rated head of 357 m. It is being implemented by EGAT. The upper pond will have a 50 m-high asphalt-faced dam, with an embankment volume of 5.34×106m3, and a reservoir capacity of 9.9×106m3. The lower reservoir is formed by an existing irrigation dam named Lam Ta Khong. Two units are scheduled to be commissioned in 2000, and the other two by 2002.

Two pumped-storage plants are now at the feasible study stage:

Khiritharn (three 220 MW units0, planned for completion in January 2005; and,

Chulabhorn (four 200 MW units), planned for completion in 2007.

Small hydro
There are 19 small, mini or micro plants in operation, with a capacity of 42.17 MW. Another two are under construction, with a total caacity of 11.28 MW. The largest of these is Klowg Thung Phen small hydro project, which incldues a rockfill dam, 46.4 m high, will have an installed capacity of 9.8 MW from two units.

Future outlook
As a result environmental concerns, it is difficult at present to develop conventional hydro projects in Thailand. Projects in the country's Power Development Plan are therefore mainly thermal and pumped-storage plant.

Tonga

The Kingkom of Tonga is situated 2, 000 miles northeast of Sydney of Australia, comprising of three major islands-Vavau, Haapai and Tongatopu. The whole country covers a land area of 697 sq.km, and has a population of about 110,000(1996 statistics).

Tonga has long been using diesel-electric set to generate electricity. The rising of oil prices makes the Tongan government begin to study the development of renewable resources and explore the possibility of utilizing local of this generation works as follow: first let the momentum of marine currents bring sea water into a small reservoir, then install at the other side of reservoir turbine generators to generate electricity with ultra-low head. It has no essential difference with the customary means of SHP generation. The only different is that SHP plant generate electricity with natural runoff while wave power generation utilizes the momentum of marine currents. Both fill reservoir first, then generate electricity through generator unit.

In additional to the wave generation, Tonga is also considering making use of the technology of tidal generation introduced from Norway & Japan to relax the tension of diesel generation. Two Norwegian corporations-Nowwave and Kvaerner have been negotiating with the Tongan government on the construction of a pilot wave power plant in Tonga. And Japanese government is also seeking some cooperation projects. The crux of the matter is the technical level of marine energy development which requires the cost of wave generation lower than of diesel generation (35 cents/kWh). Study shows it is workable. So a pilot wave power plant with a 1,000 kW installed capacity is designed to alleviate 25% of the peak load of the national grid. Officials of energy program of the Tongan government believe that this ultra-low head marine wave generation has great significance in promoting Tonga's economic development, for Tonga's import volume of oil for generation has surpassed the total volume of export, and it is probably the best substitute energy for some small islands.

At present, the SHP development of Tonga is in the stage of feasibility study. The main SHP resources are in the island of Eua. The highest mountain in the islands is 1,017 feet above to sea level. It is intended to build a pilot SHP plant to accumulate experience for the construction of the other SHP hydropower plants.

TUNISIA

Tunisia covers 167 000 km2 and has a population of 8.96 million.

Water resources

The total mean annual precipitation is 30 km3, with a total runoff of 4 km3. The exploitable water resources are estimated as 2.7 km3 of surface water and 1.94 km3 of groundwater.

There are currently 17 large dams in operation. The Sidi El Barruk rockfill dam, which is 25 m high, and the 70 m-high Barbara rockfill dam are now being completed. The former dam has been built for irrigation and drinking water supply, while Barbara dam is for irrigation, drinking water supply, and hydropower (a 300 MW pumped-storage plant is planned).

Several other dams are planned: Khanguet Zezia, which would leave a 650 kW mini hydro plant; Oued Rmel; Oued El Abid; Oued Zergua; and, Sfisifa.

Societe Nationale d'Exploitation et de Distribution des Eaux (SONEDE) and the Ministry of Agriculture are responsible for water resources management SONEDE is responsible for water supply to villages of more than 300 inhabitants and for industrial supply in urban areas, while Genie Rural is responsible for smaller villages and industrial uses in less populated areas.

The Ministry of Agriculture is responsible for irrigation, barrages and wells (hand-dug and drilled). For hydropower use, surface water is controlled by the Ministry of Agriculture (Civil Works), and power development is controlled by the Ministere de l'Economie Nationale (MNE) via Societe Tunisienne de l'Electricite et du Gaz (STEG). Equipment design and construction are co-ordinated between the two ministries.

For large water resource projects, the Ministry of Equipment, via ONAS, builds and develops facilities such as waste treatment plants, while the Ministry of Agriculture, via the Director de Grands Travaux, covers projects such as large reservoirs. Co-ordination with the Ministry of Agriculture is carry out at all levels.

Environmental impact assessment is under the supervision of Ministere de l'Environnement et de l'Amenagement du Territoire. For each project, depending on its size, environmental impacts have to be studied prior to project execution.

Energy and power sectors

The MNE's Direction Generale de l'Energie is responsible for energy. The national power authority is STEG, which has the authority to generate, transmit and distribute power. STEG covers four regional Districts. All powerplants are publicly owned and operated by STEG.

The main sources of primary energy in 1996 were: oil (72 per cent); natural gas (27 per cent), hydropower(0.5 per cent); and, others (0.5 per cent). Total primary energy consumption was 5593 kTOE.

The main sources of electricity in 1996 were: natural gas (93.8 per cent); heavy fuels (5.7 per cent); and, geothermal, hydro and others (0.5 per cent).

Total electricity consumption in 1996 was 6906 GWh, with per capita electricity consumption is 744 kWh/person/year.

Energy consumption is expected to increase by 6 per cent/year on average over the next 10 years, and electricity demand is expected to increase by 6.5 per cent/year.

Hydropower development

Tunisia's gross theoretical hydro potential is 1000 GWh/year; the technically feasible potential is 250 GWh/year; and, the economically feasible potential is 160 GWh/year (all estimated in 1993).

Tunisia has 1700 MW of capacity at all its powerplants, of which 64.3 MW is hydro. Hydro generated 64 GWh in 1996, but 100 GWh/year on average.

STEG is involved in the planning of the 300 MW Barbara pumped-storage which would involve three units operating under a 400 m head, using the storage created by the recently built Barbara dam.

Small hydro

There are three small, mini or micro plants in operating, with a total capacity of 2.25 MW.

Two 1 MW small hydro plants should be commissioned during 1998.

There is also a programme under development which includes nine small and mini plants, with a total capacity of about 10 MW (60 GWh/year).

Planned small and mini hydro plants include: Barbara (3 MW), Sidi Saad (1750 kW), Siliana (850 kW), Bejaoua (750 kW), Medjez el Bab (250 kW), Nebhana (500 kW), Sejnane (1 MW), Bouhertma (1.2 MW) and Khanguet Zezia (650 kW).

Future outlook

STEG continues to plan, develop and manage all sources of renewable energy. For example, an advanced 10 MW wind project at Hawaria in northeast Tunisia, will be commissioned during 1998, as well as two small hydro plants of capacity 1 MW each.

In future STEG intends to integrate a hydro plant where possible at each dam it Studies.

In view of the load demand conditions, STEG is continuing to survey several sites for pumped storage, with capacities of 300 to 500 MW. The most interesting site is Barbara. However, a seawater pumped-storage project, Korbous. 40 km from Tunis has also been identified.

Development of future steam and gas-fired powerplants will be carried out exclusively by IPPs. However, between 1998 and 2001, STEG will install five 100 MW gas turbines.

During 1998, companies have been invited to bid for construction of the power transmission interconnection between Tunisia and Libya, which will involve a 640 km-long, 225 kV AC transmission line.

A possible interconnection between Tunisia and Italy, through Hawaria by submarine cable is at the feasibility study stage. This interconnection between Africa and Europe would complement interconnection between Morocco and Spain.

Turkey

Turkey has an area of 799 500 km2and a population of 63.4 million.

Water resources
The total means annual precipitation volume is 501 km3, of which 186.05 km3 is runoff.

The General Directorate of State hydraulic Works (DSI) is in charge of water resources: it has 26 regional Directorates.

The total number of large dams in operation, higher than 15 m, is 461. The total storage volume of all dams in Turkey is 111.8 km3. There are 207 large dams under construction. The largest ones include Topcam (122 m high), Dim Dim (135 m), Kigi (168 m)and Atasu (118m), in addtion to those listed in Table 1. Some of the most important dams planned are given in Table 2. Hydropower is an integrated function at many of Turkey's water resources development projects.

Per capita water consumption is 540 m3/person/year total and 85 m3/person/year for domestic consumption.

The ministry of Environment ids responsible for environmental issues and is the co-ordinating body for energy projects. The 1993 Regulation on Environmental Impact Assessment requests an EIA for new investments. Including powerplants which will have a reservoir capacity of more than 0.1 km3.

The main domestic civil contractors for dams and hydro projects include AATA. ERG, Kiska, Dogus , Limak, Gris, MNG, Nurol. Ozzaltin. Gunsayin, Aaydincr, Yucelen, Gama and Yuksel.

Energy and power sectors
The main sources of primary energy in 1996 were lignite (40.5 per cent); wood (20.5 per cent); oil (13.7 per cent); hard coal (5.1 per cent); hydropower (12.9 per cent); and others . sucfh as asphalt, natural gas , ge4othermal and solar (1.6 per cent). The total primary energy consumption was 68.04 MTOE.

The main sources of electricity production in 1996 were: hard coal (3 per cent); hydro 943 per cent); lignite (29 per cent); oil (7 per cent);and, natural gas and geothermal (18 per cent). The thermal sources were hard coal (43 per cent); lignite4 (30 per cent); oil (7 per cent); and, natural gas and geothermal (19 per cent). The total electricity consumption was 94 789 GWh, representing per capita consumption of 1161 kWh/year.

Energy consumption is expected to increase by 10 per cent/year during the next decade, and electricity demand by 7 per cent/year.

During 1996, 270 Gwh of electricity was imported and 343 Gwh was exported.

The ministry of Energy and Natural Resources is in charge of energy and power. The Turkish Electricity Authority (TEK) owns most plants, and is divided into regional organizations. There are also various private companies, such as KEPEZ and CEAS. TEK is organized as two separate corporations: the Turkish Electricity Generation –Transmission Corp (TTEAASs) and the Turkish electricity Distribution Corp 9TTEDAS). Thus, TEAS instead of TEK is now responsible for administering hydropower plants.

Studies on various organizational changes relating to the construction and operation of powerplants and the transmission and distribution of electricity are still being carried out.

Approximately 8.5 per cent of powerplant capacity is privately owned, and 6.9 per cent of hydro capacity. To attract private sector investment in hydropower projects, BOOOOOOT models and TOOR (transfer of operating rights) models are being developed.

At present, about 7 per cent of hydro plant capacity and 3.3 per cent of total powerplant capacity are privately owned.

Hydropower development

The gross theoretical hydropower potential of Turkey is 433 000 GWh/year and the technically feasible potential is 215 000 GWh/year. The economically feasible potential has been re-evaluated in 1997 as 123 385 GWh/year, equivalent to 34 862 MW. So far, about 17 per cent of the technically feasible potential has been developed. It is planned that by 2010, 60 per cent of the economically feasible hydropower potential will be developed and the installed capacity will reach 22 509 MW.

The total installed capacity of all thermal and hydro plants is 21 247 MW. There is about 10 108 MW of hydro capacity in operation, generating on average 36 866 GWh/year. Actual generation in 1996 was 40 475 GWh.

It is estimated that the hydro potential in operation could be uprated by tetween 10 and 15 per cent. About 57 of the 493 hydro projects are part of multipurpose schems.

A further 3938 MW of hydro capacity is under construction, and 19 433 MW is planned for the next 10 years.

The largest hydro plants under construction include: Birecik (672 MW), Deriner (670 MW), Berke (510 MW), Obruk (203 MW), Batman(198 MW), Karkamis *189 MW), Ozluce(170 MW) and Alpaslan (160 MW).

The mean cost per kW of the hydro capacity under construction is US$ 1350 /kW (excluding transmission costs).

The Southeast Anatolia Project (GAP), a large water resources development project involving 22 dams, 19 hydro plants (7474 MW, 27 TWh/year), which will provide irrigarion for agricultural production over an area of 1.7 ha in the region, is important for the sustainable development for the whole of Turkey. So far, about 60 per cent of the hydro capacity is in operation, including the Keban (1330 MW), Karakaya (1800 MW)and Ataturk(2400 MW) plants, and 15 per cent is under construction, which includes Birecik and Karkamis.

About 40 per cent of the total US$ 32 billion cost of the GAP has been expended so far.

Small hydro there are 57 small, mini or micro hydro plants in operation, with a total capacity of 126.5 MW. Two plants are under construction (3.6 MW) and 98 are planned (493 MW). It is planned that many of the small plants plants will be implement as BOT projects.

Future outlook

According to the result of the Long Term Generation Expansion Plan study of 1994 carried out by TEAS, the first priority is the development of Turkey's domestic renewable resources, such as hydropower, maintaining the least cost solution during 1997 to 2020. Considering an demand increase in electricity demand of 8 to 10 per cent/year, demand is forecast to increase to 347 GWh in 2010 and to 623 800 GWh in 2020. The country's installed capacity must be expanded rapidly to meet these requirements.

It will be difficult to meet the high investment costs for new hydro projects, especially or those with large dams, form Government sources will be important, in parallel with the programme of Liberalization implement by the Government, and to facilitate investment in the most important sectors, a new financial model is being introduced for the privatization of the electricity sector.

A BOT model is being developed for the construction of large scale projects with the participation of the private sector, allowing for local and foreign private enterprise to take part in the power sector. The relevant law is No. 3096.

In addition to those hydro plants being implement by DSI and those to be carried out within the framework of the BOT model, some large-scale hydro projects will be carried out with foreign partners under turnkey processes. Bilaterial co-operation between Turkish and some foreign governments has high-lighted some projects for turnkey implementation.

UGANDA

Uganda covers an area of 236 860 km2 and has a population of about 20 million.

Energy and power sectors

The energy sector is under the control of the Ministry of Natural Resources. The Uganda Electricity Board (UEB) is the sole organization responsible for power generation, transmission, distribution and marketing, it reports to the above Ministry through a permanent secretary. The Board of Directors of UEB is responsible for policy formulation, and any other organization seeking to enter the power business in Uganda must seek UEB's permission.

Other energy related functions come under the Ministry's Directorate of Energy and Minerals.

Uganda has no known reserves of coal or petroleum. Petroleum exploration surveying in the west of the country began in 1995.

Energy consumption in Uganda is now beginning to increase again after a decline between 1970 and 1990, resulting from the country's political instability.

The main source of energy is traditional wood fuel (70 per cent), with imported petroleum products and electricity making up the remaining 30 per cent. Only about 6 per cent of the country's population are consumers of electricity.

Of a total powerplant capacity of 190 MW, 186 MW is hydro capacity, the other 4 MW being six thermal (diesel) stations which supply remote administrative centres.

Power demand currently exceeds generation in Uganda (estimated to be 228 MW and increasing at 2 per cent per month), necessitating load-shedding during peak demand periods (especially evenings) as a result of the high proportion of domestic demand.

hydropower development

Uganda's future power development is based on making use of the country's available hydropower potential, estimated to be

More than 200 MW, with firm annual generation 12 500 GWh/year (excluding the abundant mini and micro hydro potential).

A national Energy Mater Plan Study is soon to be completed, which will establish all the hydro potential sites in the country. Most potential is on the River Nile.

Only 186 MW of this hydro potential has so far been developed. Most of this is at Owen Falls (180 MW) on the River Nile. There are also three small and mini plants. Hydropower thus supplies 98 per cent of power production in Uganda. The hydro generation in 1996 was 985 GWh.

Owen Falls is the only major powerplant in the country. Its ten 15 MW units were recently uprated to 18 MW each through modernization of the generators. However, the uprating has led to accelerated cavitation damage. A project is now under way to construct an extension to the existing station, with a caacity of 200 MW.

The Government of Uganda and Nile Independent Power (an enterprise of the Madhvani Group of Uganda with AES Electric Ltd, a subsidiary of AES Corp of the USA), recently reached an agreement to develop the 290 MW Bujagali hydro plant, downstream of the Owen Falls plant on the River Nile. Construction is scheduled to be completed by 2001, and it is expected that this scheme will meet power demands until about 2009.

With the extension of Owen Falls, scheduled to be completed during 1998, a transmission line has been constructed to supply power to northwest Tanzania. At present 5 MW is exported, and this is expected to be increased to 15 MW.

A deficit in power supply is thus likely to continue until full commissioning of the Owen falls extension project.

To assist in the development of new capacity, two memoranda of understanding have been signed with independent power producers, and more investors are being, encouraged to join the market. One of these agreements is to develop the 290 MW Bujagali plant on the River Nile.

Small hydro
There has been very little development of small, mini or micro hydro in Uganda to date. Only about 8 MW has been developed at four sites, of a total 46 MW of potential identified it 16 sites.

Two of the schemes have been implemented by UEB and two by private developers. They are: Mubuku II (5 MW); Maziba I (1 MW), Kisizi (0.075 NIW); and, the 1.25 MW Kikagati plant which has now been decommissioned.

Other are at various stages of planning, including: Muzizi(10 MW), Paidha (7.5 MW), and Ishasha (4.5 MW).

There are also many possible sites for micro hydro plants, but external funding agencies have considered these too small or uneconomic to develop. UEB is now aiming to identify the available micro hydro potential, with a view to obtaining external help to develop Uganda's equipment manufacturing capacity.

UKRAINE

The Ukraine covers 60 370 km2 and has a population of 51.9 million.

Water resources

The average annual precipitation is 625 mm, and the total aver-age annual precipitation is 377 km3, of which 87.1 km3 is runoff.

There are nine large dams in operation. according to ICOLD,s dams is 48.3km3.

Per capita water consumption is 700 m3/person/year in total

The State Committee for Water Management is responsible for water resources; and there are 25 regional authorities

Energy and power sectors

The main sources of energy in 1995 in the Ukraine were: fossil fuels (about 60 per cent);nuclear energy (about 35 per cent); and , hydropower (about 5 per cent)

The main sources of electricity were thermal plants (65.1 per cent); nuclear plants (26 per cent); and , hydropower (8.9 per cent including pumped –storage plants)

The Ministry of Energy is in charge of the energy sector, while the national power authority is the National Dispoatch Centre of Electrical Energy; there are also eight local energy management organizations .The state owns and operates almost all poowerplants ,and hydro plants currently come under either the Ministry of Energy or the Ministry of Agriculture , although a small number are owned by other organizations . However the power industry is now being transferred to a free market system Several public power companies, power associations and incorporated power producers have recently been formed

Per capita power consumption is 3650 kwh/year.

Hydropower development

The gross theoretical hydropower potential of the Ukraine was estimated during the 1970s to be 45 000 GWh/year. During the 1980s .the technically feasible potential was estimated to be between 22 000 and 25 000 GWh/year. More recent estimates between 22 000 and 25 000 GWh/year More recent estimates in the 1990s calculated the economically feasible potential to be 18 000 to 20 000 GWh/year. About 50 per cent of the technically feasible potential has been developed

The installed capacity at all powerplants is 53 120 MW. Of which 4465 MW is hydro capacity . A further 55 MW of hydro capacity jis under construction and 56 MW is planned. The average annual generation of hydro plants in operation is 10 800 GWh/year (8.7 per cent of the total power production)

The Ukraine has 235 Mk of pumped –storage capacity in operation and a further 2730 MW under construction

The estimated potential for uprating existing hydro capacity is about 300 MW.

The following projects are under construction:

Dniester hydro plant (940.8 MW). Its three units will operate under a head of 13.1 m. Completion is scheduled for 1998.

Dniester pumped-storage plant (seven units, with a design head of 159.4 m). The installed capacity will be 2268 MW in the turbining mode and 2856 MW in the pumping mode. This plant has been under construction since 1988.

Alexandrovka hydropower plant, on the South Bug river. The two units, operating under a maximum head of 20.6, will provide 14.3 MW of installed capacity. The plant is due to be completed in 1998.
There are also several projects planned:

Rehabilitation of the six hydro plants in the Dnieper cascade, which includes a pumped-storage station. This projects is scheduled to be completed in 2010.
Hydropower plants Nos. 11 and 12 on the Tisa river. These will each have a capacity of 2×14 MW and a maximum head of 13.6 m. The project are currently at the design stage and work is scheduled to begin in 2000.
Small hydro
Small hydro is defined as plants of up to 30 MW capacity.

There are 149 small, mini and micro plants in operation, with a total capacity of 100 MW (more than 250 GWh/year). One 10 MW plant is under construction, and a further six are planned, with a total capacity of 54 MW. The Ulrhydroproject Research Institute has studied the construction of several old schemes, one of which is being refurbished. However, there are limited funds available for implementing such projects.

Future outlook
Ffurther development of the hydropower industry will mainly involve: completion of the projects which have been temporarily suspended; rehabilitation and uprating of small hydro plants; and, the construction of new plants, including mini and micro hydro, in the basins of the Tisa and Upper Dniester rivers. New plants will also be built at canals and reservoirs which currently have no power generation function.

According to the National Energy Programme, it is planned to install about 500 MW of additional small hydro capacity by 2010.

United kingdom

The United Kingdom covers an area of 243 300 km2, and has a population of 58.3 million.

Water resources

The water utilities in England and Wales are privatized, effectively fragmenting them into independent, regional companies. Ownership of these companies is now evolving through takeovers and mergers.

Scottish water authorities remain in state control, reporting to the Secretary of State for Scotland, while in North Ireland water comes under the Department of Environment.

There are 517 large dams in operation, according to ICOLD's definition.

Energy and power sectors

The main sources of energy in the UK in 1994 were: petroleum (35 per cent), natural gas (30 per cent), coal (24 per cent), nuclear power (10 per cent), imported electricity (0.75 per cent) and hydropower (0.25 per cent).

The main sources of electricity are coal (50 per cent), nuclear (29 per cent), gas (13.5 per cent), oil (5.5 per cent), hydro (0.5 per cent) and others (1.5 per cent).

The UK has several major private generating utilities and about 12 Regional Electricity Companies (RECs), which are effectively regional distributors. The make-up of the industry is now steadily changing, with super utilities beginning to appear through the merging of power and water companies such as: Hydro and United utilities.

National Power and PowerGen, the two largest generators in England and Wales, compete with each other as well as with smaller generators (some of which are owned by the RECs) and with power from France and Scotland.

The Director General for Electricity Supply (DGES) and the Secretary of State for Energy regulate the industry, under the Electricity Act, assisted by the Office of Electricity Regulation.

Hydropower development

The total hydropower potential of the UK is not known. The technically feasible potential for small hydro sites (defined as less than 5 MW) is estimated to be 4577 GWh/year, about 3 per cent of which has been developed. The economically feasible potential for undeveloped plants of less than 5 MW capacity is 1100 GWH/year.

The total installed hydro capacity in the UK in 1995 was 1370.3 MW *5918.4 GWh/year), at 139 sites (including 92 small ones), most of which are storage schemes. A small amount of additional capacity is under construction and planned, all at small sites. Eight small plants were completed during 1997, with a total capacity of 9.7 MW.

The generation from hydro plants in 1996 was below average at 3275 GWh in view of continuing drought, compared with generation in 1994 of 5076 GWh.

There are four pumped-storage plants in operation, two in north Wales and two in Scotland, which a total capacity of 2800 MW.

Scotland

Most pure hydro capacity in UK is in Scotland, and is owned and operated by the privated utilities, Scottish Hydro Electric and Scottishpower. The total hydro capacity in Scotland is about 1250 MW at 83 sites, which 61.35 MW is at 41 small plants.

The 0.92 MW Novar small plant was completed during 1997.

Scottish Hydro-Electric is the largest hydro generator in the UK, with about 1100 MW of hydro capacity (about 3000 GWh/year). Hydropower supplies about 25 per cent of electricity in northern Scotland. Hydro-Electircs Sloy plant has recently been reurbished and uprated from 130 MW to 152 MW. The company also cpmpleted a major refurbishment of its 300 MW foyers pumped-storage plant several years age, and refurbishment is now under way at its fasnakyle, Rannoch and 36 MW glenmoriston plants. This marks a move towards a major refurbishment programme, with spending of about 10million/year(US$ 16 million/year) for the next 15 year.

ScottishPower owns and operates two hydro schemes, with a total capacity of 125 MW and operates the 400 MW Curachan pumped-storage schems.

Wales and England
There is 171.43 MW of hydro capacity in Wales and England. Mostly in Wales. There are more than 30 small plants, as well as other micro plants owned by auto-producers.

National Power Hydro owns and operates Dolgarrog 935 MW) and Cwm Dyli (10 MW). The two other large plants in Wales are Maentwrog (30 MW) and Rheidol (49 MW).

Two large pumped-storage plants in north Wales, dinorwig (1740 MW) and Ffestiniog (360 MW), owned and operated by first Hydro (formerly National Grid Company, and then Pumped-storage Business), are both being upgrated.

Three small plants were completed in Wales during 1997: Elan valley (2.95 MW), Llyn Brianne (4.35 MW), owned by Northumbrian Water Co. Two small plants were completed during 1997: trelubbas (0.03 MW) and Trecarrel (0.175 MW).

Northen Ireland
Northern Ireland electric (NIE0, the privatized power utility in Northen Ireland, recently changed its name to Virdian.

There is about now about 3.5 MW small hydro capacity, following the completion of Sion Mills (0.78 MW) and Blackwater (0.1 MW) during 1997.

Small hydro
Small-scale hydro plants are defined ad those of less than 5 MW capacity. There are about 100 such small plants in operation. There are also an estimated 200 mini and micro plants operated by auto-producers.

Uruguay

The Republic of Uruguay covers an area of 176 215 km2 and has a population of about 3.2 million.

Water resources

The average annual precipitation is 1180 mm. The average total precipitation volume is 207.9 km3/year.

The national authority in charge of water resources is the Ministry of Transport and Public Works-National Department of Hydrography (MTOP-DNH).

There are six large dams in operation. The total water storage volume of all dams is 17.29 km3.

There is a legal framework for environment impact assessment and management, which applies to certain types and sizes of engineering projects, including powerplants of up to 10 MS. It also covers the exploitation and regulation of hydropower resources.

Energy and power sectors

The national energy and power authorities are UTE (Usinas y Transmisiones Electricas) and the Ministerio de Industria, Energia y Minieria (Ministry of Industry, Energy and Minerals MIE).

Hydropower is Uruguay's only sources of commercial primary energy. The sources of electricity production in 1996 were: hydro (87.25 per cent) and imported thermal fuels (12. 75 per cent). Hydro contribute 91 per cent of electricity production in an average year.

During 1996, 309 GWh electricity was imported and 296 GWh was exported.

Powerplants are publicly owned, by either UTE or Comision Tecnico Mixta de Salto Grande (CTM).

Total electricity consumption in 1996 was 6196 GWh, and per capita consumption was 1998 kWh/person. It is estimated that total electricity demand will increase by an average of 340 GWh per year during the next decade.

Hydropower development

The gross theoretical hydropower potential in Uruguay is 32 000 GWh/year is hydro capacity, of which 945 MW is Uruguay's 50 per cent share of the 1890 MW Salto Grande project on the Uruguay river(shared with Argentina). Hydro plants generate 5642 GWh in 1996.

Refurbishment of the Gabriel Terra scheme has recently beeen completed. It now has a capacity of 152 MW from units.

There are no small hydropower plants in Uruguay.

Usa

The United States of America has an area of 9.37×106 km2 and a population of about 263.8 million.

Water resource

The main agencies for water resources development and management are the US Army Corps of Engineers (USACE) and the Department of the Interior's Bureau of Reclamation (Buree).

USACE provides support to the other Government agencies, in particular the: Environment Protection Agency, Federal Emergency Management Agency, and the Department of Energy, Interior, Justice, State, housing and Urban Development, as well as state and local government.

USACE had 75 hydro projects (20 720 MW, 77.4 TWh/year) at the end of September 1995. During 1998, it is continuing major hydropower rehabilitation work at nine projects. These include: Bonneville and The Dalles in (Oregon/Washington), thurmond (Georgia), Garrison (North Dakota), W.E George (Alabama/Georgia), Woodruff (Florida/Georgia), Buford (Georgia), Dardanelle (Arkansas) and Hartwell (Georgia). Additionally, USACE has variou construction projects under way to repair and modify dams or safety purpose.

The USA has about 75 200 dams more than 1.83 m (6 feet) high, of which 6356 are higher than 15 m (50 feet). The total water strong volume of all reservoirs is 1302 km3. Less than 3 per cent of dams in the USA are owned by the Federal Government. The greatest use of large dams is flood control.

Of the 6356 large dams, 1649 are principally for flood control, 1160 are for water supply, 899 are for recreation, and 612 are for hydropower. A total of 2179 large dams are multipurpose. A further 248 large dams have hydropower as a secondary function. The highest dams under construction are Seven Oaks (168 m high), Eastside reservoir(three dams, 87 m) and Portegues (82 m).

Energy and power sectors

The USA has vast energy resources and is by far the largest producer and consumer of energy and power in the world. Despite producing more than 25 per cent of the world's electricity, however, it consumption significantly more energy than it produces.

The US Department of Energy is responsible for general energy use and protection. The Federal Energy Regulatory Commission(FERC) licenses and regulates the construction and operation of non-federal hydro projects.

The main sources of energy production in 1995 were: coal (32.3 per cent), dry natural gas(28.4 per cent), crude oil (20.4 per cent), natural gas liquids (3.6 per cent),nuclear power (10.6 per cent), hydropower (4.48 per cent), geothermal energy production was 68 quadrillion BTU.

The main sources of electricity production in 1995 were: coal (55.2 per cent), nuclear (22.5 per cent), gas (10.26 per cent), hydro (9.897 per cent), petroleum (2.3 per cent), wind (0.0004 per cent), and photovoltaics (0.0001 per cent). The total power production was 2995 TWh.

Per capita domestic electricity consumption in the USA is 3982 kWh/year, while total per capita consumption is 11 483 kWh/year.

While USACE build and operates dams and hydro plants, for power it generates is marketed by the Department of Energy (DOE) to public bodies, power co-operatives and private utilities. Five regional power marketing agencies sell power from USACE projects.

Hydropower development

There is no official figure for gross theoretical hydropower potential in the USA, although a USACE study in 1979 indicated that, if all potential sites were fully developed, the USA could have as much as 512 GW of installed hydro capacity (equivalent to 4485 TWh/year of gross potential). The technically feasible capacity is estimated to be 146 700 MW (about 528 500 GWh/year). The economically feasible hydro potential is about 376 000 GWh/year.

The total powerplant capacity is about 750 GW, of which the hydro capacity is about 75 400 MW, which represents about 51 per cent of the technically feasible hydro capacity (of 146 700 MW). The production from hydro plants was 347 319 GWh in 1996.

There is a modest amount of additional hydro capacity under construction, and about 350 MW planned.

About 52 per cent of the hydro capacity in operation is privately owned by many different organizations: 24 per cent belongs to the USACE, 16 per cent to Burec, 6 per cent to the Tennessee Valley Authority (TVA), and 3 per cent to others. There are 14 292 MW of hydro capacity at 58 plants.

USACE estimated that about 1000 to 2000 MW of extra capacity could be obtained by upgrading is hydro plants.

There was 21 773 MW of installed capacity at pumped-storage plants in 1995.

Of the USA's 6356 large dams. Only 860 are used for hydropower generation, while of the total 75 200 dams, only 2744 are used for hydro generation. There is thus ample opportunity to add hydro generating facilities at existing dams.

Small hydro

There is about 3000 MW of small hydro capacity in operation in the USA. A further 40 MW is planned.

Further outlook

Hydro development is now restricted by extensive and complex regulatory procedures and environmental opposition. Lobbying by environmental organization has made it increasingly difficult to license hydro projects. Few new license are being issued by the FERC, while renewed license for many existing projects stipulate reduced generation possibilities.

The Government aims to promote development of renewable energy resources, including small scale hydro. In particular, a programme is under way to develop hydro turbine, design to minimize adverse environmental effects.

Uzbekistan

Uzbekistan covers 447 000 km2 and has a population of about 23.1 million.

Water resources

The total mean annual precipitation in Uzbekistan is 107.7 km3 of which the total mean annual runoff is 19.81 km3.

There are 19 large dams in operation. The total storage of the country's 25 dam is 12.1 km3. The Ministry of Agricultural Water Resources is responsible for water resources.

Per capita domestic water consumption is 945 m3/year total and 191 m3/year for domestic construction.

Two major earth-and rockfill dams are under construction on the Pekem river: the 195 m-high Pstem dam and the 80 m-high Mullak dam, there is also a 188 m-high embankment dam, Mush, under construction on the Tupolang river.

Energy and power sectors

The main sources of primary energy in 1996 were: gas (71 gas per cent); coal (9 per cent); oil (19 per cent); and, hydropower (1 per cent).

The main sources of electricity were: thermal plants (88 per cent)and hydro (12 per cent). Total electricity consumption was 46 492 GWh, representing per capita consumption of 2700 kWh/year.

Per capita electricity consumption is 2700kWh/person/year total and 450 kWh/person/year for domestic consumption.

During 1996, 10 674 GWh of electricity was imported, and 271 GWh was exported.

All powerplants are publicly owned: 97.3 per cent of them are operated by the Ministry of Power and electrification, the remainder being under other Government department.

Of the 28 hydro plants in operation, 83 per cent (1419.6 MW) of capacity is under the authority of the Ministry of Power and Electrification, while the other 17 per cent is at two hydro plants (290 MW) under the auspices of the Ministry of Water Management.

The gross theoretical hydropower potential of uzbekistan is 88 000 GWh/year. The technically feasible potential is 27 400 GWh/year. In 1993, the economically feasible potential was estimated to be 15 000 GWh/year. So far about 20 per cent of the technically feasible hydropower potential has been developed.

The total installed capacity of all the country's powerplant is 11 422, of which 1710 MW is hydro capacity in operation. The hydro plants, all of which are part of multipurpose developments, generated 7100 GWh in 1995, 15 per cent of total power production.

A further 175 MW of hydro capacity is under construction at the Tupolang project, which will have a gross head of 170 m and will have four units. It will commissioned between 2000 and 2005.

There are no pumped-storage plants in operation or planned.

About 755 MW of hydro capacity is planned at small plants beyond 2010. In addition, the Pskem project is planned, on the Pskem river. Eight other stations could be built at irrigation canal drops (total 143.5 MW). All of these would give a total capacity of about 600 MW.

Small hdyro

There are currently 23 small, mini or micro plants, of which only 17 are in operation, with a total capacity of 152 MW (1314 GWh/year). No plants are under construction, but several are planned for development soon, with a total capacity of 134.2 MW.

Beyond 2010, it is planned that small hydro plants will be built, with a total capacity of 755 MW, generating about 3300 GWh/year.

Future outlook

The Government plans to exploit the energy resources of the Pskem and Chatcal rivers, and to construct small hydropower stations to exploit irrigation flows.

Recent studies identified a total of 43 potential powerplants with reservoirs (total 505.1 MW, 1370 Gwh/year), 98 hydro schemes on irrigation canal drops (total 621.8 MW), 3064 GWh/year), and 80 run-of-river schemes (total 2894.2 MW, 7878 GWh/year). Of these hydro plants, only Tupolang plant is under construction so far.

Vanuatu

The Republic of Vanuatu has an area of 12 200 km2 and a population of about 173 000. It comprises a group of mountainous islands in the Pacific Ocean.

Energy and power sectors

Vanuatu depends entirely on impacts to meet its petroleum requirements, which are used mainly for transportation and power generation. Its major indigenous energy resource is fulewood it has potential for hydropower generation, geothermal power, and possibly offshore hydrocarbon reserves.

The only indigenous competitive resources for electrical power generation currently available is small/mini hydro potential. Much attention has been focused on this resource in recent years, in particular the Teouma small hydro development.

The Teouma reiver is the largest river on Efate Island, is near the load center of Port Vila. It thus has potential to displace existing diesel capacity.

Thr reports have been completed during feasibility studies for the project: by EDF of France in 1983; by COWI Consult for the ADB in 1986; and, by the Hangzhou Regional Centre of China in 1989.

Venezuela

The republic of Venezuela covers an area of 916 729 km2 and has a population of about 22 million.

Water resources
Average annual precipitation is 1705 mm, giving a total mean annual precipitation volume of 156.3 km3, of which 1180 km3 is runoff. Planned per capita domestic water consumption is 250 litres/person/day.

There are 79 dams in operation, of which 70 are large structures. Three water supply projects are under way: Taguaza, Macarno and EI Diluvio.

The Ministro del Ambiente y de los Recursos Naturals Renovables (MARNR) is responsible for water resources.

Major dams are being built for the country's new hydro projects, Caruachi and Tocoma; La Vueltosa dam was very recently completed. Other large dams under construction include: Yacambu (158 m high), Taguaza (90 m) and EL Diluvio (75 m).

There is a law on environment which applies to any project which could cause an impact on the environment.

Energy and power sectors
The national authority responsible for energy development and power production is the Ministro de Energia y Minas.

CVG Electrification dl Caroni CA (EDELCA) is responsible for hydropower development of the Caroni river basin, where the major plants are being developed.

The main sources of primary energy in 1997 were: gas (38 per cent), petroleum (31 per cent) and hydropower (31 per cent).

Electricity production in 1996 was from: hydro (74 per cent), fuel-oil (1 per cent), gas-oil(1 per cent) and gas (24 per cent). The total electricity production was 72 680 GWh, representing per capita consumption of 3257 kWh/year. During 1996, 151 GWh of electricity was exported.

Annual energy consumption is expected to increase by 2.5 per cent up to 2007, and electricity demand will increase by 4.7 per cent for the same period.

The Congress is holding discussions about two planned laws relating to deregulation of the energy/power sectors. It is envisaged that a deregulated market would have separated, transmission and distribution.

The market currently involves pool bidding.

Hydropower development
The gross theoretical hydropower potential of Venezuela is 345 000 GWh/year, of which 260 720 year was estimated in 1981 to be technically feasible. The economically feasible potential is about 100 000 GWh/year. About 21 per cent of the technical feasible potential has been developed.

There is now about 20 844 MW of powerplant capacity in operation, of which about 13 216 MW is hydro capacity. These figures include the 2540 MW Maeagua II hydro plant, which was recently commissioned.

The average annual generation of the hydro plants now in service, including Macagua II, is about 65 000 GWh/year, although the actual generation in 1996 was 53 844 GWh.

There is 4800 MW of new hydro capacity under construction at the Caruachi, Tocoma and La Vueltosa projects, and several more gigawatts are planned.

The 2160 MW Tocoma projects, where construction is just beginning, will have twelve propeller units, to be commissioned between 2007 and 2010. This project is downstream of Guri and upstream of Caruachi: it will be the last major powerplant on the Lower Caroni.

The construction of the powerhouse and appurtenant structures at La Vueltosa project in western Venezuela, which will have a capacity of 480 MW, has recently been restarted. The project will completed around 2002 to 2003.

The mean cost per kW of the current hydro plants in Venezuela are: US$ 800/kW for Macagua II: US$ 695/kW for Caruachi and US$ 616 kW for Tocoma (at December 1997 prices).

The hydro plants planned include La Colorada (460 MW, 2080 GWh/year).

Small hydro

There are eight small mini and micro hydro plants in operation, with a total capacity of 1360 kW. Several more are under construction and planned.

Future outlook

Opening up of the petroleum market has led to a significant increase in investment in the energy sector. The consequence has been a greater demand for electricity, which is expected to increase by 4.7 per cent/year during the next 10 years. It is likely that after completion of the hydro projects on the Low Caroni river, it will necessary to install more thermal generating capacity.

Vietnam

Vietnam covers an area of 331 689 km2 in southeast Asia and has a population o about 76 million.

Water resources

The mean annual rainfall is about 1861 mm, ranging from 1842 mm in the north to 1880 mm in the south. Some locations receive more than 5000 mm/year.

Flow rates in the rivers are thus high, at about 10 to 90 l/s.km2. the total average flow of all the country's rivers is about 275 000 m3/s.

A rockfill dam more than 60 m high is under construction for the Ham Thuan/Da Mi hydro project, on the La Nga, while a 67 m-high dam is under construction for the 720 MW Yali hydro project.

Energy and power sectors

Vietnam has abundant resources of hydropower, coal, oil and gas. Much of the hydro potential is the central and northern region, while the oil resources are mainly in the south.

The main sources of energy of energy in 1994 were: oil (61.8 per cent); coal 925.5 per cnet); and, electricity (12.7 per cent). Biomass plays a very important role in rural areas, which has resulted in severe deforestation.

The main sources of electricity production in 1996 were: hydropower (70 per cent), thermal plants (coal. Oil and gas)(13.5 per cent), gas (8.8 per cent). Oil (5.9 per cent)and diesel (1.8 per cent). Total electricity consumption was 12 300 Gwh.

Electricity of Viet Nam (EVVn) is in charge of energy resources , and the construction and operation of power plants. It distributes power in the north. South and central regions through its five regional power companies: power Companies Nos. 1, 2 and 3 respectively, the Hanoi Power Company and Ho chi Mimh Power Company. The Planning and design of power generation Projects is carried out by Power Investigation and Design Companies 1 and 2. Which are also under EVN. There is no private ownership of powerplants.

As a result of nearly 30 years of war. The organization and management of the power sector need to be improved.

Vietnam began a major power sector reform in January 1995 aimed at developing a system that would operate more efficiently, and to allow for integrated strategic planning. As one of the steps the Government set up EVN in January 195, with a holding company comprising 34 business units engaged in generation, transmission, and distribution.

Electricity demand is increasing very rapidly, with increases exceeding 20 per cent/year in recent years. Chronic and severe power shortages in the south have now been eased through the interconnection of the northern/central and southern grids.

About 51 per cent of households have an electricity supply. The per capita electricity consumption is 149 kWh/person/year total and 53.8 kWh/person/year for domestic consumption (1995). There is thus vast potential for increased power demand in the future, with per capita electricity consumption expected to double in the next decade, and with predicted annual growth rates of about 14 per cent up to 2000, reducing to around 11.5 per cent between 2001 and 2005. About 600 to 700 MW of new generation capacity will thus need to be commissioned each year up to 2005.

To reach this targets, the Government is encouraging private investment in the power sectors. Many new projects are planned, and restricting of the country's power industry, financial and legal system are under way.

EVN expected total power output in 1996 to be 16.4 TWh. 35 per cent more than in 1994, but still

1 TWh below the demand. The company aims to almost double its production to 26 to 29 TWh/year by 2000. Demand is expected to continue to increase considerably, possibly reaching 60 TWh/year by 2006.

Vietnam's power sector development includes the refurbishment of existing plants, the construction of new capacity and the conversion of existing gas turbine plants from single to combined cycle. Among the plants scheduled for refurbishment is the Da Nhim hydro plant, and of the new powerplants planns, son La hydro project will be the largest, with a capacity of 2400 to 3600 MW.

Private hydropower and coal-fired power projects are to be implemented, particularly in the north of the country. The Ministry of Industry recently invited private firms to submit proposals for BOT projects totalling 1.6 GW, and a number of memoranda of understanding have been signed. The Ministry also expects to offer one coal-fired project, one hydro project and four gas-fired projects, with a total capacity of about 2000 MW, to the private sector.

It is estimated that Vietnam requires an investment of US$ 23.5 billion between 1995 and 2010 for power sector development, two-thirds of which will be spent on power generation projects. It is expected that half of the additional capacity will come from BOT projects. Therefore , the Government is working hard to attract private and foreign participation.

Hydropower development

A preliminary estimate of Vietnam's gross theoretical hydropower potential is about 300 TWh/year(34 700 MW).

The technically feasible hydro potential is estimated to be 80 to 100 TWh/year, representing about 17 700 MW. Of this, 51 TWh/year of potential is in the north, 19 TWh/year in the central regions and 10.5 TWh/year in the south. A ptreliminary estimate of the economic hydro potential is about 18 000 MW (80 417 GWh/year).

The hydropower potential is mainly concentrated on three rivers: 6258 MW on the Da river in the north. 1485 MW on the Sesan river in central Vietnam, and 2500 MW on the Dongmai river in the south.

Vietnam has about 4600 MW of installed capacity at all of its plants, of which 2883.5 MW is hydro capacity. About two-thirds of the powerplant capacity is in the north, despite half of the power demand (1280 MW of 2600 MW)begin in the south. Hydro plants generated 12 343 GWh in 1995 (83 per cent) of power production and 11 900 GWh in 1996 (70 per cent).

There is 1262 MW of hydro capacity under construction, the four largest plants all being scheduled for completion in 1999. Yali (720 MW); song Hinh (70 MW); and Ham thuan and Da Mi (300+172 MW). However, the Yali project could begin service by the second half of 1998. Ham Thuan-Da Mi will be the largest hydro plant in the south of the country. A transmission lines is to be built connecting Yali to Thailand, via Laos.

The feasibility study and preparation of tender documentation for Dai Ninh (300 MW), in binh thuan province in the south, and now being completied by Sogreah of France and PACIFIC Rim Power of Canada. Funding has not yeat been finalized.

Other large hydro projects planned for implementation up to 2010 include: Son La (2400 to 3600 MW); Thuong Kon Tum (260 MW); Ban Mai (350 MW); Upper Kon tum (260 MW); Dai Thi (250 MW); An Khe (116 MW); Se San (366 MW); and, Can Don-huoi Quang 9650 MW).

Small hydro

Some 400 small hydro stations (1 to 10 MW)have been constructed, with a total capacity of 70 MW, representing only about 3 per cent of the potential. However, more than a third of these plants (20 MW) require renovation. For 100 kW to 1 MW plants (500 sites), 10 MW of a potential 200 MW (5 per cent) has been developed. There are also estimated to be 2500 possible sites for micro hydro plants (up to 100 kW).

The Government has a policy of promoting micro hydro, to improve living standards in mountainous areas. At present, the priorities are to import low cost micro hydro equipment, train technical personnel and transfer technology to Vietnam. Intention co-operation is thus being strongly encouraged. Foreign funding of mini hydro schemes and public investment is to increase, and the Prime Minister has expressed an intention to construct up to 200 schemes with capacities of about 1 MW each. Investment would come from international loans and with joint venture agreements for equipment manufacture.

Future outlook

The energy sector of Vietnam urgently needs to be developed. However, the country still faces a number of problems, one which is lack of adequate capital for investment.

Hydropower is a major priority for future years, as well as completion of the grid interconnection program allowing for development of large hydro sites such as the major Son La project on the Da river upstream of Hoa Binh, in the north.

The masterplan for development of hydro projects is concentrated mainly on the Da river in the north, the Sesan river in central vietnam and the Dong Nai river in the south, a total of about 4000 MW capacity.

Western samoa

Western samoa has utilized run-off-river hydropower since the 1920's. Currently all hydropower generation is on Upolo. This comprises of four run-off-river power schemes providing a combined capacity of 7.4 MW and one (Afulito) 4 MW storage hydropower scheme. The total installed hydropower capacity is 11.4 MW. On Savai'I, no hydropower resources have been developed. However, hydropower potential has been identified and it is expected that this will be further investigated. Plans are currently proposed to upgrade the Afulilo scheme up to 6 MW.

As Upolo is more than 90% electrified, there is little scope for the development of micro hydropower. However, there is potential for further investigation of hydropower potential on Savai'i.

Yugoslavia

The Federal Republic of Yugoslavia covers an area of 102 173 km2 and has a population of 11 million.

Water resources.
The average precipitation (in 1995) was 961 mm, giving a precipitation volume of 98.19 km3.

The Federal Ministry of Agriculture has overall responsibility to for water resources. These are two regional authorities; the Ministry of Agriculture; Forestry and water Management of the Republic of Serbia and the Ministry of Agriculture, Forestry and Water Management of the Republic of Montengro.

Per capita water consumption is 188.7 m3/year/person/year total and 75.5 m3/person/year for domestic consumption.

There are 66 large dams in operation, 27 of which were built primarily for hydro generation, the rest being multipurpose. The total water storage of all the dams is 3.7 km2.

Three dams higher than 60 m are under construction: Pronek (90 m high, rockfill, for water supply and flood control, due to be completed in 1999); Rovni (75 m high, rockfill, for water supply, 1999); and Selova (70 m high, rockfill, for water supply, 1998).

There are various laws relating to environmental impact assessment and management, the main ones being: the Law on Environmental Protection; the Law on Waters; the Law on Protection of Nature; and the Law on the Construction of Investment Projects.

Energy and power sectors
The sources of energy in 1995 were: coal (72.4 per cent0, oil (10.3 per cent), hydro (10.2 per cent) and natural gas (7.1 per cent).

The sources of electricity in 1996 were: thermal plants(58.7 per cent)and hydro (41.4 per cent). Total electricity consumption was 27 049 GWh, representing per capita consumption of 3520 kWh/year.

During 1996, 3206 GWh of electricity was imported and 4975 GWh was exported.

The Federal Ministry of economy is in charge of the Republic's energy. The national power authority is the Union of Yugoslav Electric Power Industry, which has two major subsidiaries: Electric Power Industry of Serbia and electric Power Industry of Montenego.

Hydro power development
The gross theoretical hydropower potential has not been evaluated. The technically feasible and economically feasible potential have both been estimated as 27 00 Gwh/year, of which 45.2 per cent has been exploited.

There is 2711 MW of hydro capacity installed, of a total installed capacity of 9954 MW at all powerplant.

The average annual generation from hydro plants is 12 00 GWh/year, with the actual production in 1995 being 12 204 GWh.

Before the recent war, plans had been completed for a further 50 dams. However, the plans now need to be revised. With regard to future hydro plants, priority will be given to those which will provide for increase water management.

In the near future four hydro plants are planned for the moraca river: Andrijevo (195 MW, 329

GWh/year); raslovici (55.5 MW, 116 GWh/year); Milunovici (55.5 MW, 129 GWh/year); and zlatica (55.5 MW, 17 GWh/year).

There is 642 MW of installed capacity at pumped-storage plants (generation on average 800 GWh/ycear) and there are no further pumped-storage schemes under construction. future plans are not available.

Small hydro

There are 44 small, mini and micro plants in operation, with a total capacity of 57 MW.

The Electric Power industry authorities have made plans for about 900 small hydro plants, with a total installed capacity of approximately 1800 MW.

Future outlook

Development of the electric power sectors is likely to focus on the rehabilitation and modernization of existing stations, as well as the construction of new capacity to substitute thermal powerplants which are now approaching the end of their projected lives.

The Government of Montenegro recently announced an open public competition for concessions to construct the four powerplants listed above on the Moraca. A feasibility study for them has been completed.

ZAMBIA

Zambia covers an area of 753 000 km2 and has a population of about 9.5 million.

Water resources
Zambia's largest river, the Zambezi, flows south through the western part of the country and then forms the southern border with Zimbabwe for a length of about 760 km. The water resources of this section of the river come under the auspices of the Zambezi River Authority, a binational organization jointly owned by Zambia and Zimbabwe.

Besides the Kariba dam on the Zambezi river, Zambia also has two other major dams: Itezhi

Tezhi and Kafue.

No large dams are under construction, although several have been proposed for possible funding by NORAD.

Energy and power sectors
Hydropower supplies almost 100 per cent of Zambia's power requirements, and enables Zambia to be a net exporter of power. In the year to March 1996, the country exported 975 GWh and imported 573 GWh.

The major power producer is the national power utility, ZESCO (Zambia Electricity Supply Corp), which has 1961 MW of capacity, 1722 MW of which is effective. There are also some private producers at mines: hydro (38 MW); gas turbines (80 MW); and, geothermal (20 MW).

Hydropower development
The gross theoretical hydropower development of Zambia has not been evaluated. The technically feasible potential is 28 753 GWh/year, evaluated in 1984, and the economically feasible potential was 17 233 GWh/year in 1990.

In the year to March 1996, ZESCO had 1670 MW of hydro capacity, of a total powerplant capacity of 1776 MW. Its hydro plants produced 7821 GWh, and its diesel plants, 15 GWh (excluding private generation at mines). Hydro thus represents 99.8 per cent of power produced by ZESCO.

A major reservoir, Katombora, is proposed on the Zambezi river some 60 km upstream of Victoria Falls, to regulate flows at the Victoria Falls plant(s) and for the proposed Batoka Gorge hydro project. Construction of this reservoir and Batoka Gorge would enable Zambia's Kariba plant to be uprated from 600 MW to 900 MW.

Batoka Gorge, a binational hydro project between Zambia and Zimbabwe about 50 km downstream of Victoria Falls, would include a 181 m-high RCC dam, and would provide up to 800 MW of hydro capacity each for Zambia and Zimbabwe.

Another proposed project on the Zambezi is Devils Gorge (1 200 MW), at a site between Batoka Gorge and Kariba, which would have a capacity of 600 MW at each bank.

Mupata Gorge, sited on the Zambezi just before the point at which it flows into Mozambique territory, would have an installed capacity of between 640 to 1200 MW.

There is potential for installing a second large hydro plant downstream of Kafue Gorge on the Kafue river, the Kafue Lower project (450 MW), just upstream of the confluence with the Zambezi river.

ZIMBABWE

Zimbabwe covers an area of 391 000 km2 and has a population of about 12 million.

Water resources

The total mean precipitation volume in Zimbabwe is 260 km3, of which 20 km3 is runoff.

The Department of Water Development and one regional water authority are responsible for water resources.

Per capita total water consumption 1991 was 360 m3 /year.

There are now 223 large dams in operation. The total storage volume of all the country's reservoirs is more than 7.5 km3.

Construction of the 90 m-high Mukorsi concrete-faced rockfill dam, on the Tokwe river, has recently begun. It is being built for irrigation.

The Biri earthfill dam is planned, also for irrigation purposes. It will be about 48 m high, with a volume of 2.8×106 m3, and will have a reservoir capacity of 355×106 m3, Tenders have been invited from prequalified firms.

Energy and power sectors

ZESA is the energy and electricity authority, which owns and operates all major powerplants.

The Zambezi River Authority is a binational organization jointly owned by Zimbabwe aid Zambia mandated to develop and manage resources of the section of the Zambezi river forming the common border between the two countries (about 760 km). This Authority is funded by both Governments

equally, and each country is entitled to half the water available for power generation.

The main sources of energy in 1995 were: biomass (53.7 per cent); coal (19.9 per cent): liquid fuels (oils) (13.9 per cent), and, electricity (12.5 per cent). Total power production was 7323 GWh, of which hydro contributed 2163 GWh.

The main sources of electricity production in the year to June 1996 were : thermal (70.5 per cent) and hydro (29.5 per cent), imports (30 per cent). Zimbabwe also imported 3172 GWh in the same year, 30 per cent of power consumption, from SNEL (of Congo, Dem. Rep.) and ZESCO (of Zambia).

Per capita total electricity consumption in 1996 was about 945 kWh.

Hydropower development

The gross theoretical hydropower potential is 1 8 500 GWh/year, and the technically feasible potential is 17 500 GWh/year. About 19 per cent of the technically feasible potential has been exploited.

The total installed capacity in Zimbabwe is 1946 MW, of which 666 MW is hydro capacity at the Kariba South Bank station, which has an average annual generation of about 2500 GWh/year. This plant is currently being upgraded by 84 MW to 750 MW. No other hydro scheme is under construction or definitely planned.

However, there are a number of proposed developments in the Zambezi basin, intended to develop fully the potential head between Victoria Falls and the Indian Ocean.

A 390 MW plant could be installed on the south bank at Victoria Falls (on the Zimbabwe side) if a proposed reservoir is built; the Katombora regulating reservoir would have a live capacity of about 6 km3.

The Batoka Gorge project would include a 181 m-high RCC dam, about 50 km to be sited downstream of Victoria Falls, and could provide 800 MW of capacity each for Zimbabwe and Zambia.

Devils Gorge is proposed at the headwaters of Lake Kariba, with an installed capacity of about 1200 MW, 600 MW for Zimbabwe and Zambia.

Construction of the Katombora reservoir and Batoka projects would provide for both of the powerplants at Kariba dam to be uprated by about 300 MW each.

The Mupata Gorge project, downstream of Kariba, would provide a capacity of between 640 and 1240 MW.

There are also three mini or micro plants in operation, with a total capacity of less than 1 MW.

Future outlook

Finance is a major constraint for future projects. There is hydro potential which could be developed in the future at irrigation and water supply dams.

Batoka Gorge project will be required for future hydropower generation.

Annex 16

Annex 16

PEREZ-GUERRERO TRUST FUND Project INT/98/k06/A/95/99

Research Paper

Second Survey of Medium/Small Hydropower Equipment in China

Submitted by

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中国中小水电设备第二次调研

前言

随着中国农村水电电气化县计划的实施与不断深入，中国小水电建设得到了持续高速地发展。据水利部统计年报，至1996年底，全国已拥有小水电装机容量1921.8万千瓦，占整个水电总装机容量的34.5%。目前乃至今后几年，由水利部管辖的中小水电建设仍将在整个水电行业占据主导地位。

但是，目前小水电开发的单位千瓦造价已接近发达国家的平均水平。机械部门出台的主机设备行业价格一涨再涨，发电机价格甚至已达到了国际水平。而新技术采用较少，技术水平和设备质量不高、不稳，甚至还出现大的问题。如设备转动部件静平衡严重超标、转子“扫膛”、碳刷烧熔、机组异常振动使轴承盖螺丝剪断、水轮机转轮椭圆度偏大现场无法组装等质量严重缺陷也偶有发生。设备的质量与价格将有可能成为今后中小水电持续发展的严重制约因素之一。

为阻止中小水电设备价格的不断攀升，防止一些不合理产品进入水电行业，减少日后技术改造工作量和对我行业效益的影响。同时促使企业提高质量和采用新技术，保障中小水电“九五”期间持续稳定发展。

一·中小水电设备主机现行价格情况

自93年以来，机械行业的指导价大幅攀升，97年的韶关价格已达93年重庆价格的1.53倍，而作为设备主要价格成份的原材料价格稳中有降，银行利率也有较大幅度的下降，这种行业价格严重背离了市场实际，使设计阶段设备的概算价偏高。根据96～97年主机设备供货合同价格调查，中小水电设备现行合同供货价格实际仅为机械行业93年重庆行业价格的1.0～1.1倍。

建议中小水电设备水轮机参考价格采用1.05～1.1倍的机械行业93年重庆行业价格，发电机参考价格为机械行业93年重庆行业价格。对于采用新机型、新技术，或用户评价产品质量满意的设备价格可适当上浮。此参考价格建议同时作为中小水电站设计概算和项目审批时的价格参考依据。

二·中小水电主机设备质量情况

根据用户调查统计，供货质量和售后服务满意率分别仅占34.32%和31.92%。近几年生产的设备总的质量有所下降。根据调查统计，质量反映较好的制造厂家有重庆水轮机厂、原杭州发电设备厂的中型水轮机发电机；昆明电机厂、潮洲电机厂、临海电机厂、江西电机厂的小型发电机；金华水轮机厂、重庆水轮机厂的小型水轮机；天津控制设备厂的调速器；和河北工学院的励磁装置。

建议订货时针对机组容量大小和机型实际使用性能等情况，慎重选择厂家。对容量较大的机组应由水利（水电）厅行业主管把关，选择质量较好、售后服务好的制造厂家。

三·设备供货合同的签订与管理

根据对用户的调查，目前中小水电设备订货以货比三家或议标方式采购的用户数量依然不少。供货合同的技术条款、供货范围和备品备件范围、货款的支付方式、质保期和质保金等由于不够明晰，往往缺少依据而一直与厂家界定不清。合同的签订与执行不够顺畅，有些厂家合同签订的是“闭口合同”，但在合同执行过程中，提出种种理由要求提价。

建议水电行业抓住当前买方市场的有利时机，在全国 100 多家水电设备生产厂家生产能力大大过剩的形势下，象国产彩电、汽车行业淘汰不合格产品和企业一样，按市场规律进行规范和引导中小水电设备市场，使设备生产企业重合同、受信用，注重质量、注重新技术的采用。建议水电行业按《小型水电站设备管理》（已付印）进行合同设备的采购和管理。具体参考意见如下：

设备供货合同签订前，必须事先订立技术协议，只有在技术协议签订后，才能洽谈和签订经济合同。供货合同原则上应为不受任何涨价因素而调价的“闭口合同”。

（一）技术条款

技术协议建议；对于容量较小的机组可以参考“小型水电站设备管理”中的有关设备技术协议格式签订机组容量较大的设备套用水电规划总院编制的招标文件格式，以免项目的遗漏和技术要求的不周全。技术条款中应特别明确供货范围、性能保证、质保期、技术要求、验收标准、性能的评定方法等，同时应尽可能列入如下的规程规范：

国标 GB/T15468-1995《水轮机基本技术条件》

国标 JB3160-82《水轮机通流部件技术条件》
国标 GB/T14478-93《大中型水轮机进水阀门基本技术条件》
国标 GB/T15469-1995《反击式水轮机空蚀评定》
国标 GB7894-87《水轮发电机基本技术条件》
国标 GB1029-80《三相同步发电机的试验方法》
电力部 DL443-91《水轮发电机组设备出厂检验一般规定》
水电部 SD135-85《大中型静止整流励磁系统及装置技术条件》
国标 GB10585-89《中小型同步电机励磁系统基本技术条件》
国标 GB9652-88《水轮机调速器与油压装置技术条件》
国标 GB11805-89《大中型水电机组自动化元件及其系统基本技术条件》

（二）备品备件和专用工具

备品备件和专用工具是设备供货不可缺少部分。水轮发电机组的备品备件应按技术规范中的规定数量配置。如有特殊要求的备品备件，与厂家协商并必须在技术条款中单独列出，价格单列。

（三）质保金

质保期按规程规范规定的条款执行，这也是制约厂家履行售后服务的措施。但可考虑 5%的质保金采用以厂家出具以用户为收益方的银行保函形式。

（四）支付方式

货款的支付考虑到小水电设备行业的实际情况，采取折中的办法。比如：合同生效后一个月内支付设备款的 10%，三个月支付设备款的 20%（厂房布置参考图、总装图和重要部件图、埋件基础图提交并批准后），六个月支付设备款的 20%（合同规定按

设计进度由厂家提供的技术资料和图纸提交并同意后）。设备交货时支付设备款的 45%，剩余 5%为质保期保证金。如采用 5%的质保期保函，则设备交货时可支付设备款的 40%，调试验收完成并收到 5%的质保期保函后，支付剩余的 10%合同款。

附件 1：机械行业主机设备行业价格 93-97 年价格涨幅统计表

（相对于 9 3 年重庆价格的涨幅 %）

涨幅百分比（%）	93 ~ 95 年	95 ~ 97 年	93 ~ 97 年
中型水轮机	35%	23.12%	66.21%
中型发电机	30%	24.54%	61.90%
小型水轮发电机	15%	15.61%	32.95%
综合平均涨幅（%）	**53.6%**		

附件 2：中小水电主机设备 96 ~ 97 合同价格调查统计表

（相对于 9 3 年重庆价格的涨幅 %）

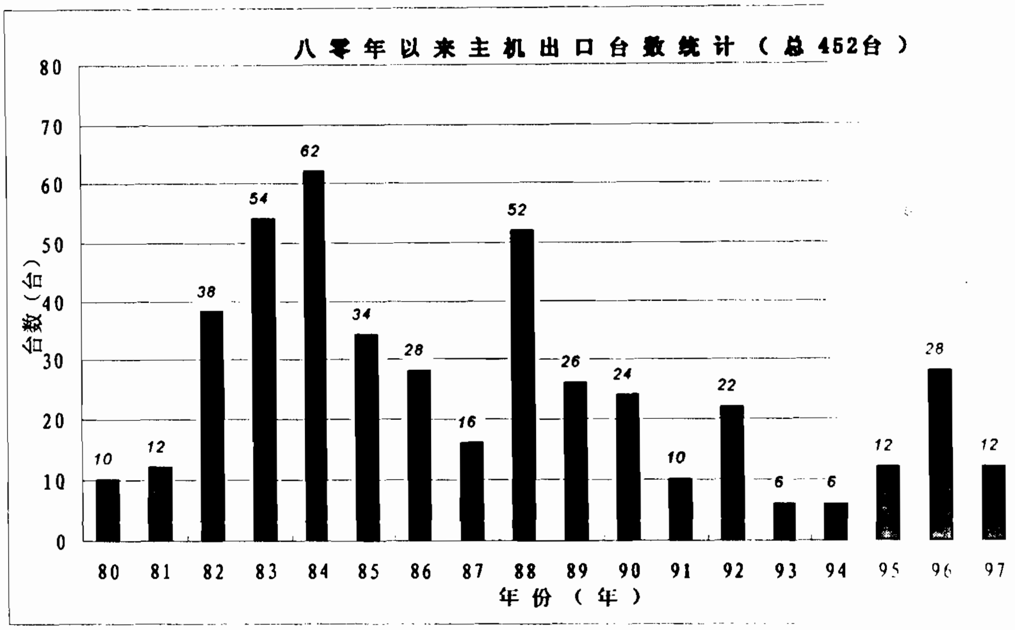
93 重庆价的（%）	水轮机	发电机
最高	13.4%	6.55%
平均	6.66%	1.32%
最低	0	-8.0%
综合平均涨幅（%）	**5 ~ 10%**	**0%**

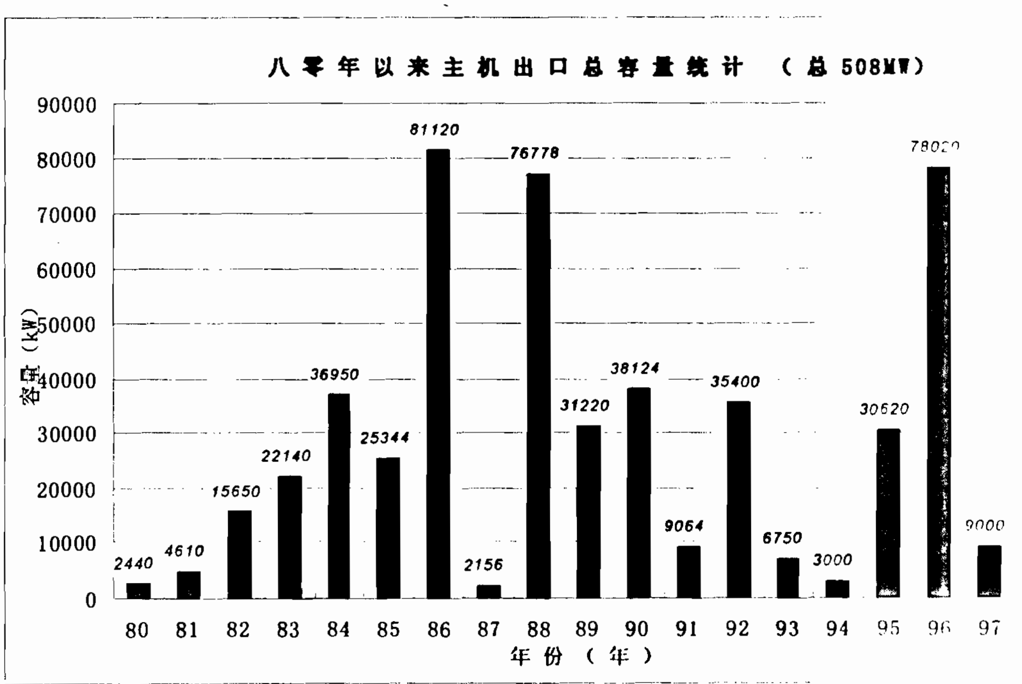
附件 3：中小水电主机设备质量售后服务情况调查统计表

用户反映满意百分比(%)	质 量	售后服务
水轮机	33.3%	38.8%
进水阀	50.0%	20.0%
调速器，油压装置	41.6%	41.6%
水轮发电机	27.7%	30.7%
励磁装置	18.5%	28.5%
平均满意率（%）	**34.32%**	**31.92%**

附件4：八零年以来中小水电主机设备出口情况统计

单机容量：小于10 MW
统计年份：1980-1997
统计厂家：9家（国内主要出口厂家）





Annex 17

Annex 17

PEREZ-GUERRERO TRUST FUND Project INT/98/k06/A/95/99

Research Paper

Structural Reform in Medium/Small Hydropower Sector in China

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电力体制改革的关键在于打破垄断

当前，世界上出现了一个打破垄断、实现经济全球化的潮流。从微软的被判解体到美国司法部即将对维萨和万事达信用卡的反垄断起诉，从英国中央电力公司一分为四的改革到保守的法国被迫开放电力市场，整个欧洲正在逐步形成“一个市场，多个公司（竞争）”的局面。新近排序的世界50强能源公司也一改过去按能源产量大小的排序方式，改为按财富多少来排名，使一些所谓“国家的”电力公司纷纷出局，以反垄断为前提的经济全球化有力地推动了世界经济的发展。

近年来我国开始积极与世界接轨，我们在行政机构改革、国有企业改革、在打破所谓“机密”的电信行业垄断等方面，受到了外界的普遍好评，我们中国的老百姓也因此而受惠。但是，改革不一定都是提高，历史也不一定是对未来最好的指导，在我国即将加入世贸组织前，作为“先行官”的电力行业如果搞越来越垄断的逆向改革，那么我国电力行业一万多亿元固定资产的改革重组以及农村电力体制的改革是很难完成的，其最终结果只能是要么被人家垄断，要么象一些国家一样，最后只有靠政治家的决策去解决问题了。

一. 电力垄断的几种表现形式

1. 行业垄断和行业管理

传统的经济理论认为，水力、煤炭、石油等国家资源是公共资源。它的开发能给社会以外部效益，而市场交易不可能把一个项目的外部效益考虑进去。因此，为了避免由于市场交易所造成的对资源的不适当分配，要求对能产生外部效益的活动必须由政府用公共资金来承担和控制。

今天这种理论的表现形式主要是所谓传统意义上的行业管理。政府承认电力市场中的垄断公司，把电力工业看成是一种可以在长期发展中能“自我完善”的、具有“自然垄断”性质的行业，允许其独家垄断市场，并由政府发给执照作为一定供电区内特许的垄断经营者。同时，要求电力公司为供电区内所有的用户服务，且电价应受政府的审查，使其获取的利润限制在合理的范围之内，以保证公共资源的合理分配等等。显然，在这种情况下，不但其它部门的参与受到限制，就是电力工业自身的发展也是受到限制的。

2. 行政垄断和部门垄断

行政垄断是行业垄断的必然结果，它把企业的运作看成是一种政府行为。行政垄断使得电力生产和销售带有浓厚的计划经济色彩，兴建电厂完全由政府部门计划、立项和审批，发电计划由政府下达，电力销售由国家统一调配，电价由国家以“成本加利润”的方式确定，电力生产企业和用户没有选择的余地。

行政垄断还有可能演变为部门垄断。本来市场竞争不是政府职能，对电力工业的管理也应该由几个互为补充、互为监督的有关职能部门来进行，如果出现执政失误，或者让某一部门的职能任意膨胀，则会造成部门垄断。部门垄断使得电力企业成了该部门的附庸，企业的运作多来自政府该部门的意志，企业自身就缺乏了发展的动力。

部门垄断还有可能导致公司对政府的垄断。由于部门管的不是市场，而是所谓“行业”，可能还会造成有的大公司从事“经商又行政”的越位经营，对一些小厂小站实行垄断经营，甚至让该政府部门倒过来服从于自己的经营。政企关系如果到了这一步，要防止出现让公司反而“领导”政府的情况。

3. 企业垄断和公司垄断

企业垄断是市场竞争的结果。一些大企业热衷于经营旧日的垄断王国，总想由自己一家公司来控制市场，并靠老的一套经营方式排斥竞争对手。但是，时代在发展，竞争的要素也在发生变化，今天，一些巨型公司的解体表明，尽管他们都自认为具有“自我完善”的机制，但是搞企业垄断的最终结果却使他们自己成了公司的掘墓人。

还有一些公司利用政府职能撤出市场竞争的机会，在本行业以“政府”的代表自居，在维护行政垄断的同时搞起了公司垄断。他们既是竞争者，又是仲裁者，大一点的常概念不清地被称为“国家公司”，而不是“某某国”的公司，那么除了跨国公司之外，还有谁又怎么能与代表“国家”的公司竞争呢？公司垄断事实上已成了现代企业制度下电力垄断的新的形式。

4. 网垄断和用电权垄断

用电权是一种基本的人权。公民有权得到可靠的、价格合理的、技术标准一致的、安全的电力供应。但在许多发展中国家，由于农村能源供应不足，已给这些国家的发展带来了很大的困难。在过去 20 年里，非洲的农村人口增加了 1.18 亿，而新增用电人口不足 2000 万，净增了约 1 亿无电人口，电力的供应远远落后于人口的增长。据联合国统计，全世界还有约 20 亿人没有用上电，为了满足这些无电人口最低标准的用电需要，一些发达国家认为约需 2 亿吨石油，只占世界石油产量的 7%左右，因此他们认为这不是能源垄断问题，而是贫困问题。也有一些国际组织认为，农村电气化只对那些用电用得多的人有利，反而会造成贫富不均，因此不主张搞农村电气化。上述主

张无论出发点如何，其结果都是一样的，排斥了广大农村人口的用电权，也等于制约了当地农村的发展权。

电源开发权的垄断。在电源开发的审批上实行双重标准，那怕象小水电那样的优质电源、也很难审批。如美国水电执照的再注册工作一般要经历数年时间，申请者不得不揣摩决策者在报告中到底想看什么，除了复杂的费时费力的过程外，最后还由于利益可能受到影响的部门持不同意见而遭到否决，而不得不从头再来一遍申请。据介绍有一个电站甚至批了 25 年，电源开发上的双重标准把电力行业的竞争精神都消耗完了。

联网、用网、建网的垄断。电力垄断已逐步演变为以电网为重点、以市场利润为导向的对输电系统的控制和垄断。在联网、用网上一些地区仍在实行双重标准，造成一些电厂上网困难。在农村电网建设上排斥输电系统的竞争者等。此外，在电网的操作上也是不透明的，造成极大部分的利润集中在电网上，使电厂还本付息困难，不良资产增多，影响到整个电力工业的发展。

公民对电力公司应有选择权。目前电力工业的发展已进入了所谓“用户时代”，打破电力垄断的最终受益者将是广大的用户及电力工业本身。既然是市场经济，买卖双方就有互相选择的权利。电力公司有权选择用户，用户也有权选择电力公司，包括国有控股大公司、投资者所有的独立电厂和农村小型发电站，也包括用户自己创办的自发自供、多余上网的小电站。

二. 国外电力工业反对垄断的主要做法

反垄断是电力工业发展的动力，它在不同的历史时期有不同的内容。在九十年代之前主要表现在如何保护供电区，电力体制改革后重点转到怎样保证在输电系统上的公平竞争，以及如何监督政府部门在行使管理职能时的公正性。

1、 制订由垄断进入开放的积极的能源政策

目前，国外电力工业发展已经到了一个新的阶段。电力工业发展面临的问题，不再是如何高速发展，而是怎样打破垄断，为用户提供质优价廉的服务已成为电力工业竞争的主要内容。在这种形势下，电力工业传统的垄断经营已经不能适应需要，相反，必须适应市场经济规律，通过市场竞争降低发电成本，使国家资源能得到更合理的利用，以适应用户的需要。电力工业的这种发展趋势，使得产权的多元化、体制上的自由竞争、电力市场由垄断进入开放的积极的能源政策正在被越来越多的国家所采纳。

在美国，电力正越来越成为一种非垄断性经营的普通商品。电力工业改革的先锋加利福尼亚州已经沿着“开放、竞争、形成交易系统”这条路走了很长时间。从 1998 年 3 月起，电力在加州正式成为一种普通商品参与交易。就象其它的商品交易所一样，加州建立了电力期货交易市场，发电商生产的

电力在电力市场进行交易，用户象挑选其它商品一样可自由选择发电商。目前，加州的这种做法正逐渐被美国其它州和欧洲国家所仿效。

在欧洲，去年以来欧盟国家的电力市场已陆续向竞争者开放。目前，年消费电量在 9GWh 以上的用户可以自由选择供电商，这个指标将来还会降低。在发电方面，任何有能力建造新电站的开发商从 1999 年 2 月开始都可参与竞争，只要新建的电站符合所在国的规划、环保要求和供电标准就能得到批准。同时，为了保证电力工业竞争的公平性，出现了一种将输电系统分开管理、输电和配电分开结算的趋势。电力法规明确电网必须公正地为所有供电商服务，不能拒绝任何一种电源上网，因此电网只是一种完成电力交易的通道，其任务是有偿地把发电商和电力用户连接起来。此外，由于存在着全球性的电力工业改革浪潮，电力市场的竞争不仅在一个国家内部产生，也面临着来自其它国家的竞争对手的挑战。正在进行一体化进程的欧洲自不必说，由于独立开发商的存在，即使两个国家在地理位置上相距甚远，一个国家的独立开发商也可到另一个国家的电力市场参与竞争，正在出现所谓一个市场，多家公司（竞争）的局面。

2. 实行产权改革，组建新的电力工业体系

引进竞争机制，实现资产重组。所有制的变化可以从本质上对已发展了多年的国有电力工业产生深刻的影响，并通过转变观念、培育竞争性电力市场使得电力工业成为独立于政府财政之外的、拥有更多持股人的一种产业，其发展也与公司的每个员工有着更密切的关系。如英国在原有的电力管理体系中，占主导地位的是一家高度垄断的大型发电和输电部门，即中央电力局（CEGB）。它把电卖给 12 个地方电力局，由他们负责向各自所在的地区或在特许的地区内供电，而电力委员会只是一家负责处理有关政策性事务的协调机构。这种垄断体系表现为以建设工程为目的，由集中计划进行投资，并着眼于建立一种成本加利润的价格体系。由于这种垄断体制具有一定的局限性，早些时候英国也曾制订了一些能源法规，试图开放市场以吸引更多的电力生产商，但由于英国中央电力局利用其集发电和输电于一体的优势，有效地进行了抵制，使得当时电力体制改革未能成功。

新的电力法规的出台为电力工业机构重组和所有制改革提供了法律依据。他们利用证券市场的价格机制出售了国有电力公司，不仅使得电力公司的所有权由国家向私人投资者（包括公司的员工）的转变，更重要的是在发电和供电领域引入了电力市场竞争机制。重组后原先的 中央电力局被分成四个部分，电厂分给两大火电公司 National Power 和 PowerGen 及另外一个核电公司 Nuclear Electric,National Power 和 PowerGen 溶入了私人股份，而核电公司在 1996 年以后又完成了产权改革。同时，新成立了国家电网公

司(NGC)，负责输电。随后国家电网公司在股票市场被出售，其原先的12个地方电力公司（它们的前身是地方电力局）不再作为公司的股东，电网公司也完全按电力期货交易市场的方式运作，不再代表国家进行“行业管理”，只起到市场导向的作用。

重组后 National Power 和 PowerGen 分别从国家电力局接管了 17000 和10000名员工，而到1996年员工分别减少到4727和4148人。1999年底 National Power 又分为 Npower 和 International Power，公司利润反而由9400万英镑升到1.91亿英镑。各大公司这种尽量减少运行成本的强烈欲望清楚地表明，在充满竞争的市场中，减少管理成本意味着一个公司能生存下去，它使得电厂的效益不断得到提高。

3. 严格防止部门垄断

部门垄断容易造成执政的失误。电力部门由于涉及面广，很难想象由一个综合部门的几个人去管理一个国家的电力工业，为了防止少量人管理时极易产生的个人观点不同的影响及部门决策的失误对电力工业造成的伤害，需要设置互为补充、互为监督的政府部门。如美国水电许可证由联邦能源委员会、内务部、国家海运和渔业服务部、美国林业部以及环境、资源部门共同审批，避免可能出现某一政府部门偏袒某一电力公司的情况。印度除了设立电力部门外，还设置非常规能源部，分管农村能源，如同我国过去几十年来行之有效的两条腿走路的做法，实现大电大网国家办，小电小网地方建的方针，并从中央到地方都设立了专门的电力秘书，代表行政长官从事协调、监督的工作。

转变政府职能，实行公正管理。政府部门逐渐撤出公司的竞争领域，只对电力工业发展的规划、政策和市场培育等进行宏观指导。在电力体制改革后，电网公司按非赢利方式经营（一般收用网费的5%左右），实用联网自由、用网公开，以保证各电厂竞争上网的公正性。在此基础上一般会转移国家电网公司的产权，使电网公司成为产权多元化的、不再冠以“国家”姓的公司，并由独立电网操作员来管理、其作用如同证券市场中的操作员，国家对电网公司也不再行使传统意义上的管理。

制定服务标准，坚持依法办事。为了加强供电市场的有序竞争，政府需在各种情况下保证电力法规的执行，以便在出现不正当竞争时可采取措施，保护用户的利益。一些国家规定用户有权预先了解电力公司的服务，如果公司的服务达不到要求，它必须给受影响的顾客以相应的赔偿，通过加强监督，帮助公司提高服务水平，增强竞争能力，

各部门协作扶持农村电力系统。目前国际上对农电管理大致存在着单一的公用事业局、中央局和农村电气化局分设、地方自治管理以及农村村社等

几种管理形式，并认为发展农村电力系统主要是地方政府的职责，如果让成千上万的人员离开农村，会影响当地的发展，也会毁了国家的未来。因此，有不少国家农村电力系统是按非赢利方式运作的。一些国家农村电力部门的规模很小，其地方电力工业以自发自供为主，主要为当地农村的综合发展服务，需要兼顾社会效益和环境效益，这些都要政府各有关部门的协作和扶持。

4. 建立独立于发、供电之外的输电系统

电网公司的职责是发展和维护一个高效的、协调的、经济的输电系统并促进发供电的竞争。新的公共电力市场的一个重要特点是要求电网的管理者独立于发电和供电之外，以便公平地操作输电系统以提供联网服务。这种将输电系统独立于发电和配电之外，既非出于对所有权的考虑，也不是私有化的原因，而是由输电部门的性质所决定的。

联网的申请和要求。电网公司对联网是开放的，但有专门的电网法规对联网规定了相应的技术要求，所有需要联网的发电商和配电商必需符合相应的标准，以确保其他的发电商和配电商在联网时不会发生技术性问题。这些联网的条款是对大家都是平等的，避免了对不同电厂实施双重标准。为了促进联网，在营业时有一些严格的规定，要求电网公司在收到联网申请后在规定时间内必须作出答复。在这期间，电网公司将对与联网有关的设计、法律和经济特性进行审查，并对申请者提出相应的要求，申请者在收到电网公司的有关要求后，也有一定的时间来考虑是否接受联网条件。

有关联网和用网费用。发电商和供电商需要向输电系统交纳的费用分为两个部分，即联网费和用网费。电网公司根据发电商净资产的不同征收联网费用，用网费用则由联网和用网的发电商和供电商支付。电网公司应定期公布收费标准和结算费用，以保证公众知道与用网有关的费用，并说明这些费用是合理的，同时也使得电网公司重视做好服务工作，降低电价。目前电费构成中大约发电占 1/2 到 2/3，输电占 5%，配电占 25%，供电占 1%到 7%。

电网的计划和调度。电网的计划和调度是根据每个发电商前一天的报价进行的。每天早上 10 点由各发电商报各自的电价，自报售电价的标的也包括可提供的发电容量，双方从这些报价中可初步确定买卖定单。同时电网公司每隔半小时对电力需求作一个预测，然后对发电作出安排以满足用户的需要。从这些信息得出的电力市场电价，当天下午 4 点就传到各个发电商和供电商，同时也刊登在当地报纸上。根据“电力池（Electricity Pool）”的购电价，电网公司要制订电厂的运行计划，频率控制、电网稳定及电压控制，并把每半小时的价格及电网的技术参数传给发电商，指示发电商第二天可能的发电量及参考电价。输电系统的这种改革是公平竞争的前提，它极大的刺激了新建发电项目的增加以及供电市场的竞争。

5. 厂网分开，组建独立电厂

积极开发优质能源，大力发展可再生能源。电源开发从过去排斥小电源到强调分散方式的发电（Decentralized），认为今后以煤电、油电为主的大电厂将不复存在，电源开发将从资源型向制造型方向发展，有小型化的趋势。欧盟新近决定可再生能源发电比重要从现有的3.2%增加到2010年的12.5%，并主张大小电源一律平等，都可公开上网竞争，甚至有些家庭所有的几十千瓦的微型电站也可自发自供、多余上网，自由进入市场。

实现电源端的产权转移。如英国在改制过程中，National Power获得了发电装机30，000MW，PowerGen则拥有18，000MW的火电站，原先由中央电力局拥有的大约8400MW核电划给了核电公司，容量为2100MW的抽水蓄能电站划给了新的电网公司。后来第一水电公司从电网公司接管了抽水蓄能业务，现在其资产已由美国的Mission能源公司拥有。National Power和PowerGen还把6000MW的电力装机出租给了东方电力公司。尽管如此，这些由国家电力局派生出来的公司并不是电力市场上唯一的公司。允许发电并出售电力的公司还有诸如法国电力公司等其它国家的公司和一些新组建的发电公司，所有这些都增加了在发电端的市场竞争。

发电与供电分开，发电商不再承担供电任务。新的体系有一些重要的特征，电力贸易是通过开放的公共市场来进行的，发电商不再承担供电任务，不向任何特定的市场供电，而是把电卖给一个开放的共同的市场，即人们所说的“电力池”。它取代了电力工业中传统的供电区的概念，打破了对电力销售的垄断。

竞争的出现改变了发电端管理的重点。虽然在过去整个发电行业为业主和政府带来了很多效益，并在保证“灯总是亮的”方面有很好的业绩，但这种体制不是以用户需求基础的，不能适合市场竞争的情况。为了能在竞争日益加剧的市场上争取更多的份额，发电商必须积极努力。

6. 配供分开，取消特许供电区

开放配电网络。地方电力公司的主要业务是配电和供电，为了在供电领域内形成竞争，要求地方电力公司在公平的基础上开放配电网络，这就使得地方电力公司的配电用户并不一定是该公司的供电用户。虽然如此，但对一个典型的地方电力公司来说，其效益主要来自公司的配电业务。如英格兰电力公司每年的配电营业额有3.3亿英镑，而其利润可达1.2亿英镑，而公司的供电业务每年大约有13亿英镑的营业额，但其利润只有3千万英镑。

降低配电费用。配电就是在每个取得许可的地区内把电力从电网送到用户。通过价格调节措施，并随着线损的降低，配电网的使用费在不断下降。如英国政府规定了各个公司允许收取的配电费用应该从1996年起连续3年

每年下降 3%，以便降低电价。

取消特许供电区，用户自由选择供电商。在改革初期为了保证配电端改革的有序进行，采用了颁发供电许可证与用电大户自由选择发电商并存的体制，只有持有供电许可证的公司才能卖电。许可证可分两类，第一类称为公众用电供电许可证，每个地方电力公司都拥有该类许可证，它规定了在经过授权的地区内电力公司可向自己供电区内的用户供电。公众供电许可证只在被授权的供电区内有效，仍具有垄断性质，故要设立相应的价格控制措施。

另一类称为第二许可证。持有此类许可证的地方电力公司能对本供电区以外的地区供电，这类许可证还允许发电商或者其他人直接对用户进行供电，取消了垄断的供电区，允许所有用户可自由选择供电商，这样电力市场的竞争就更为激烈，使得德国在改革次年电价就降了 30%左右。

7. 组建非赢利性的农村电力系统

农村需要适合农民特点的电力市场。很多国家农村供电都经历了由孤立电厂供电、农村地方电网供电、及发展成整个农村电力系统几个阶段。即使对美国这样的发达国家，其农村供电也是由公共电力公司，投资者所有的私人公司及农村电力合作社三家分别供应的，其中农村电力合作社向美国全国 7%的人口供电，供电电量约为全国农村用电的 40%左右，避免了对农村电力市场的垄断。

组建非赢利性的农村电力系统。如美国农村电力系统的主要特点是为它们服务的对象所拥有，实行自建、自管、自有的方针，由用户入股组织起来，组建非赢利性的农电合作社，并保证农村供电区的基本不变。股东和用户有截然不同的利益，股东理所当然地要得到较大的回报，以及股票在市场上增值，而用户则希望得到较低的电价和较好的服务。美国农电局资助的农村电力系统是非赢利性组织，其唯一的目的就是在可行的最低电价下提供尽可能好的服务。

由地方自主管理农村电力市场。由美国公用事业局支持的农村电力合作社内接受服务的用户同时也是合伙的所有者，农村供电区以及合作社都是为当地所有、由当地管理的，它可以更好地适应农村当地用户的特点，这比把所有权和控制权给纽约市、费城或者芝加哥州政府要有效得多。由于美国公用事业局是如此的有影响，以至一些人至今还误认为农村电力合作社是联邦政府所拥有的基层组织，其部分原因是因为许多农民对早些年美国农电局提供的资金和技术上的援助心存感激，甚至今天，一些人仍在回答电话时会说是县公用事业局，而不是某某县电力合作社。美国农村电力合作社成功运作表明，当地决策权、所有权与政府扶助的有效结合的重要性，它促进了美国农村电力系统的长期稳定的发展。

8. 防止垄断农村电力市场

农电市场由于覆盖面大、起点低，随着农村经济的发展，前景十分看好，因此往往成为公司追逐的目标，使农村电力系统常常受到侵占。如在美国出现了:

抢占农村主要用户。在农村电气化计划开始之初，一些公司采取的是“撇奶油末（cream-skimming）”的方式，急速地建立起一条输电线来拉拢那些最好的用户，以此抢占农村电力市场。这种做法极大的破坏了农村电力系统的规划和服务区域，造成一些无人供电的死角，甚至几十年后，仍有小部分农村地区受不到用电服务。

侵占农村供电区。对于一些电力公司原来不愿去供电的农村人烟稀少的定居点，在农村电力合作社为了少数的几个用户而付出很大的代价和繁重的劳动建立起供电服务体系后，现在却因为有利可图而使这些公司越来越向农村扩张，农村电力系统的供电区和用户也被电力公司所侵占。

恶意接管农村电力系统。农村电力合作社总在人所不屑的地方默默耕耘，而随着他们的目标：用户更多、经济更发达逐步实现的时候，他们所得到得回报只是将自己供电区中的精华部分乃至自身让给了这些公司。这种恶意的接管和购买用意昭然，面对一个让电力公司梦寐以求的整个农电系统的资金和供电区，他们的欲望如何会不膨胀呢？

美国在反对农电垄断方面的经验值得借鉴。1995 年春，许多投资者所有的电力公司从联邦新税法的变革中意外地获得了大量现金收入，他们之中有许多公司不得不成为“忙碌的收款员”。密西西比州，衣阿华州和怀俄明州一些有大量现金的电力公司把目标转向于并吞这些州的农村电力合作社上，他们把农村电力合作社看作是可以接管的“猎物”，通过接管和扩充的措施来为他们应付的税款寻找合适的“收容所”。但是电力公司的企图没有成功，经过多次裁决，美国最高法院裁定了在丹佛的三个州的农电合作社的地位，毫不含糊地指出：这一事例已取得一致意见，应把第十巡回上诉法庭的决定看作是对电力公司的一次警告，美国将采取一切必要步骤来保证纳税人支付数十亿美元所支持的农村电气化计划得以实施。

1987 年，Brighton 农电合作社成功地抵制了科罗拉多州电力公司的恶意接管。当时 100 多名农电合作社职员和成千上万的用户一起聚集在 Brighton，给合作社最有力的支援。美国农村电气化协会也给那些遭受围攻的合作社提供了资金援助，它筹建了一项“正义基金”来帮助合作社同那些恶意接管历史上由农电合作社长期供电的供电区做斗争，还安排专门人员帮助受到接管威胁的成员。美国农村电气化协会认为，如果农村电力系统还想继续实现把电力和光明以合理的价格送给需要它的人们的目标，必须要保持农村电力系统这一竞争力量，并要依靠法律抵制那些恶意的接管。

三. 关于我国电力工业打破垄断的几个问题的思考

1. 我们能打破电力垄断吗?

长期以来,我们还没有改变层层垄断的局面。从技术上看一个乡镇电管站就可以垄断公民的用电权,基层电力公司还可能制约小电站上网发电的权利,还有部门垄断、计划垄断、技术垄断等等。但是这个垄断那个垄断都是去垄断别人的,经济全球化后,如果我们自己不迅速把我国的电力工业发展起来,就会由别人来垄断我们,到那时我们就更被动了。

事实上,经济全球化会产生两种绝然不同的效果。一方面它打破了地区、国家、行政垄断,使竞争与兼并加剧,极大地促进了全球经济的发展;另一方面,经济全球化又造成了一大批富可敌国的超级大公司,在全球实行公司垄断,促成了全球垄断经济的形成和发展,这将会对我国的电力工业发展带来极大的冲击。问题在于:

我们能打破行业垄断、按市场需求实现资产重组、调整我国的电力工业体系吗?

我们能打破行政垄断和部门垄断、根本改变由一个部门管电的状况吗?

我们能打破企业和公司垄断、坚决撤消那些集发、供、输、配电为一体的高度垄断的所谓“电力”公司吗?

我们能建立公平竞争的机制、组建若干个电网公司吗?如果能做到这些,那么就象设在上海、深圳的证券交易所一样,需要考虑怎样由市场导向代替行业管理,在全国办几个电网公司的合理布局问题。

我们能反对双重标准、按产权关系建立独立于电网公司的规模不等的发电公司、供电和配电公司、并让各类公司参与公平竞争吗?

我们能保持当地政府和人民几十年来历尽艰难建立起来的以自发自供为主的农村电力系统的财富、重组前一阶段被搞乱了的农村电力市场吗?

2. 我们还要小水电吗?

过去没有人问过这个问题,我们中的极大多数人认为中国是需要小水电的。但是,现在全国有 5 万多座小水电站,总装机相当于一个半三峡工程,全国二分之一的国土面积、三分之一的县、四分之一的人口主要靠小水电供电,有人就认为小水电“多”了,小水电“大”了,体会到了小水电的竞争力。

事实上,我国小水电发展的道路是不平坦的。如同八十年代美国的里根执政时期,当时在遗产基金会的支持下,一些急燥的改革者和不完全了解农电的城里人认为罗斯福总统建立起来的美国农电局已没有存在的必要,并中止了美国农电局向政府财政、银行借款和取得优惠贷款的权利。但是幸运的是美国农电局不但生存下来了,而且改名为美国公用事业局后,业务范围涵

盖了农村供电、供水、电信、卫生等，今天美国农村大约有 40%的电力是由其所属的全国一千多个农村电气化合作社供应的。

其实道理很简单，农村需要适合农民特点的电力市场。如果想到全国有 4000 万、世界还有 20 亿人口没有用上电，农民们沿袭着日出而作、日落而息的生活方式，妇女们仍然摆脱不了木柴和洗衣板，孩子们还要在昏暗的油灯下看书，盐制食品仅仅是为了便于保存，户外的粪坑对健康又十分有害……，这些作为回忆可能还会引起人们的怀旧情绪，但对于现实生活中的无电地区人们来说，无论如何总不是愉快的，更不要说电视、冰箱、洗衣机等等科学技术带来的现代文明对农村发展的影响了。

今天无论是你还是我，如果去我国极大多数可居住的乡村，都能够在那里找到可靠的电力服务，能够在那里定居、工作或者是休息看电视，小水电是这么简单地改变了我们的生活方式，它使得我们在选择住处时，消除了那里是否有电力供应的顾虑，这种无顾虑的选择使得全国人民受益。因此，在我国农村还不是太富裕、大量农村青年正往城里去寻找他们理想的时候；在我国还有约 4000 万人饮水困难无电用、农村面临着日益增大的环境与发展压力的时候；在我们面对着今后 25 年将出生的中国 3 亿、世界 20 亿人口的用电需求的时候；我们为什么不把我们身边的上亿千瓦的小水电资源开发出来呢？这种依靠当地力量、自力更生办电、促进山区农村发展的小水电精神和农村电气化事业，我们这一代人怎么能把它丢掉呢？

Annex 18

Annex 18

Report on the Recruitment of International Staffs

The recruitment of international staffs are made in accordance of the requirements as described in table 1 "International Volunteers at IN-SHP".

Table 1. Posts for International Volunteers at IN-SHP

Ref	**Position**	**Role**	**Qualification**
V99-1	Consultant to SHP Trust Fund Establishment	Help establish a SHP Trust Fund	Senior 20+yrs experience
V99-2	Consultant to Fundraising & Special Projects	Help secure adequate funding for IN-SHP operations and activities.	Middle 5+ yrs experience
V99-3	Accounting Consultant	Support IN-SHP financial department	Middle 5+yrs experience
V99-4	Consultant to IN-SHP Technical Cooperation	Support and participate in IN-SHP Technical Cooperation.	Senior 10+ yrs experience
V99-5	Project Manager	Help successful integration of small hydro into multi-funded rural development programs	Middle or Junior 0-5 yrs experience
V99-6	Consultant to IN-SHP Relations with UN & other Int'l Organizations	Enhancing IN-SHP relations with UN system Support IN-SHP cooperation with other Int'l organizations	Senior 10+ yrs experience
V99-7A	IN-SHP membership Networking Consultant	Support all aspects of IN-SHP membership networking	Middle 5+ yrs experience
V99-7B	IN-SHP membership Networking Executive Officer	Support all aspects of IN-SHP membership networking	Junior 0-2 yrs experience
V99-8	Project Editor	Support IN-SHP in editing, planning & public relations	Middle or Junior 0-5 yrs experience

We put the volunteer opportunities on various web site such as IN-SHP home page, Idealist web site, NetAid web site and others. By April 2000, there are 11 international staffs were recruited. Please refer to the following table for details.

Table 2. Recruited International Staffs

No.	Name	Position	From	Duration	Results
1.	Prof. Hans Petry	Senior Consultant to SHP Database and IN-SHP Development Strategy	Germany	Feb. 22 - Mar. 12, 1999	Helped collect SHP data in Germany & other European countries; provided suggestions in the capacity building of IN-SHP and establishment of SHP Trust Fund
2.	Mr. D'Arcy Alarie	Senior Consultant to Public Communication	Canada	Feb. 22 - Apr. 24, 1999	Co-organized the 1999 Annual Meeting of IN-SHP Coordinating Committee in Montreal, Canada
3.	Mr. Hubert Zimmer	Head, International Relations	Germany	Apr. 1, 1999- Apr. 1, 2001	Now in charge of International Relations Division of IN-SHP, supporting all aspects of IN-SHP international affairs
4.	Mr. Michael Molnar	Technical Consultant	Germany	Apr. 1, 1999- Apr. 1, 2001	Now working for Economic Development Division of IN-SHP, supporting all technical activities
5.	Mr. Alessandro Moretti	Senior Consultant to HIC/IN-SHP Management	Italy	May 15- 27, 1999	Recommended optimal proposals to HIC/IN-SHP administration
6.	Mr. Marino Nadalutti	Senior Consultant to SHP Automation	Italy	Oct. 12 -Nov. 9, 1999	Participated in a SHP automation project in Southwest Guizhou province
7.	Mr. Lee Yang Hun	Project Officer	Rep Korea	Feb. 28 – May 2000	Supported TCDC Division and its activities
8.	Ms. Jang Yun Jeong	Project Officer	Rep Korea	Feb. 28, 2000- August, 2000	Finished a 96-page research paper on the environmental impact of small hydropower
9.	Ms. Park Hye Jun	Project Officer	Rep Korea	Feb. 28, 2000- Feb, 2001	Supported TCDC Division and its activities
10.	Ms. Kim Eun Jin	Project Editor	Rep Korea	Feb. 28, 2000- Dec, 2000	Editing IN-SHP monthly Newsletter and the introductory brochure
11.	Mr. Kieran Morel	Project Officer	Germany	Apr. 2 –Sept. 2000	Supported International Rela-tions Division in developing new concepts of IN-SHP's future

Annex 19

Annex 19

TRUST FUND AGREEMENT

between

THE UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

and

THE GOVERNMENT of the PEOPLE'S REPUBLIC OF CHINA

WHEREAS the United Nations Industrial Development Organization (hereinafter referred to as "UNIDO") and the Government of China (hereinafter referred to as "the Donor") have agreed to cooperate in the implementation of a Project entitled " Initial Establishment of the International Centre on Small Hydro Power (IC-SHP) in Hangzhou/China ", (hereinafter referred to as "the Project") which Project is more fully described in the Project Document no. TF/CPR/01/001, which has been signed by the Donor and UNIDO, and which is attached as Annex A hereto and made an integral part here of;

WHEREAS the Donor has informed UNIDO of its willingness to contribute funds to meet the costs of the Project, as indicated in the attached Project Document;

WHEREAS, it has been agreed between UNIDO and the Donor that UNIDO shall be responsible under the terms of this Agreement and the UNIDO financial regulations and rules for the management of the funds contributed by the Donor for the Project;

NOW THEREFORE, UNIDO and the Donor hereby agree as follows:

ARTICLE I

1. The Donor shall, in the manner referred to in paragraph 2 below, place at the disposal of UNIDO a sum estimated at USD 100.000 and UNIDO shall use such funds to meet the costs of the project, including programme support cost.

2. The Donor shall, in accordance with the Schedule of Payments set out in Annex B of this Agreement, deposit the aforesaid funds, upon signature of the Trust Fund Agreement by both parties, in convertible currencies USD of unrestricted use, to UNIDO General Account No. 0127-00662/00, Creditanstalt AG, Schottengasse 6, A-1010 Vienna, quoting Project Number.

3. UNIDO shall establish a trust fund under its financial regulations and rules for the receipt and administration of the aforesaid funds, including interest accruing.

4. The trust fund and the activities financed there from shall be administered by UNIDO in accordance with its applicable regulations, rules and administrative instructions or directives. Accordingly, personnel shall be engaged and administered; equipment, supplies and services purchased, and contracts entered into in accordance with the provisions of such regulations, rules and directives.

5. All financial accounts and statements shall be expressed in United States dollars and there shall be no accounting or reporting in other currencies. For the purpose of recording receipts and/or payments, all transactions shall be converted into United States dollars at the official United Nations accounting rate of

ARTICLE II

The trust fund shall be utilized by UNIDO for the purpose of meeting the actual costs specified in the Project Document in Annex A and to finance the programme support services provided by UNIDO in the implementation of the project. The costs of programme support services shall be calculated as 13 percent (thirteen) of all expenditures from the trust fund.

ARTICLE III

1. UNIDO shall commence and continue to conduct operations under this Agreement upon receipt of a copy of this Agreement, signed by both Parties, and upon receipt of sufficient funds in accordance with Article 1.

2. The Donor undertakes to meet the actual costs of the services specified in the Project Document in Annex A, and UNIDO undertakes not to make any commitments for services not specified in the Project Document without the approval, in writing, of the Donor.

3. If UNIDO considers that changes between components and/or additional services, not foreseen in the Project Document, are required, UNIDO will submit a revised budget for approval by the Donor showing the required changes in inputs and/or adjusted financing that will be necessary.

ARTICLE IV

Ownership of equipment, materials, supplies and all other property financed form this trust fund shall vest in UNIDO. Unless otherwise provided in the Project Document, following operational completion of the Project, ownership of equipment, of materials and supplies, as well as other property necessary for operation of the Project, shall be transferred to the Donor or to an entity nominated by it.

ARTICLE V

Evaluation of the activities financed from this trust fund shall be undertaken in accordance with the provisions specified in the Project Document in Annex A.

ARTICLE VI

The trust fund shall be subject exclusively to the internal and external auditing procedures laid down in the financial regulations, rules and administrative instructions and directives of UNIDO.

ARTICLE VII

In addition to any reports specified in Annex A, UNIDO shall provide the Donor with the following statements and reports in the format normally followed by UNIDO for accounting and financial reporting:

(a) An annual financial statement showing income, expenditures for the year, and assets and liabilities as of 31 December with respect to the funds provided by the Donor;

(b) A final financial statement within six months of termination or expiration of the Agreement.

ARTICLE VIII

UNIDO shall notify the Donor when the activities for which the trust fund was established have been completed. The date of such notification shall be deemed to be the date of operational completion of the Project. The Agreement shall continue in force for the purposes stated in Article X.

ARTICLE IX

This Agreement may be terminated by either party on 30 days written notice to the other party, subject to the continuance in force of Article X for the purposes stated therein.

ARTICLE X

On operational completion of the Project as specified in Article VIII, or termination of this Agreement as specified in Article IX, the trust fund shall remain open until all expenditures incurred by UNIDO have been satisfied. Any balance due to UNIDO under Article III shall be charged by UNIDO to the trust fund and the Donor will reimburse UNIDO for any negative balance in the trust fund.

Upon submission of a final financial statement in accordance with Article VII (b), any surplus remaining in the trust fund shall be returned to the Donor or disposed of as requested by the Donor.

ARTICLE XI

The following addresses are specified for the purpose of this Agreement:

(a) For the Donor:

Address:
Ministry of Foreign Trade and Economic Cooperation (MOFTEC)

Fax:

(b) For UNIDO

P.O. Box 300
Vienna International Centre
A-1400 Vienna, Austria

Fax: (+43-1) 26026 6855

ARTICLE XII

This Agreement shall enter into force upon signature.

IN WITNESS WHEREOF, the undersigned, being duly authorized thereto, have signed the present Agreement in two copies in English on this 3rd day of December 2000.

For the United Nations Industrial
Development Organization:

(Name and Functional Title)

Director-General

For the Donor: Government of the
People's Republic of China:

(Name and Functional Title)

Mr. Sun Yong Fu
Director General, CICETE, China International Centre for Economic and Technical Exchanges, MOFTEC, Ministry of Foreign Trade and Economic Cooperation