Mini- and Micro-Hydropower for Mountain Development in the Hindu Kush-Himalayan Region

International Experts' Consultative Meeting

Kathmandu, Nepal
13 -17 June, 1994

ICIMOD

International Centre for Integrated Mountain Development

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Cover photographs:	Background	:	Purang MHP Electrification Plant, Mustang
	Inset top right	:	A rice huller powered by a small MHP plant
	Inset bottom left	:	Participants of the International Experts' Consultative Meeting

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Foreword

An adequate supply and efficient usage of energy is critical for the development of remote and inaccessible mountain areas and for improving the living conditions of mountain people. Traditional sources of energy, in particular firewood and biomass, still dominate the energy scene of the Hindu Kush-Himalayas. Any new initiative in developing alternative sources of energy should be as far as possible based on an assessment of the appropriateness of the different options that might be available for satisfying the specific needs of specific mountain communities. For centuries Mini- and Micro-hydropower (MMHP) has been used in the HKH in various applications, mainly for agroprocessing. Over the last 30-40 years considerable efforts have been made to use hydropower also for generating electricity in remote areas of the HKH mountains, where connection with the national grid would be unlikely in the short or medium term.

This Consultative Meeting of MMHP experts was organised to review the status of some of the MMHP projects that have been implemented so far in different countries, including the status of MMHP policies and the experience of the private sector. In terms of outputs, the Consultative Meeting formulated appropriate recommendations for the acceleration of MMHP programmes in the HKH Region and for solutions to the problems being faced by private decentralised MMHP plants. More specifically, the Meeting also identified and evaluated the training needs of various groups and prepared outlines for an orientation-cum-training programme for high level decision-makers which would enable them to evolve and adopt suitable policies for the promotion of MMHP. It is hoped that the concerned agencies and government departments in the participating countries will be able to take advantage of these recommendations.

Participation in the Meeting was of a very high level, both from the Region as well as from abroad, and highly experienced persons from international agencies, such as the Intermediate Technology Development Group (ITDG), the Swiss Centre for Development Cooperation in Technology and Management (SKAT), and the Association for Promotion of Appropriate Technologies (FAKT), participated.

An important aspect of the Consultative Meeting was the presentation of information about the extent and diversity of the programmes and approaches in the implementation and management of MMHP plants in the Region, as well as the level of achievements. It is hoped that, as a result of participation in this Consultative Meeting and the subsequent orientation programme for decision-makers, these countries might also introduce private sector programmes.

ICIMOD has always considered renewable energy resources for the mountains to be a priority area. Development of a better understanding of appropriate energy systems and policies will continue to be accorded high priority in the future in ICIMOD's activities.

The Meeting was part of an ongoing project in which five HKH countries are participating. This project is sponsored by the Norwegian Government and its main aim is to evolve ways and means to strengthen the capabilities of the participating countries for the implementation of MMHP programmes in a sustainable and efficient manner.

Egbert Pelinck
Director General

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1. INTRODUCTION

Background

The overall level of development in the Hindu Kush-Himalayan range, home to about 120 million people, is very low. Agricultural productivity, infrastructure, and many other aspects are quite inadequate. The same is the case with energy. Not only is the per capita usage of energy very low, there is an almost complete dependence on fuelwood and other biomass, and tree cover is becoming scarcer, leading to degraded lands and destabilised mountain slopes. Some of the mountain areas are already barren and the people, especially women, are facing considerable difficulties in obtaining adequate biomass even for basic needs such as cooking. Industrial activities, both modern as well as traditional, are minimal; and non-availability of adequate and affordable energy supplies is at least partly to blame for these difficulties.

Most of the mountain areas in the HKH Region are endowed with a renewable and environmentally-friendly resource; i.e., hydropower, especially in the mini- and micro-range (say up to a 1,000 kW capacity per plant), which has many advantages over other fuel systems, including large hydropower (HP) plants. Some of the main advantages are listed below.

- A sizeable potential exists in almost all the areas of the HKH Region.
- The plants are comparatively more viable for remote and inaccessible areas than other commercial fuel systems.
- They are easier to design and manufacture locally.
- Sophisticated and expensive instrumentation and control systems can be avoided for the most part.
- The plants are cheaper to manufacture and install by a factor varying between two to five compared to imported plants, and they can be repaired easily using local facilities.
- The problem of transporting other fuels to such difficult areas can be offset.
- The organisation and management (O&M) costs of privately-owned/-operated plants are also much lower.
- Indigenous design and manufacture of such plants contributes towards development of the local industrial base as well as technical expertise, which is useful for other development work.
- Adverse environmental effects are minimal.
- Mini- micro-hydropower (MMHP) is more suited to decentralised development, and this includes the design, manufacture, installation, and operation/management.
- MMHP can also be integrated with other rural water utilisation schemes to increase benefits and reduce costs.

Unfortunately, MMHP also has some shortcomings; for example, the capital costs are high; the overall performance of endogenously manufactured equipment is usually low; and the resulting breakdowns may be frequent and difficult/expensive to redress. In addition, the locations of the plants may be out of the way and shifting or selling them may be a difficult prospect. However, the overall benefits, including those associated with the environment and indigenous technology development far outweigh the drawbacks. Other problems mainly associated with the implementation and operation/management (low plant factors, untrained staff, inadequate management) can be overcome through amicable inputs such as training programmes, financial incentives, research and development (R&D), and so on. The main advantage is that MMHP is an indigenous, renewable, and environmentally friendly resource; therefore it should be promoted and used to meet local energy needs. MMHP is a comparatively viable option for many remote areas even now, and with the right inputs and support it can become a financially viable and self sustainable system.

The MMHP project is mainly focussed on private, endogenously-developed and implemented power plants, because it has been observed that the principal government electricity agencies, such as Nepal Electricity Authority Nepal (NEA) or Water And Power Development Authority Pakistan (WAPDA), do not consider the MMHP range to be economically viable or easy to manage. In fact, many such agencies are in the process of handing over MMHP installations to the private sector. Additionally, there have been new moves in inviting the private sector to generate power. Also, the more remote and inaccessible mountain areas are usually given least priority by government agencies in the context of providing elecricity or other forms of energy. Recent experiences in Nepal and Pakistan have shown that MMHP can be developed and operated in remote and undeveloped mountain areas by personnel having minimum qualifications or training. Admittedly, the problems are also sizeable, but a process has been established and it can become self-sustainable and reliable, contributing towards further development of mountain areas. Significant progress has been made in evolving different management systems for private MMHP plants. These range from family-owned and operated informal plants to more sophisticated systems managed and operated by trained employees and supplying electricity to a variety of consumers, from households using one bulb to industrial units or commercial establishments such as hotels. Electricity is also used for cooking, heating, hot showers, and even irrigation.

Many international agencies, such as the Intermediate Technology Development Group (U.K) and the Swiss Centre for Development Cooperation in Technology and Management (SKAT), have been promoting the use of MMHP in many parts of the world, including the HKH Region, and especially in Nepal. More recently, the International Centre for Integrated Mountain Development (ICIMOD) introduced a project in this field mainly to assess the current status, policy support by governments, problems, and prospects. Under this project, financially sponsored by the Norwegian Agency for Technical Cooperation (NORAD), country reports were commissioned in five countries of the region; i.e., Bhutan, China, India, Nepal, and Pakistan. These country reports also included specific case studies and accompanying video documentaries to highlight certain aspects of development. Subsequently, a Consultative Meeting of Experts, both from the HKH Region and from outside, was organised to assess the available information and formulate a future course of action. This Report is about the Consultative Meeting held in June 1994 in Kathmandu.

In addition to the Consultative Meeting, the following activities are also planned under the same project.

a) Organisation of national seminars, in each of the participating countries, to disseminate the information acquired through the Country Reports and the Consultative Meeting to a wider audience and to stimulate discussions.

b) A Familiarisation Seminar for decision-makers from participating countries to apprise them of the achievements and prospects. For this purpose, a training manual is also to be developed for use during the Seminar and for possible future use.

c) It is also planned to establish a Regional Information Exchange Network for MMHP to link various agencies in the Region, so that access to information is easier and collaboration facilitated.

Objectives and Expected Outputs of the Meeting

The following were the main objectives of the International Experts' Consultive Meeting.

- **General:** to pursue ways and means to proliferate MMHP and meet the energy needs of remote and inaccessible mountain areas by rendering MMHP technically and economically viable.
- To discuss issues, share ideas, and draw upon replicable experiences.
- To identify training needs and priorities on all aspects of MMHP.

In addition there were two specific outputs expected from the Consultative Meeting.

- Outlines of a training programme for the decision-makers of the HKH Region.
- Conclusions/recommendations for a future course of action leading to sustainable and enhanced growth of MMHP in the region.

A training/familiarisation programme for decision-makers is the main activity under the current MMHP project, and this is expected to take place in January 1995. The training programme is aimed at top-level decision-makers involved in planning, allocation of funds, and overall implementation.

Participants and the Programme

Thirty experts participated in the Consultative Meeting. Eight of them were from outside the HKH Region. There were three experts each from India and Pakistan and two from China, and twelve participants were invited from Nepal, the host country. Most of the participants belonged to implementing agencies in the region, or supporting international organisations. Some professionals also came from the donor agencies working in Nepal. The finalised programme of the consultative meeting, covering five days from 13th to 17th June, 1994, is given in Annex 1.

The Inaugural Session was addressed by prominent people associated with MMHP in Nepal. This session was followed by Planning Session Two, during which the objectives, anticipated outputs, and other aspects of the Meeting were presented and discussed. The proposed programme was also presented, reviewed, and finalised. Country statements were presented during the Third Session by principal participants from the countries of the HKH Region. During the Fourth Session, the Synthesis Report was presented before the plenary body. This was based on country reports from five countries of the Region, giving data and information about installations and programmes. The Synthesis Report was the base document for the

Consultative Meeting. The experts invited from outside the region presented their views on some specific and important aspects of MMHP programmes during the Fifth Session.

The third day was mainly devoted to Group discussions. Five groups (Annex 4) were formed to discuss given aspects of MMHP and formulate initial conclusions. These highlights/conclusions were then presented before the Sixth Plenary Session and comments and suggestions were incorporated. The Groups then continued with discussions and presented their conclusions/recommendations on the fourth day. During the Seventh Session extensive discussions took place. Following this, two small committees were formed to prepare the two main outputs of the Meeting, i.e., Outlines of the Training Seminar and Conclusions/Recommendations for the Future. These outputs were presented before the Concluding Session of the Meeting on the fifth day (morning), followed by discussions in which many suggestions were made. Important suggestions were later incorporated in the finalised outputs of the Concluding Session. After the Concluding Session the participants visited Mohantar village in Dhading District. Unfortunately, the arranged site could not be visited due to a landslide the night before. However, about three other running MMHP plants were visited and discussions were held with the owners.

2. THE INAUGURAL SESSION

Introductory Remarks

Dr. A.A. Junejo, Project Coordinator of the MMHP Project welcomed the participants and outlined the background and purpose of the Consultative Meeting. He stated that this was a very important occasion for ICIMOD and proponents of private/decentralised MMHP in the region, because the participants were going to review the status of MMHP within the region as well as the associated problems and issues. He stated that the Consultative Meeting was being organised under the auspices of a NORAD-sponsored project on MMHP being implemented by ICIMOD, the main objective of which was to assist the countries in the Region to facilitate the growth of MMHP, especially in remote and inaccessible areas. Dr. Junejo also gave some details of the activities and outputs under the project. He further explained that experts in the field having working experience in the Hindu Kush-Himalayan Region were participating in the Meeting.

Dr. Mahesh Banskota, Director of Programmes of ICIMOD, spoke next and welcomed the participants and the Chairman of the Session, Dr. Binayak Bhadra. He then gave a brief overview of ICIMOD, its main concerns, and its various energy-related activities and programmes and explained that ICIMOD's main thrusts were to support the development of national capacities; since, ultimately, the task of integrated mountain development has to be accomplished by national institutions. International agencies, such as ICIMOD, provided assistance so that these agencies could achieve the desired goals. Dr. Banskota also stated that ICIMOD accorded high priority to energy for mountain development. In fact, one of the first programmes introduced in 1984 was an assessment of the rural energy situation and available options. This was followed by a comprehensive programme on 'District Energy Planning and Management for the Mountain Districts of the Hindu Kush-Himalayan Region' and involved a major training programme for planners and implementers at the district level. Energy was a very important input for economic activities in mountain areas, such as sustainable agriculture and cottage industries, and decentralised development of indigenous resources, such as MMHP, which also has clear environmental and local socioeconomic advantages, could play a significant role. However, it was also necessary to demonstrate its viability, both economical as well as technical. Dr. Banskota hoped that the experts attending the Meeting would look at the pros and cons of MMHP thoroughly and put forward practical recommendations to make MMHP an important energy resource for alleviating the energy crisis in mountain areas of HKH Region.

Mr. Odd Hoftun, from Butwal Power Co. (a private enterprise), then gave a brief perspective of MMHP as a useful energy resource based on his 30 years of experience in Nepal. Mr. Hoftun stated that even the smallest Micro-Hydropower (MHP) Plant was a fully-fledged power plant having most of the traditional components and prone to the usual hazards, e.g., floods, landslides, etc. If the engineering was faulty and the components failed then the consequences were also similar to those of larger plants; although the resulting damage might not be so serious for the area or the people, and it could be redressed more easily. This was an important advantage of MMHP over larger HP plants. Nevertheless, failure would cause serious loss and distress to the owners and the beneficiary community. Therefore, mistakes or short cuts in design, construction, and operation should be avoided. This could be done by referring to design books, of which some excellent ones were available. Another important factor about hydropower sites, including MHP, was that each site was different. Therefore, standard designs must be adapted and modified to suit each site. Technical problems were perhaps the easiest to deal with, whereas other problems, especially economic ones, were more difficult. Mr. Hoftun stated that, in the case of MMHP, it was usual and practicable to cut costs through using simpler equipment and using less gadgetry. However, one must be careful not to compromise performance and expected life. It was accepted that MMHP was very practical. However, in order to make it succeed in a given situation, something more than practical smartness was needed, and this was vision: the vision of local entrepreneurs, community leaders, promoters, and installers.

Mr. Hoftun went on to add that rural electrification was rarely economically viable in the short run; unless a well-developed cash economy already existed which made electricity affordable for ordinary people, and not just for lighting. In order to make rural electrification work, its distribution must also be given full attention, in optimising costs, inculcating safety, and promoting proper and productive use. The latter was perhaps the most important factor in determining the economic viability of plants, especially in economically weak rural areas.

Mr. Hoftun explained his own vision concerning rural electrification. He believed that electricity could influence the unhealthy trend of migration to larger cities. Apart from the lights shining from hill villages, it was also necessary to facilitate the productive use of electricity for irrigation, agriculture, and light cottage industries. The Government could assist by establishing a framework of regulations to encourage private entrepreneurs to move their businesses to rural areas. Other agencies, such as NGOs, could also play a part in decentralising the economy through rural industrialisation, development of utilities, and establishment of infrastructure. In this way, the population pressures on big cities could be reduced and the waters of the Bagmati could become clean once more.

Keynote Speech by Mr. Ueli Meier

Mr. Ueli Meier[1], former Director, SKAT (Switzerland), and currently managing a development and consulting firm dealing with energy-related technologies, then delivered the keynote address. Mr. Meier noted that, in order to achieve sustainable development, assessing the real needs of the ICIMOD member countries was a sound strategy. The same criterion must apply to mini- and micro-hydropower development; i.e., assessing the need for and applicability of its output. Unfortunately, this was not being done at present; therefore, only a fraction of schemes were sustainable. One must work towards long-term sustainability of MMHP schemes. At present, various influencing factors were not so clear in this respect. Therefore, ICIMOD's initiative in organising the current meeting in order to exchange ideas and experiences was very welcome. Mr. Meier then elaborated upon two key issues related to the success of MMHP, (i) the basic philosophical concepts and (ii) the implementation aspects, including technology. Touching upon the first category, he suggested that it was important to avoid a major risk of failure and to start with smaller (micro) installations for learning and experience. One should also be careful about reliability standards and the ensuing costs. Unfortunately, it was not easy to make decisions on the drawing boards and the most optimum mix could be arrived at for a given area through experience only. Usually, as more experience is accumulated and plants become popular,

1 Mr Meier has many years of experience in developing countries of the HKH Region and has contributed towards development of indigenous technologies for MHP, especially in Nepal.

technology and sizes could be upscaled. Thus, the basic issue to be addressed was what should be the level of quality control and safety standards for MMHP for a given area/sub-region. With regard to the financing and economic concepts, Mr. Meier stated that, in order to satisfy private investors or communities about reasonable returns or benefits from their investments, local opportunities for the sale of energy must be assessed along with the willingness and capacity to pay the bills and, of course, the total consumption. The economic feasibility of plants must be computed in this way. Subsequently, the level of amortisable capital may be established on this basis and the remaining (non-amortisable) component may be computed for the project and arrangements should be made to secure the non-amortisable investment from other sources. Government support through policies and fiscal assistance were also necessary, including delicensing, waiving water royalties, and facilitating feeding into national grids. There were signs that some governments had taken steps in the right direction, but more needed to be done especially in those countries that have not made much progress. Governments could also help by enacting and implementing legislation on environmental controls.

Mr. Meier then touched upon the reliability issue; explaining that keeping investment costs very low might be desirable for planners but could compromise the reliability of a plant. This may only be tolerable in the case of lighting applications. However, if viable plant factors, which were necessary for reasonable economic returns, were to be realised, efforts must be made to promote more productive power uses for business and industry. For such applications, supplies must be regular and reliable in terms of time, quality, and quantity. Ingenious efforts were needed in this respect, both in the generation as well as in the use of power.

In the context of isolated or grid-connected schemes, Mr. Meier remarked that, although the latter had more sophisticated equipment and were more expensive, they were easier to operate since the main aim was to produce maximum power, 24 hours a day. Isolated schemes, on the other hand, were more difficult in terms of operation, management, and supply. He, therefore, suggested that the ultimate objective should be to interconnect all the isolated units eventually, and, for this, the electro-mechanical design should have such a provision. While suggesting standardisation of MMHP equipment, the diversity of sites and the number of units being produced must be given due consideration. Generators, turbines, and other electro-mechanical components should be standardised if they were being produced in sufficient numbers.

With regard to design and implementation issues, Mr. Meier stated that the training of managers and operators was very important. However, actual working experience with a plant could not be fully replaced by training. The training aspect should, therefore, include implementation of some MMHP schemes in a given area for the purpose of training-cum-demonstration. It was also important to determine and match optimum plant capacity with the potential demand during planning. Availability of adequate discharge during the dry season must also be given due consideration in determining the plant size. Over-designed schemes were unnecessarily expensive and inefficient. Mr. Meier further explained that cost saving was an important and desirable aspect of MMHP schemes; however reliability and performance should not be compromised. On the contrary, in order to make the plants more reliable and efficient, additional expenditure was a better option.

Mr. Meier also noted that, in the case of private MMHP schemes, many diverse parties were involved. Therefore, coordination between them and assignment of responsibilities were important tasks for the main implementing agency. It was better to put things down in writing. In the case of management and operation also, it was important to delineate duties and responsibilities clearly.

Chairman's Closing Remarks

The Chairman of the Session and the Chief Guest, **Dr. Binayak Bhadra**, then addressed the Session. He stated that achievements in this field in Nepal were encouraging; however the question of the role of MMHP in overall power sector development and utilisation must also be addressed. The general feeling amongst planners was that **'small may be beautiful, but large is cheap'**. At the same time, it was also accepted that the answer was neither completely small or large; but each size should be area-specific and MMHP was clearly the answer for meeting the energy needs of the more disadvantaged, remote and inaccessible communities. Another important aspect was competition for MMHP installations, amongst both manufacturers and implementers. Many governments in the Hindu Kush-Himalayan Region had now allowed the private sector to compete in power generation and distribution. This had opened new avenues for indigenous MMHP plants. Institutional set-ups had also to be developed to cater for decentralisation and the ensuing aspects such as tariffs, improvement of efficiency, and so on.

Dr. Bhadra also pointed out some other pertinent issues that had recently emerged, such as conflicts in water uses, including irrigation. He suggested that, in due course, the overall development of a watershed needed to be considered, including water resources development and usage. End-use diversification and enhancement was another important issue. Dr. Bhadra believed that, if attempted properly, MMHP could contribute significantly towards diversification of the rural economy. Thus, the development of MMHP should follow the bottom-up approach; i.e., working out and promoting the demand and end-uses and then developing MMHP sources accordingly. The costs of indigenous MMHP should also be given due consideration. Research and Development and other efforts needed to be increased to bring about a breakthrough in this area. Training was also a very important contributor to the success of MMHP. The current efforts in this area were not so successful. Training aspects for various groups needed to be planned properly with clearly defined objectives. ICIMOD could also play an important role in this area by developing and conducting such programmes for the region. Finally, Dr. Bhadra thanked ICIMOD for organising the Consultative Meeting and for inviting him to share his views and concerns with the participants.

Concluding the Inaugural Session, Dr. Junejo thanked the Chief Guest, the resource persons, and other participants for attending the Meeting.

Session Two of the programme was taken up with discussions on the structure of the meeting and the expected outputs. The participants suggested that group discussions for one full day were probably too long and that certain delegates might like to move from one group to another. Therefore, it was decided that the groups would hold discussions for two hours initially and then report to the plenary session for discussions or suggestions. After lunch, the groups would be reformed and continue their deliberations to formulate conclusions.

3. COUNTRY STATEMENTS AND SYNTHESIS OF EXPERIENCES

During the **Third Session** in the afternoon, Country Statements were presented by the principal participants from China, India, Pakistan, and Nepal. There was no participant from Bhutan. The highlights of these statements are presented here while summarised versions are given in Annex 1.

China - Recent Development

Dr.Tong Jiandong presented the **China** Report concerning the status, government strategies and support, and the impending problems. He stated that the figures presented in the China Report, submitted to ICIMOD, had been updated and new figures included installations during 1993. At present, there were about 48,300 installations in the MMHP-SHP range (up to 25 MW capacity) in China having a total installed capacity of about 15,000 MW; whereas installations in the MMHP range (up to 500 kW) were about 45,600, with a total installed capacity of about 6,000 MW. Giving a brief history of MMHP-SHP development in China, Dr. Tong noted that China had started MMHP development in the fifties and progress over the years was remarkable. Almost all the equipment for MMHP-SHP plants was being manufactured locally. There were about 100 equipment manufacturers, having a cumulative production capacity of about 1,200 MW/year. Most of the MMHP capacity was connected to the local grids. The overall development of MMHP for rural electrification was also progressing at a very fast rate of about 1,000 MW/year. Over the years, the technology had improved considerably, and many small, low quality plants had been replaced by more reliable and larger plants. About 73 per cent of the electricity in rural areas was being consumed by industry and only 13 per cent for lighting purposes. The main features of MMHP development in China were decentralised development and operation; extensive planning policy and material support from various government levels (e.g., Central, Provincial, County); emphasis on 'self-construction, self-management, and self-consumption'; and diversification of end-uses. Dr. Tong thus concluded that MMHP had become an important energy resource for rural areas and a precious contributor to the booming rural economy.

India - Current Initiatives

Mr. Arun Kumar then presented the Country Report for **India.** He stated that the Indian Government had embarked upon promotion of MMHP-SHP (up to 3 MW) capacity on a preferential basis, so that about a 600 MW installed capacity could be added in the 1992-97 period, both in the public as well as in the private sector. MMHP-SHP was being promoted to provide electricity to the people of remote hilly regions, to help protect the environment, and to encourage private sector participation in this important endeavour for national development. He further eleborated that the private sector was being encouraged through many incentives such as subsidies (up to 50% of cost), soft loans (at 12.5% rate), arrangements for buying back power, and encouragement to take over and manage existing MMHP plants in the remote areas. In addition, concessions in custom duties and tax holidays were also being provided. In some areas, portable MHP sets were being provided to communities free of cost for installation and use of electricity. Mr. Arun Kumar further noted that some problems had been encountered with MMHP installations, such as, silting, damage to civil works, non-availability of adequate workshops for repairs, inadequate institutional support, and lack of people's participation. He also mentioned some constraints, especially regarding detailed investigations and preparation of Detailed Project Reports (DPRs), land acquisition, government clearances, coordination between the various government agencies giving clearance and poor infrastructural facilities for the north-eastern mountain regions. The State Electricity Boards (SEBs) were also according low priority to MMHP projects.

Mr. Arun Kumar also made some suggestions regarding specific issues raised in the Synthesis Report, e.g., MMHP should be given preferential support, especially in the poorer, remote areas and for isolated plants; networking of repair workshops; encouragement for establishing small-scale industries, and water pumping for irrigation or domestic use. Mr. Arun Kumar also gave the details of some MMHP plants that had been handed over to local communities in the Uttar Pradesh hills for operation, distribution, and revenue collection. Similar efforts were underway in other States also.

Pakistan - Highlights

Dr. M. Abdullah presented the Country Statement for **Pakistan**. He noted that the recoverable hydropower potential in Pakistan was about 21,000 MW out of which 3,330 MW had been exploited mainly in the medium and large range. The Government of Pakistan accorded high priority to the development of indigenous energy resources, especially for rural electrification. The Pakistan Council of Appropriate Technology (PCAT) and the Aga Khan Rural Support Programme (AKRSP) were assisting in the installation of private MMHP in the northern mountain areas of Pakistan. So far, about 190 plants had been established, by these two organisations, with an installed capacity of about 2.6 MW and providing electricity to more than 11,000 households. PCAT provided cost subsidies of from 40-50 per cent whereas subsidies from AKRSP varied from 20 to 80 per cent. No loans or other incentives were available in Pakistan. The recipient communities provided the remaining cost in cash or kind. After installation, the communities owned the plants and were responsible for operation, maintenance, repair, distribution, and revenue collection.

Dr. Abdullah went on to state that electricity had considerably improved the life of the people in the remote mountain villages and also provided some relief from drudgery and unemployment through agro-processing units, which had been established in about 20 per cent of cases. The MHP plants, mostly in the five to 30 kW range, were indigenously designed and manufactured, costing around US$ 250 to 600 per kW (installed). They did not have any automatic control systems, and regulation was carried out manually. At present, there was no formal training available for the installers, manufacturers, or operators. Villagers usually had some experience in building and maintaining irrigation channels. However, the capability to repair electro-mechanical equipment was weak. Some training was provided to the operators during installation, but that was also inadequate. The need for training various groups could not be over-emphasised.

Dr. Abdullah further noted that the prospects for MMHP development in the Northern Areas of Pakistan were considerable and could meet the energy needs of these areas, especially for the establishment of local industries. People recognised the benefits of MMHP and the demand was quite high.

Dr. Abdullah also identified a number of problems associated with private MMHP in Pakistan, i.e., lack of proper systems to deal with conflicts in the villages, lack of adequate funds, and lack of technical and transportation facilities in the remote areas. He, therefore, made the following recommendations to accelerate the MMHP programmes. Decentralised/private MMHP should be recognised as a viable option for remote rural areas; PCAT and AKRSP should further strengthen their technical/professional capabilities, local industries should be encouraged to diversify the end-uses, an adequate training system should be devised for concerned groups, and electrification through grid extension and through MMHP plants should be properly coordinated.

Nepal - Programme Status

Dr. K.B. Rokaya presented the country statement for **Nepal**. He remarked that per capita energy usage in Nepal was very low and was characterised by a heavy dependence on traditional biomass fuels which had many ill effects. Therefore, it was necessary to develop indigenous and viable sources such as MMHP, which had been around for centuries, and considerable expertise had been accumulated within the country in developing and installing modern MMHP plants. Dr. Rokaya added that, until the present, about 37 plants had been installed in the government sector in the MMHP range (up to a 1,000 kW capacity), and about 900 more were installed in the private sector in the MHP range (up to a 100 kW capacity). These plants were mainly for agro-processing, but about 100 or so also generated electricity. The privately installed plants were contributing significantly to meeting the energy needs in many remote areas. His Majesty's Government of Nepal (HMG/N), had also contributed significantly towards the development of private MMHP through delicensing plants of up to 100 kW and by providing subsidies for the equipment. Installation rates had declined during the past five years.

Dr. Rokaya further noted that capital costs, as well as repair costs, for MHP were site-specific and varied considerably. During recent years, the cost per kW was between NRs 77,000 to 100,000 (US$ 1,530-2,000). Over all, MHP plants for agro-processing were reported to be viable both financially and technically. Some factors affecting the profitability of the plants could be improved through appropriate efforts; e.g., consistent and transparent government policies, effective management and monitoring of loans and subsidies, R & D, promotional activities, adequate training facilities, and establishment of an independent institute to promote MMHP.

On the technical side, Dr. Rokaya remarked that lack of standardisation and quality control, plus improper installation practices had caused frequent breakdowns and the repairs were not easy to carry out. Therefore, the owners faced considerable hardships in getting repairs done which were difficult, time consuming, and expensive. He stated that political commitment, institutional arrangements, financial support, coordination, training, and improvement of technology would be helpful in enhanced dissemination of MMHP technology.

Discussions

After the presentation, discussions followed. A question was asked from the floor concerning how MMHP-electricity was able to replace biomass to that extent in China. Dr. Tong pointed out that proliferation of rural industries was remarkable, therefore use of electricity had risen considerably to cater for this need. Also, cooking was carried out on electricity in many areas for a good part of the year. There was some discussion on why cost/kW of generation varied so much across the countries. It was clarified that cost figures in some cases represented just the plant cost; whereas, in other cases, costs such as civil, electro-mechanical, and distribution lines were also included. The cost per kW was also dependent upon plant size and it was pointed out that in China the cost was inversely related to the size. Therefore, at present, manufacturers were reluctant to manufacture turbines with less than a 50 kW capacity.

Plant/load factor was another intensely-discussed issue. Low plant factors in general were observed across the countries in the HKH region, but it was pointed out that this factor alone should not be used in deciding the viability of MMHP. It was again pointed out that, in China, many isolated and old micro-stations were decomissioned each year due to low load factors. The floor also discussed the grid connected MMHPs and the system of power sale and buy-back arrangements prevalent in China. It was pointed out that transactions between local grids took place in the form of barter. With regard to the subsidy issue, it was observed that cost/kW was quite low in Pakistan and a still sizeable subsidy programme was in place. It was clarified that, even though both PCAT and AKRSP had decreased the subsidy in the recent past, there was still a need to support MMHP development by subsidies from the Government. Only in the long run could it be completely withdrawn. The local user organisations, it was pointed out, were using their savings to meet their share of obligations in availing of MMHP plants.

In the Indian case, it was pointed out that MMHP in the stand-alone mode were not considered to be viable. They were also not very reliable because of frequent breakdowns caused by mechanical failures or damage to civil structures. In remote areas these units primarily provided electricity for lighting. Other household needs were being met by fuelwood. In the case of Pakistan also, electric lighting was the first priority followed by other secondary uses. Therefore, investment in MMHP should also be seen as an investment in improvement of the quality of life. There were some questions from the floor regarding the modalities of implementation by AKRSP in Pakistan. It was pointed out that basically two stages could be visualised. Firstly, local people had to be organised into groups (village organisations) and, secondly, they had to arrange for operation and maintenance expenses. Only then was the plant to be provided.

The floor discussion also touched upon the objectives of MMHP development which were seen to be more than economic objectives alone. Similarly, discussion took place on the need to expand end-uses. With regard to the question of subsidies for increasing end-uses, it was found that only in Nepal was there such a provision in the Annapurna Conservation Area Project (ACAP). The other countries had no policies in this respect.

After concluding the discussions, the Chairman of the Session, Dr. Mahesh Banskota, made his observations and suggested that MMHP should not be seen in isolation but in the totality of its forward linkages. He cited the Chinese experience in this respect. The Chairman underscored the need for political commitment for the development of MMHP. Only then, he observed, would proper policy support, legal backing, skill development programmes, fund allocations, etc, become meaningful. The Chairman also underlined the importance of the participative process for MMHP development. This process could be extended to each phase of MMHP development, e.g., construction, operation, and maintenance. The Chairman concluded by observing that it was essential to speak the same language while promoting MMHP, otherwise, he cautioned, there were dangers of misunderstanding the basic objectives of promotional efforts.

Synthesis of Country Experiences

During **Session Four** on the second day, Dr. Junejo presented the Synthesis Report on the Status, Policies, Problems, and Prospects of MMHP. The Synthesis Report was the base document for the Consultative Meeting and had been sent to participants in advance. A summarised version of the Report is given in Annex 2. Highlights of the Report are briefly given below.

There were considerable advantages of MMHP in remote mountain areas compared to other systems, such as diesel plants and grid electricity, and a sizeable potential also existed in the mountain areas of all the countries in the HKH Region.

Only China had exploited the MMHP-SHP resource to a significant extent. The level of exploitation in most other countries was around one to two per cent of the viable potential. Dr. Junejo then gave some installation figures for Bhutan, China, India, Nepal, and Pakistan. He stated that there were 19 MMHP plants (up to 1,000 kW) installed in Bhutan with a total capacity of 3.40 MW, and 145 plants were working in India with a total installed capacity of about 106 MW; in both cases in the public sector. In Nepal, there were 36 existing MMHP plants in the Public Sector with a total capacity of about nine MW. In addition, there were about 900 private MHP plants (up to a 100 kW capacity), mostly used for agro-processing, with a total installed capacity of about 11 MW. However, about 200 plants had the facility to generate electricity, either in addition to agro-processing or as stand-alone. In Pakistan there were about 65 MMHP plants in the public sector, with an installed capacity of about 17 MW and 186 plants in the private sector with a total capacity of 2.6 MW. In China, the maximum number of MMHP plants had been installed, and currently there were about 49,000 MMHP plants (up to 500 kW in capacity) with a total installed capacity of about 4,800 MW. These plants were installed and were being managed by local administrations at the village, county, or township level. Except for Bhutan, where the manufacture of MMHP equipment was not being undertaken, all the other countries had a sizeable capacity to manufacture most components. The costs of such equipment was lower than those for imported equipment by a factor ranging from two to five.

Dr. Junejo further explained that many Governments of the Region, including China, Nepal, and India had made special provisions for MMHP through legislation, policy declarations, and provision of incentives. HMG/Nepal had allowed the delicensing of plants of up to 1,000 kW in capacity, announced special incentives for private sector participation, and provided loans and subsidies for such installations. Grants and loans were also being provided by the Governments of China and India, while the Government of Pakistan provided some subsidies for private MHP installations. Many of the private plants in Nepal and Pakistan were owned and managed by local people from consumer communities, while implementing agencies, such as the Pakistan Council of Appropriate Technology (PCAT) or the Agricultural Development Bank of Nepal (ADB/N) (in collaboration with the manufactures/installers), surveyed the sites, designed the plants, and had them manufactured, installed, and commissioned. After commissioning, the plants were handed over to the users/owners for operation, maintenance, and utilisation. In China also, plants were managed and utilised in a decentralised manner at the village or county level.

Dr. Junejo noted that funding for private/decentralised plants came from various sources such as bank loans, subsidies, and owners' contributions. The level of external funding varied considerably. In Pakistan, for example, villagers were contributing about 60 per cent of the costs of plants at present, whereas in most other cases the contribution by villagers was around 10 to 20 per cent, mostly in kind. In Nepal, applicants for plants obtained bank loans at interest rates which were only slightly lower than the commercial lending rates. The Government of India was also providing loans to the extent of 75 per cent of plant costs at 12.5 per cent interest rates. However, in India, entrepreneurs had to obtain clearances from three government departments and were expected to pay about 10 per cent in royalty to the Government for use of water.

Dr. Junejo went on to explain that only in a very few cases were the plant factors reasonable, i.e., 40 per cent or above; otherwise factors varied between 10-30 per cent. The plant factors were even lower for electrification schemes than for agro-processing units, and incomes from the plants were barely enough to cover operation and maintenance costs. This was, in fact, one of the serious problems of private MMHP plants. Another serious problem concerned the inadequate capabilities of the managers and operators of the plants who usually had had no schooling and were insufficiently trained to manage and run the plants properly. Carrying out of repairs was also quite difficult and expensive in remote and inaccessible areas.

In terms of the impacts and benefits of MMHP, China had achieved the maximum benefits and even now they were talking of increasing the pace rather than slowing down. They were improving the technology, enhancing plant factors, and diversifying end uses. Technology and its advantages, as well as its limitations, were also well known in Nepal and Pakistan. However, the associated problems had also become serious, especially in Nepal. Training was one aspect which could alleviate many of the problems, and this was necessary for various groups including decision makers, village elders and influentials, surveyors and assessors of sites, various technical personnel, plant managers, operators, and repairers.

During the discussions that followed the presentation of the Synthesis Report, the meeting was informed that the rates of interest for MMHP/SHP installations in India had gone down to 12.5 per cent recently and that subsidies were available only up to three megawatts. In the case of Nepal, it was stated that surveys for potential assessment of the installations were usually not adequate and many MMHP plants were not running well. One of the main installers, the Development and consulting Services (DCS) was only undertaking technical feasibility, and commercial feasibility was almost non-existent. In many cases, the consumers were not paying the bills because electricity supply was unreliable and poor. Steps to improve the MMHP plants and electrical supply were discussed in detail, and it was pointed out that these steps would escalate the costs. There were inevitably many responses to this aspect. General consensus was that it was necessary to improve plant reliability and performance. This approach might even be more cost effective in the long-term since other end-uses could only come about when the supply was good (quality-wise) and reliable. Another issue raised was that, in many areas of the HKH Region, especially Nepal, the people were so poor that electricity was a luxury for them and they found it quite difficult to pay cash for it. This point was conceded and it was suggested that the only worthwhile suggestion could be that this point be given due consideration at the time of feasibility. The possibility of establishing an independent institution was also discussed in detail. General consensus, especially from the Nepali participants, was that such an Institution was necessary. However, if it was in the private sector (totally independent) then it may not have adequate authority to implement the rules or guidelines. On the other hand, if it was in the government sector, it may not be efficient enough. This situation needed more thinking and debate.

The viability of MMHP was discussed next. It was reported that agro-processing units were generally doing well economically but that electricity generation through MMHP had serious problems. What could be done to improve the viability of electricity plants? The response was that electrical light was the best lighting system; therefore, it should not be compared with kerosene lamps. Additionally, the amount of money being spent on electricity was comparably even lower than the cost of kerosene. Therefore, this must be considered as an additional benefit. It was also stated that MMHP and electricity generated by it could be an effective tool to promote rural development. However, other inputs had also to be provided to make it work. Various training aspects were than discussed and most participants were of the opinion that adequate training to various groups, including engineers (electrical, mechanical, civil), managers, operators, wiring technicians, and installers would improve the situation and make the electricity supply more reliable. The proposed training of decision-makers was also discussed and suggestions were made to make it effective. It was suggested that an attempt should be made to convince the decision-makers about the usefulness and advantages of MMHP, highlighting the success stories, comparing it with other energy options, focussing on its suitability for specific remote areas, and outlining the constraints. It was also suggested that, instead of calling it a training course, the programme should be called a Seminar. It was also suggested that, ICIMOD should play a major role in developing and organising training programmes for other groups.

The Chairman of the Session, Mr. Ueli Meier, then thanked the speaker and the participants and stated that viability and reliability had become the important issues concerning MMHP.

4. HIGH PRIORITY ISSUES OF MMHP

Policies and Government Support

During **Session 5**, a number of experts presented their views regarding some important aspects of MMHP. The first speaker, Mr. Alex Arter of SKAT, talked about 'Policies and Government Support for the MMHP Sector'. He stated that a policy environment conducive for promotion of MMHP usually has three possible components; i.e., policies, legislation, and material incentives. While there may be a considerable amount of stated support, as was the case in Nepal, implementation practices could greatly influence the outcome of policies. Policy objectives for MMHP development were watershed management, coordination with the overall energy policy, and other macro-policies such as agriculture, rural development, and industries. Other objectives could be promotion of MMHP use and encouragement to private sector participation. The main thrust in the legislation had been deregulation aimed at inducing private investors, allowing 'market' tariffs, and simplified licensing. Other useful legislation mechanisms were waiving water-use royalties, access and sale of electricity to the grid, and fiscal incentives. In some cases 're-regulation' was introduced in the garb of deregulation. Incentives might also become dis-incentives if proper care was not taken. In practice, the incentives might also not be certain and consistent. Sometimes, implementation practices had been such that financial risk to the investor had not decreased and many conflicts remained. Consequently, Mr. Arter concluded that the situation regarding private investment in the MMHP sector was still in the embryonic stage and a financial payback dilemma persisted. Similarly, the role of donors and development agencies was uncertain. The main concern for forums, such as this meeting, was to discuss ways and means of making MMHP more competitive. During the discussions it was asked what were the main reasons for the policies not achieving the intended objectives. The response was that usually the objectives were not clear and implementation practices were problematic.

Indigenous Technology Issues

Mr. Allen Inversin then spoke on the subject of 'Indigenous Technology Issues'. He stated that many technology-related issues could significantly affect the viability and attractiveness of indigenous MMHP options and could affect the opinions of the decision-makers. First among the important issues raised was costs vs quality; did the effort to reduce the cost of indigenous technology actually diminish its efficiency and reliability and thus discourage further dissemination? Mr. Inversin went on to highlight various aspects of the issue, quoting some examples. Lower costs were important, however, the quality and life were more important and, if *lowest life-cycle costs* were estimated, more reliable but expensive/imported turbine equipment could be a better alternative. If this line of thought was to be countered, a careful survey of a proper sample of installations must be undertaken to assess the true costs of technology. Under these circumstances, there was a need to put a mechanism into place to ensure quality control, including replacement/correction of flaws observed in installed equipment. The second issue raised by Mr. Inversin concerned 'Honesty in Labelling'. In many cases the rated outputs of MMHP plants were unattainable. Most probably this was due to the lack of expertise of the manufacturers/installers. However, such false claims could cause discredit for the technology as a whole as well as disillusionment of the owners. To deal with such circumstances, a special organisation could be authorised to test the equipment for claimed outputs. This organisation could also set performance standards and enforce guarantees from the manufacturers to their clients.

Mr. Inversin also suggested that the traditional low-cost designs of civil works must be investigated to determine an optimum trade-off. He, however, warned that increased use of concrete might not solve the problem. Appropriate guidelines must be drawn up by the experts in the field. Governments had been variously criticised for not taking appropriate action to promote MMHP. However, a survey might be useful to find out whether the lack of interest was not due to the fact that they were not adequately convinced about the viability of the technology. Studies could reveal that the necessary convincing of the concerned agencies, based on facts and other supporting material, had not been attempted. Listing objections/arguments from the government side could also be helpful in developing arguments and also in undertaking other efforts to make MMHP more viable. Mr. Inversin further pointed out that complementary efforts were usually missing in the implementation of MMHP projects. Such efforts should be in the form of R & D for end-use development and should include appliances, preparation of various guidelines/standards, organising of training programmes for different groups, and establishing working relationships with other relevant government agencies. He felt that a centralised organisation to support MMHP development could play a better role by making complementary efforts as well as arranging funding.

The follow-up discussions mainly dwelt upon indigenous technology issues. It was observed that indigenous development helped an area in other ways also. The response was that indigenous technology development was not being rejected. Studies were suggested to assess how cost-effective indigenous technology was.

Plant Utilisation

Mr. Reinhold Metzler then presented his views about increasing the plant factor through better utilisation of available power. He stressed the need to develop attractive end-use applications and then develop the power from MMHP to meet the needs. He gave the example of the role of oil refineries in the development of automobile vehicles around the turn of the century, in order to bring about increased sales of refined oils and stated that end-use development was also very important for the promotion of MMHP technology. Governments should be persuaded to support such endeavours and provide the necessary incentives, especially for productive applications such as rural industries. In this respect, the quality of electricity and the reliability of supply were very important.

During the discussions that followed it was suggested that end uses must be financially rewarding for people in particular areas. Some people had been using MMHP electricity to distil brandy from apples. Another important end use in many countries was selling electricity to the grids. The possibility of building ropeways in Nepal could also be explored.

Training and Promotional Aspects

The fourth speaker, Dr. Adam Harvey, then spoke about the training aspects involved in the successful and sustainable promotion of micro-hydro. He remarked that effective institutional support was necessary. Training programme(s) would be effective only when the system they taught was effective. Training was needed at every level; at the level of senior decision-makers, the purpose would be to inspire confidence and win over the support of key individuals. Based upon the past experience gained by the Intermediate Technology Development Group (ITDG) in the U.K., Nepal, and Sri Lanka, the following could be considered as 'Golden Rules': thorough preparation over a long time; use of participation techniques; worked examples on important topics; very careful selection of participants to ensure that they were really the concerned decision-makers and would remain so for some time to come; clear selection and statement of the overall objectives, as well as the objectives of each component of the course; and follow up training and networking activities. Dr. Harvey then presented a set of strategies as sub-objectives for training. These included accredited feasibility studies; a participative planning process encompassing different energy options; commitment to an infant programme; availability of funds (credits, local investment, subsidies) and accurate cost projections; ownership and management of schemes by accredited bodies; establishment/existence of authorised coordinating agencies for rural energy in each country; and development of end uses by affiliated agencies. The above sub-objectives could be refined to develop various components of the course and perhaps a series of courses for people having different roles.

It was necessary to convince the decision-makers about the value of technologies that needed subsidies. In this respect only those schemes ought to be accepted that had sufficient local business and revenue. Many other arguments had to be thought over and developed. During the discussions, the idea of attempting to convince decision-makers was supported; however, it was also pointed out that bureaucrats were usually transferred from one post to another. The response was that selection of the participants was even more important here and that perhaps second level professional personnel, who might stay in their posts for longer periods of time, should be selected to attend the training course. It was also suggested that the course contents ought to be interesting, convincing, and not very technical.

Management and Operations

Lastly, Mr. Lahiru Perera of ITDG, Sri Lanka, spoke about 'Critical Factors Related to Management, Operations, and Repairs'. He reviewed the current situation in the HKH Region and observed that access to information, adequate training, and skill development were crucial for improving the situation. Training was especially important for operators and managers. He also suggested the evolution of arrangements for repairs in a given area where a cluster of MMHPs existed. Studies of maintenance and repair practices undertaken by private entrepreneurs operating successful plants in the remote areas were also likely to be a useful learning exercise, and this knowledge could be disseminated to other areas also. During the discussions it was pointed out that plant breakdowns and the consequent repairs were very serious impediments to the MMHP programmes and caused serious financial difficulties for the owners in many cases. The response was that there were three possible options to overcome these difficulties: a) more reliable and expensive equipment; b) more training and experience for the managers and operators; and c) development of adequate repair facilities. The costs for these choices could be considerable. However, for the long-term sustainability of the programme, this extra expenditure was necessary.

Group Discussions

On the third morning (6th Session), the participants broke into five groups and held discussions about formulating a strategy and on outlines of the important aspects to be discussed (see Annex 4). The coordinator of each group then made interim presentations before the plenary body, and these were followed by brief discussions.

Mr. Ueli Meier made the presentation for Group One on **Technology** and stated that, at present, MMHP plants in the HKH Region lay within two extremes, i.e., those completely bereft of governors/controls and fairly sophisticated equipment which was especially for supplying electricity to the grid. Many plants fell in between. The number of plants belonging to the first extreme category was quite large in the private sector. The level of controls and sophistication should be objective-specific and site-specific. Standardisation for the first category was likely to be difficult and not really necessary. However, for the MMHP plants needed for grid connection or such end uses, reliability of plants and quality of electricity needed to be improved. Under some circumstances, enhancement of reliability was necessary even for the first category; therefore, appropriate technological improvements must be developed and introduced for the equipment as well as for civil works. Generally, the more remote and difficult a site, the more reliable should be the technology, including the instrumentation and controls.

A number of issues related to technology were raised from the floor. A question was asked concerning how viable were the low-tech MMHP plants. Mr. Meier responded that, for many situations, e.g., for agro-processing or electricity for lighting in the accessible areas where repairs could be carried out easily, such plants were acceptable. In such cases, the minimum level of instrumentation would be voltage and ampere-meters, and the generator should be capable of withstanding the run-away speed. The discussion proceeded to consider who should oversee or bear responsibility for quality control. One suggestion was that manufacturers or their associations must be made responsible, since manufacturers might lose their business eventually if the quality was not good. It was also pointed out that introducing quality control measures during manufacture did not solve all the reliability problems and would increase costs. Therefore, a suitable course of action was to draw up adequate quality control guidelines and the manufacturers or millers' associations could persuade their members to follow them.

The presentation for the Second Group on **Economics, Funding, and Viability** was made by Mr. D. Adhikari. He remarked that MMHP plants could compete well with other energy options such as diesel engines. However, policy support and financial support were still necessary as the present level of available incentives was inadequate. He also pointed out a number of limitations in the current MMHP technology. Mr. Adhikari suggested that policy and fiscal support should be provided for isolated MMHPs as well as grid-connected plants, since grid connection was likely to be one important future direction for MMHP. A clear and consistent policy and other support must be given concerning tariffs, buy-back arrangements, etc. With large-scale participation of the private sector in MMHP, new issues could also emerge, e.g., water use rights. Adequate legislation would be necessary for such difficulties.

During the discussions, a comment was made from the floor that the current policy environment for private indigenous MMHP was not adequate. Wherever such policies existed, ambiguities also existed and there were almost always problems with regard to implementation. This situation was not very helpful. Many participants emphasised that grid connection of the isolated plants was probably the most promising direction for the future, since up to 100 per cent plant factors could be achieved in this way. This aspect, therefore, should be given due consideration.

The presentation for Group Three, **Implementation, Operation, and Management**, was made by Mr. W. Siraj, who highlighted the current status in the region and observed that MMHP plants in Sri lanka and China were being operated by trained operators. In the rest of the region, although some training programmes were developed and conducted (mainly in Nepal), they did not meet the training needs adequately. In Pakistan, no arrangements were available. Consequently, the level of plant utilisation was low, breakdowns were frequent, and a large number of plants had gone out of operation permanently. Mr. Siraj therefore suggested that attempts be made to refurbish such plants wherever the possibility existed. Funding must be increased to enhance the installation rates, grid connections must be encouraged, and appropriate steps taken to make this possible. During the discussion, it was suggested that lower limits on power to be connected to the grids were not necessary and must be removed.

The presentation for Group Four on **Enhancement of End Uses** was made by Mr. Allen Inversin. He listed the number of end uses currently prevalent, as well those that could be introduced in future. These included rural industries, agro-processing, ropeways, irrigation, cooking, and grid interconnections. The speaker discussed the viability and practicality of these alternative uses and short-listed those which were most promising. Among the promising uses were agro-processing applications of MMHP which had been encouraging in Nepal; however, more improvements were needed in the technology, training, and repair facilities and the rates of installations needed to be enhanced. In the case of pump irrigation, the experience was limited; however potential existed in many areas; some initiatives could be taken with the right inputs. At present, lighting was the most prevalent and appreciated end use. Battery charging could also be combined to allow the benefits of lighting to reach further afield. Mr. Inversin also put forward a proposal whereby MMHP installations for the communities could be funded by donors and, in return, villagers would grow a wood-lot for their own use on a sustainable basis.

During discussions, it was stated that ropeways could be successful in some areas. The speaker, however, felt that, in remote mountain areas the payload was not adequate enough to make ropeways economically viable. Questions were also raised about the actual success of the wood-lot idea. How would the system be looked after in the long run? The speaker responded that this was only a basic idea and many details needed to be worked out. It was also suggested that pump irrigation could be combined with domestic water supplies for the villagers.

The Group Five presentation **(Planning Policy and Institution Supports)** was made by Mr. P. Venkata Ramana who briefly reviewed the prevalent situation, especially its deficiences, and made the following suggestions: support for end-use development was necessary; NGOs, the private sector, and people's representatives needed to be encouraged; long-term and consistent policies should be evolved; decision-makers and potential financiers needed to be sensitised; incentives for good performance should be introduced; policies to improve the manufacturing base and quality control should be developed; and coordination between concerned agencies should be improved.

During discussions it was stated that the public power sector in India was quite large and it did not consider MMHP to be viable. This aspect should be thoroughly covered while developing a training programme for the decision-makers of the region. Selection of participants was important: for example they should really be the concerned people who would remain so for some time. A question was asked concerning whether there had been a request to the Government in India to de-license and promote MMHP. The speaker responded that the Government of India had undertaken many initiatives in the field of renewable energy. Thus, there was no pressure on it in this respect.

Session Seven was held on day four to finalise the recommendations of the groups, and it was chaired by Mr. Lahiru Perera with Mr. Allen Inversin as the Rapporteur. Mr. Ueli Meier made a presentation on behalf of Group One on Technology issues. The highlights are given below.

- There was a need and room for the improvement of indigenous technology; policies and legislation should be supportive of efforts to improve the viability of existing technologies.
- Among the components to be improved were: intake (due consideration to floods and desilting); power canals (optimum costs should include investment and O&M); forebays (avoid vorex formation); trash racks (compulsory, adequate design gap, to withstand pressure head, to function even at 50% blockade, easily cleanable design such as vertical bars); penstocks (optimal diameters to withstand water hammer); gate valves (compulsory, to control water and to avoid freezing of water in the penstock); turbines (predictable performance and adequate lifespan); generators (standard voltage and frequency, to withstand runaway speed, induction generators should be encouraged); controls/governing (sophisticated equipment for grid connections to make synchronisation possible, for other plants as simple as possible but as good as necessary, encourage some automation); control panels (to indicate basic readings, minimum/maximum cut-out relays, new ways of metering/accounting for energy sold); and guards for equipment and human life.
- Technology development should proceed from the simple and cheap to the reliable and more expensive.
- Costs would decrease if sufficiently large numbers were being manufactured and installed.

During the discussions, additional suggestions were made concerning the improvement of technology and the accompanying cost escalations. It was suggested that desilting systems should be incorporated in canal and intake design and automatic trash rack cleaning must also be included in more sophisticated plants; trash racks should be of parallel bar type to facilitate cleaning. Corrosion allowance in the penstock was discussed and it was suggested that it was usually much smaller than the thickness required for handling, so specification was not necessary. Vortex formation was not dependent upon the forebay size, but on depth of penstock inlet below the water surface, among other factors. It was generally agreed that the quality and reliability of the equipment needed to be improved, even if it involved an increase in costs; maintenance procedures would also have to be improved through training, and this could be expensive. Unmanned (automatic) plants may be less expensive in the long run. It was also suggested that the reliability of civil works was as important as that of the equipment. The improvements in equipment quality must also be based on feedback from the field. A question was asked about the mechanism for such a feedback. The customers were usually not qualified to assess the quality of equipment, therefore they could be choosing the cheapest equipment. The general consensus was that technology improvement was necessary and opinions from the field must also be taken into account in the improvement process.

Mr. Alex Arter presented the conclusions of Group Two regarding **'Economics, Funding, and Viability'**. Reviewing the current situation, Mr. Arter noted that in Nepal there were declared policy options with regard to sustainable energy supply in the rural mountains. The group had attempted to rate various energy options for the rural areas on the basis of such factors as initial costs, sustainability, transportability, and so on. The results showed that fuelwood and other biomass were more attractive in the short term but MMHP came out better in the long run. The grid connected MMHP fared best. Mr. Arter then made the following suggestions with regard to policies, legislation, funding, and training needs.

- Policies should be transparent for the setting-up of tariff rates, buy-back arrangements, and guarantees for grid-connected systems. One basis for tariff setting could be the principle of 'avoided cost'.
- With more private sector plants the water-user right issue would become important. A clear policy/legislation was necessary to encompass priority listing of water uses and the level of compensation for discarded MMHP plants in favour of other end uses.
- Basically the MMHP should be looked at as a profit-making venture. However, if social obligations and benefits were also apparent and profit was not viable then transparent policies could provide support to the investors.
- Commercials banks must also be encouraged to make MMHP one of their loan portfolios.
- Subsidies should be provided on the product (e.g., kWh supplied) not on capital investment.
- Awareness-raising programmes for policy-makers, especially those concerned with tariff- setting for buying power from the private sector, should be organised.

The discussions that followed were extensive and involved. Many participants had serious reservations about the rating of MMHP compared to other energy options, both regarding the methodology adopted and the actual ratings, which were presented in a tabular form. It was finally agreed to remove the table from the presentation. The idea of subsidising the product rather than capital costs was also debated. Some participants felt that subsidies were needed more during the investment phase rather than later on. Also, Operation and Maintenance (O & M) should not be subsidised. Others, however, felt that focus on production was also important and incentives to run a plant efficiently were lost if subsidies were only available for installations. This had happened in other countries. Two points of views seemed to prevail; i.e., a focus on financial viability only and an accounting of other benefits for the nation in determining economic viability. Many participants felt that MMHP had other considerable benefits also, therefore they should be supported financially as well as policy-wise.

The conclusions from Group Three's deliberations on **'Implementation, Operation, and Management'** were presented by Mr. Wahaj-us-Siraj. He noted that, at present, in China, decentralised MMHP plants were fairly advanced, grid-connected, and usually well utilised. In India, MMHP had not been emphasised in the past; existing plants were in the government sector, and the utilisation level was low. Private plants existed in Nepal and Pakistan only. The rate of installations had gone down considerably in Nepal, but they were steady in Pakistan. However, the overall impact of MMHP on the energy scene of both countries was negligible. Similarly, the training system in China was adequate, but this was not the case for India, Nepal, and Pakistan. Mr. Siraj made suggestions for the future and emphasised that training courses for managers and operators should be a regular feature of any MMHP programme. Regular maintenance was very important and a system must be evolved to create awareness among the owner/managers in this respect. It was necessary to have reliable, good quality electricity supplies; therefore, quality assurance/control and design standards should be implemented and monitored. Operation and management should also be healthy and competent. Mr. Siraj also suggested that an independent institution was necessary to introduce and certify manufacturing quality, standardisation, training of operators and managers, and evaluation of the plants. There should be no size limits for supply to national grids, and sale/lease of public sector plants to the private sector should be encouraged.

With regard to training needs and awareness-raising, Mr. Siraj suggested that regional seminars/meetings be held regularly to exchange information and ideas and to raise awareness. In addition, the ownesr/managers must be advised to maintain a stock of crucial spares; technicians from the workshops in adjoining areas should be trained in repair practices for the MHP plants; regular interaction between the owners, operators, and manufacturers should be organised in order to share experiences, especially with regard to performance and O&M; and mobile workshops should be established by implementing agencies.

During the discussions, the involvement of local NGOS to provide assistance for training operators and managers was suggested. The feeling was that this was a useful idea and ought to be explored further. In response to questions about the training currently available for the private sector, it was stated that some training facilities were available in Nepal for managers and operators. However, it was not a regular process. Some participants emphasised that training at this level was important, on the site as well as at a central convenient place. A concern was also voiced regarding the establishment of a new institution; where would the funding come from, for example? With regard to leasing out or selling sick government plants, some reservations were also expressed, however the idea was supported by many participants.

Mr. Reinhold Metzler presented the findings and recommendations of Group Four concerning '**Enhancement of End Uses**'. He first talked about the experiences to date and stated that electricity for lighting was still the predominant and popular end use; however, most people in the remote areas were too poor to afford it, especially in Nepal. Some participants favoured subsidies to support electrification through MMHP at the same level provided for urban populations. However, it was strongly felt that there was a need to focus upon increasing the financial viability of the MMHP plants so that their implementation was not subject to policies and actions of governments or donors only. In order to achieve this, efforts in the past had been focussed upon **reducing the cost of technology.** However, for the future, it was recommended that the focus of activities should be on **increasing the financial returns** by maximising the productive income- and employment-generating end uses of available energy. Mr. Metzler then discussed some possible end uses and these are summarised below.

<u>Ropeways</u>. This option of transport involved significant investment; also the payload, and therefore income, was likely to be quite small in the remote areas.

Agro-processing. Nepali experience in this area was positive, and some applications, such as oil expelling, were quite beneficial for the customers as well as the plant owners. However, problems also existed with the MMHP as well as with the processing machinery.

Pump irrigation was likely to have high potential and profitability, provided strategies could be evolved to resolve management and other related issues. The option was worth exploring further.

Cottage industries. While the potential and range of industries for the remote mountain areas were substantial, inputs were required to ensure success; e.g., credit, technical expertise, financial/business management, availability of suitable equipment, product quality assurance, raw materials, transportation, etc. Addressing these inputs would require a multidisciplinary approach and assistance from numerous parties, which could be a challenging job.

Cooking. Some form of energy had to be used by everyone for cooking, MMHP had been considered as one alternative to replace fuelwood/biomass. However, the nature of cooking loads, both magnitude as well as timing, posed severe problems for small plants. Research and Development (R&D) in the development of low-wattage cooking devices had not been successful, the devices developed so far were expensive. Moreover fuelwood/biomass was the traditional, low-cost choice for rural areas.

Lighting was a popular end use, but it incurred sizeable expenses and did not generate income except for commercial establishments. Battery charging could spread the benefits to wider areas and would be helpful in raising load factors.

Grid interconnection. The experience within the region was negligible, except in China. Other mountain countries outside the region had made considerable achievements, and rural entrepreneurs had been earning considerable incomes by selling electricity to national grids.

Mr. Metzler then made the following recommendations for promoting selected end uses for income-generation; i.e., agro-processing, irrigation, and energy sales through grid interconnection.

Agro-processing. Initially, to focus on rice hulling, grain milling, and oil expelling; to organise study tours for professionals concerned with MMHP development to China to learn from their experiences; meetings of relevantly experienced experts to assess the status of available technologies; to undertake market studies and evaluation studies for the existing machinery; to organise R&D to improve technology; to promote end uses; and to create awareness among bankers/financiers concerning the income-generation potential of MMHP.

Pump irrigation. To evaluate existing experiences; organise study tours in South Asia to evaluate experiences and to support pilot irrigation schemes.

Grid interconnection. To organise study tours for decision-makers to Europe to show grid interconnections for MMHP plants; national power authorities to evolve strategies for buying back electricity from private plants; development of guidelines for standard interconnections and protection systems for small plants; and to initiate pilot grid interconnection schemes.

The group also identified the need for a national institution for proposing initiatives, arranging funding, and contracting appropriate organisations to implement the above-mentioned actions.

During the discussions, it was observed that the source of funding for the recommended institution could be difficult to come by, and that it could end up as a bureaucracy. It was also pointed out that some end uses, which were labelled as non-productive, could be very essential. A participant felt that battery systems could be expensive. The response was that it was not necessarily so, some cheaper alternatives were already available. Performance of the Indian equipment was also reported to be problematic. A participant remarked that storage or some other use of energy during the night would increase plant factors, say through heat-storage cookers. The discussion then focussed on grid interconnection; some participants felt that this option was not for Nepal at present; however, others felt that opportunities were there. One participant stated that rural electrification was not attractive because it was expensive. It was also pointed out that one World Bank study stressed utility efficiency. One reason for non-viability could be that a lot of money was being spent on rural electrification. However, another viewpoint was that, in a way, petrol, gas, and kerosene were all subsidised.

Mr. P. Venkata Ramana presented the recommendations of Group Five which was working on '**Planning, Policy, and Institutional Support**'. These are summarised below.

- Policy formulation and institutional support for end-use development, including soft loans.
- Fostering NGO and private sector involvement at the local level.
- Promotion of MMHP through demonstration.
- Fostering long-term and stable policies/funding/incentives.
- Conceptualising MMHP as an integrated energy service within the framework of policies relating to fuelwood plantations and rural income generation.
- The training programmes for rural development authorities/policy-makers to include cost-benefit analyses of MMHP, including social and environmental benefits.
- The 'life-cycle costing', approach, including maintenance and repair (M&R) cost, should be used to determine viability rather than Rs/kWh.
- Incentives for good performance, e.g., maximum kWh available or utilised, to be instituted.
- The policy environment for micro-hydro to be improved in contrast to mini-hydro, which seems to be better off at present as an option for grid connection.
- To create an association/agency in Nepal as an executive body of the interest groups in the private sector (NGOs, manufacturers, consumers, and government representatives), to be funded by its members to perform the following functions: to realise recommendations such as the above; to initiate dialogue with policy-makers on various issues; to facilitate coordination, to ensure quality, to promote awareness; to inflate stability of favourable policies; and to formulate guidelines for feasibility, implementation, evaluation, etc.
- To sensitise State Electricity Boards (SEBs)/Power Departments in India to MMHP and to create separate cells, etc.
- In Pakistan also, an association of implementing/promoting agencies was recommended to improve coordination; improve manufacturing; promote successful

mechanisms for people's participation; and sensitise NGOs, donors, and communities to MMHP promotion.

During the discussions, a number of queries and observations were made regarding tariff policies and demonstration. It was also observed that most recommendations had government officers as the intended target group and governments generally did not favour micro-hydro in particular. The overall viability of MMHP (especially MHP) again became a point of discussion, and it was expressed that plants such as *Ghundruk* (Nepal) had demonstrated the viability of such schemes satisfactorily; given the correct inputs, including adequate management systems. Other plants could also perform well if the management and other aspects were adequate.

5. CONCLUSIONS AND RECOMMENDATIONS

The Concluding Session of the Consultative Meeting was held on day five (17th June a.m.) and chaired by Mr. Egbert Pelinck, Director General, ICIMOD. Dr. Adam Harvey was the Rapporteur.

Presentations were made regarding the two main expected outputs, i.e., outlines of the training programme for the decision makers and general conclusions. These outputs had been prepared the previous day by two small committees constituted for the purpose.

Training Programme Outlines

Outlines of the Training Programme were presented by Dr. M.Abdullah. He stated that the proposed training programme for decision-makers had been prepared with the following objectives.

Familiarisation of the participants with:

- MMHP in mountain areas as a significant and viable contributor to rural development and rural electrification (overall objective);
- evaluation of MMHP feasibility documents;
- assessment and comparison of every different option; and
- optimum division of responsibilities among the parties involved.

About 20 participants would be selected from senior (preferably topmost) government levels of the participating countries. Participants should be working in areas concerned with rural development, rural electrification, planning, finance, environment, and implementation of MMHP programmes; officers from development banks and donor agencies would also be invited to participate. The duration would be for about 10 days, preferably in surroundings away from homes/offices, but in a stimulating environment and in comfortable conditions.

The following course contents would be taught.

- The role of appropriate energy systems in rural development.
- Rural electrification as a contributor to rural development - integrated approaches. Options available for supplying electricity. Adoption of an unbiased approach; for instance listing of the merits of diesel sets and recognition of the site-specificity of MMHP.
- What is MMHP?
- Institutional arrangements for MMHP. Five current approaches to MMHP.
- MMHP- economic feasibility (should also include social benefits, indirect economic benefits, and long-term national interests), financial feasibility and constraints, environmental considerations, evaluation criteria.
- Funding sources for MMHP (e.g., multilateral sources, regional aid organisations, development banks, commercial banks, NGOs, private sector, etc). Policies and practices of such sources.

- Concept of special tariffs. Methods of tariff setting.
- Significance of the management of MMHP installations (including operation and maintenance issues). Inducements for reliable operation, monitoring of kWh produced. Standards and guidelines for quality assurance.
- Two guided discussion groups focussed on reviews of prevailing policies and institutional arrangements.
  a. Mini-hydro (participants working in power supply)
  b. Micro-hydro (participants working in rural development). Plenary presentations from both groups and discussions.
- Budget allocations. Public and private funding of/investment in;
  a. individual installation and
  b. institutional support arrangements.
- The contents of the feasibility study. How to evaluate MMHP schemes on the basis of feasibility studies. One rationalised method of preparing feasibility studies and evaluating the plants.

An appropriate structure and proper techniques would be chosen to keep attention, engage, and interact; it should be an illuminating and enjoyable briefing. The techniques would include poster displays, exhibition, working models (if of high quality), synchronised audiovisual aids, OHP, slides, videos, good illustration materials, and site visits. A detailed day-to-day programme was also presented for about 10 days' training, mainly incorporating the above contents. However, in view of various comments during the meeting, as well as during the concluding session, the programme was to be redrawn for a period of five days only as presented in the 'Finalised Outputs' (Annex 3).

The presentation was followed by discussions. The overall idea of holding a training programme was supported. Several participants expressed the view that the proposed 10-day programme was unsuitable for senior decision-makers who would prefer to attend a one to three-day course. Three alternative suggestions were made: hold two courses - one to two days for top-level participants, and ten days or thereabouts for lower level participants; design one course which includes a short module of one or two days for attendance by top-level participants; and design a mid-duration course of four or five days.

The longer course could be approximately as the outline presented, with the objective of creating the capacity to assess feasibility studies, rather than to merely familiarise. The short course could concentrate on familiarisation. The mid-duration (4-5 days) course was not discussed. The working group members agreed with the suggestion that a short course was more suitable for senior officials (the original recommendation had also been for a short course).

A suggestion was made that ICIMOD should establish a continuing capability in providing training and should assist to other institutions in the same. This would allow scope to solve many of the training problems that have become apparent when trying to satisfy all requirements with one course.

One participant suggested that the word 'viable' should be dropped from the objective statement proposed. There was assent to this from at least one other participant. A view was expressed that there was also a need to further clarify the difference between macro-economic, social, and long-term viability and immediate financial viability. It was suggested that the short training course for senior decision-makers be referred to as a "Familiarisation Seminar" rather than "training". It was suggested that an effort be made to include women as participants and to make sure that gender issues were included in the seminar and/or training course contents. A view was expressed that "elected representatives" as participants may be inappropriate because of very different qualifications and base knowledge levels. They could be invited as resource people for consultation. The importance of including participants from the national finance departments was emphasised, because funding of MHP was ultimately national. A suggestion was also made to include local manufacturing as an additional topic. The participants could benefit from staying in a village for more than a day to get more immediate contact with beneficiaries. A reservation was expressed about the comfort of senior people. A suggestion was made that Switzerland would be a useful venue not just because it could attract senior officials but more importantly because it was a place where the significance of MMHP to a national economy could be demonstrated. There was a reservation about the expenditure being restricted to the region. Tibet was also offered as an alternative venue.

In view of the above discussions it was agreed that the training outlines would be modified.

Conclusions

The Conclusions of the Meeting were then presented by Mr. U. Meier. He stated that the principal concern of policy-makers was the need to achieve sustainable socioeconomic development in the HKH Region to reduce poverty, alleviate drudgery (especially for women), and reverse environmental degradation. In addition to the creation of income-enhancement opportunities, the availability of energy in a suitable form was necessary to meet the needs of agro-processing, cooking, and space heating. The hydropower resource was abundantly available in the whole HKH Region, which itself also had significant advantages. Several decades of experience with indigenous MMHP technology in the region had clearly demonstrated its viability in powering the agro-processing equipment and has amicably contributed towards the concern of the policy-makers, i.e., enhancement of economic activity and reducing the drudgery of women. However, electricity generation through isolated MMHP plants was not being viewed as economically viable as yet. The following factors needed to be addressed in this respect. **Low load factor** was the main problem of isolated MMHP plants, since electricity was only being used during the evening for lighting. The result was that most plants could not generate adequate incomes to meet the O & M and loan amortisation costs. Enhancement of end uses was the answer to this problem. Three end-use categories considered to have the highest potential were agro-processing, pump irrigation, and grid interconnection.

Mr. Meier then presented a number of findings which are summarised below.

- The existing policies, legislation, and institutional support were conducive to involvement of the private sector. However, many ambiguities still remained. Tariffs in most national grids were heavily subsidised; so were diesel or kerosene. Consequently, electricity from an isolated or grid-connected MMHP plant could not be sold at tariffs high enough to allow reasonable profits.
- Load factors could be improved sustainably only if the supply was highly reliable; which could be done through the improvement of technology, resulting in higher

costs. Thus the prime objective was to **design and build for reliability.** All the components, including civil works, should be improved to make them more reliable.

- Organisational set-ups and effective management had a strong impact on the operational costs, power availability, and, thus, on economic viability. Decentralised schemes required decentralised concepts of institutional set-ups. Management, operation, and maintenance needed to be based on a clear assignment of responsibilities for sustained operation. An incentive scheme based on the amount of energy (kWh) sold could also help to enhance the load factor.
- Many countries in the HKH Region had been facing the excessive use of fuelwood, culminating in serious ecological problems. Other social benefits, such as facilitating education and literacy, improved health services, reduction of drudgery for women, and psychological aspects, were important but not easily quantifiable. MMHP in such situations could be considered as a viable resource from the socioeconomic point of view.

During the **discussions**, the following main points were raised suggesting additions or alterations to the conclusions.

- Preference for locally-made equipment and local capacities in repair and maintenance.
- More bottom-up networking of active MMHP practitioners.
- The need for subsidies to be spelled out; noting that although direct subsidies on grid electricity had largely been removed in Nepal there were still indirect subsidies.
- On the question of fuelwood consumption, it should be clear that agro-processing and industry were main consumers rather than domestic cooking. Electricity was a potential contributor to saving fuelwood in the industry and processing area; although it was also pointed out that electricity availability may have the effect of encouraging a greater volume of industry/processing, resulting in greater fuelwood usage.

With respect to the future courses of action, the following comments were made.

- A new organisation could be established to be responsible for various tasks such as quality control, feasibility studies, training of decision-makers, etc.
- Such an organisation need not be a new institution but could be an executive arm of an association of players, such as ICIMOD, Governments, NGOs, manufacturers, all of whom have special strengths and functions. ICIMOD's roles could, for instance, be establishment of a regional network, application of a special capability in accessing senior government staff, etc.
- Project execution (e.g., training of practitioners) by technical assistance organisations. Special emphasis on in-country capacities.

It was agreed that a number of these comments and suggestions should be included in the final conclusions and reflected in the document called Finalised Outputs.

After discussions, Mr. Arun Kumar presented his observations about the Consultative Meeting and its benefits on behalf of the participants from the HKH Region. He thanked ICIMOD for organising the meeting and said that it was extremely useful to delineate and discuss various aspects of MMHP within the Region, especially new initiatives to decentralise/ privatise/commercialise the plants. Mr. Kumar remarked that the meeting was well structured and that the inputs from the support staff had been excellent. He also hoped that there would be adequate follow-up activities by ICIMOD that contributed towards the development of MMHP, especially the establishment of an information exchange network.

Dr. Adam Harvey then expressed his views as a resource person concerning the Meeting. He visualised rural development that could lead to better living conditions and the availability of necessary amenities in the inaccessible and poor mountain areas. In this context, rural electrification was an important component and mini- and micro-hydropower, which was indigenous, environmentally-friendly, and economically viable in many areas, could be easily developed. Dr. Harvey appreciated the efforts of ICIMOD towards the development of MMHP in the HKH Region and stated that he was pleased and honoured to be a part of these efforts, which included participation in the Consultative Meeting. He said that the Synthesis Report was an excellent document highlighting the status, issues, and problems. He also appreciated the level of participation. Dr. Harvey remarked that ICIMOD was well placed and had the capacity to contribute towards the development of mountain areas, including sustainable promotion of MMHP.

Finally, Mr. Egbert Pelinck, the Chairman of the Session, made some concluding remarks about the Consultative Meeting. He thanked all the participants, especially the two groups who had prepared the outlines for a training programme and the general conclusions/recommendations. Mr. Pelinck then outlined the past energy-related programmes of ICIMOD, including 'Rural Energy Planning and Management at the District Level', in the HKH Region and the associated studies, training programmes, and manuals. He also welcomed the generous offer of the Norwegian Government to support the current MMHP programme. Mr. Pelinck further noted that ICIMOD stood for mountain development through the processes of environmental conservation and poverty alleviation, for which MMHP was a particularly suitable energy resource; identification of specific opportunities that mountain areas could provide; and bringing together experts and experiences from different countries in the region. As a facilitator of sustainable mountain development, ICIMOD had been interacting with many government agencies in the member countries, exchanging experiences, and collaborating with a large number of experts in the region. Therefore, ICIMOD was in a unique position to identify and facilitate developments in many important fields. Organisations participating in the Consultative Meeting would also be a source of knowledge for ICIMOD and for the member countries.

With regard to the two major outputs of the meeting, Mr. Pelinck stated that the training programme to create awareness and capacity-building among senior government officers would be implemented as a component of the present project. It seemed clear from the set of wide-ranging conclusions/recommendations, the second output, that a continuing need was being felt for monitoring and evaluating MMHP development in this region and for the evolution of a mechanism to share information concerning the new initiatives. ICIMOD was ready to be part of such an action if requested and supported by the member countries and donor organisations.

Mr. Pelinck once again thanked the participants, organisations, and resource persons, many of whom had made special efforts to attend the meeting and had worked hard to come up with meaningful outputs. He also reconfirmed ICIMOD's commitment to sustainable energy systems for mountain areas.

Annex 1

COUNTRY STATEMENTS

1. RECENT DEVELOPMENTS OF MMHP IN CHINA[1]

General Situation

China started to harness water resources quite early in the '50s. By the end of 1993 the number of MMHP & SHP stations in China totalled 48,284, with a total installed capacity of 15055 MW and annually generated energy of 47 TWh; which is about 33.7 per cent and 35.7 per cent respectively of total hydro installations. The number of plants in the micro-range was 27,010, and in the mini-range 18,635. About 30,000 smaller plants were isolated, having a capacity of about 1,750 MW and annually generating 3.64 TWh (~7.7% of the total energy generated by MMHP-SHP). The remaining 18,300 larger plants with a generating capacity of 13,300 MW and producing 43.36 TWh energy, were grid connected (local grid/or national)

As per China's definition, hydropower stations having a rated capacity of up to 100 kW are defined as micro, those from 101-500 kW are defined as mini, and stations having a capacity between 501 kW and 25 MW are considered to be SHP stations. Nowadays, there is considerable promotion of MMHP & SHP with the adoption of some open, appropriate and cost-effective technologies resulting in simplification, standardisation, and automation which shorten the construction period, reduce the total investment, and make full use of local staff and materials. This is being achieved through a series of preferential support policies which have been introduced by the Government.

Recently, MMHP has continued to enjoy a steady increase with stress on better management and enhancement of MMHP utilisation hours. In MMHP construction, hydro-stations with reservoirs capable of regulating storage were preferred and optimised MMHP operations were widely adopted. Manufacturers began making efficient units and have already produced about 100 with an annual production capacity of almost 1,200 MW. The local grids have continued to expand. Transmission lines for 110 kV were put up and most counties set up SHP corporations which managed unified power generation, supply, and distribution. In the country, 109 pilot counties, mainly based on MMHP, were checked and accepted by the State as reaching primary rural electrification standards. In the 90s, Phase 2 of the National Programme on Rural Electrification was executed for another 200 counties in order to boost the local economy and to improve the cultural and material life of local people in rural areas. Therefore, MMHP development is still very fast so that for MMHP and SHP an installed capacity of more than one million kW is being put into operation annually.

According to a preliminary general survey in China, the total economically exploitable potential for MMHP and SHP was about 70 GW. Out of 2,300 counties, about 1,100 have more than 10 MW of economically exploitable potential. This abundant of potential is an important basis for the large-scale development of MMHP in China. Due to the vastness of

1 The Country Statement for China was prepared and presented by Dr. Tong Jiandong, Director of Hangzhou Regional Centre for Small Hydropower, China. He was also responsible for the preparation of the Chinese Country Report.

rural areas, the large dispersed population, and difficult communications, the total energy requirement is so large that no single energy resource can meet the demand satisfactorily. China still has vast rural areas where almost 150 million people are still without electricity. Therefore, the aim is to achieve quick and efficient development and use of new and renewable sources of energy based on a policy directed towards diversification and decentralisation.

Due to rapid proliferation of MMHP-SHP, rural electricity consumption has gone up, and the portion for industries and agricultural or by-product processing, including county and village-run enterprises, accounted for about 52.6 per cent, and the amount used by electric irrigation and drainage systems accounted for 12.8 per cent. Most of the county- and village-run industries have now become important pillars of the rural economy and electrical pumps irrigate or drain several hundred million hectares of farmland throughout the country. Therefore, electricity, especially from MMHP, is the lifeline for power demand in the rural areas and a very important factor for the overall development of the regions.

With the increase of MMHP sites and installed capacity, the grids have also developed rapidly. By the end of 1992, there were 75,1000 km of 10 kV to 110 kV high voltage transmission and distribution lines managed by electric power corporations in MMHP-supplying areas, 3,550 substations of 35 kV to 110 kV with 17,919 thousand kVA, dispatching 32,958 thousand kVA through 10 kV lines. Where MMHP is concentrated, a sort of trans-grid is beginning to form a regional hydro-exploitation complex over counties and basins. Thus, not only are MMHP operational functions being fully used but also energy between towns or countries, in both flood and dry seasons, can be easily transmitted.

Features of MMHP in China

The specific features of MMHP development in China are described briefly in the following passages.

Decentralised Approach

The systems' approach to MMHP development in China is considered to be a decentralised one. This conclusion has been drawn by analysing four major factors, i.e., strategy and policy-making; administrative infrastructure; implementation; and management, operation and maintenance. Except for the main policy and strategy and overall national planning, which have always been undertaken by the Central Government, all other aspects are decentralised to different government levels, i.e., provincial, prefectural, county- or even township-level, in order to cater for local conditions and requirements. In addition, the decentralised approach to raising capital has also greatly alleviated the financial burden of the Central Government and involves various levels of local governments.

Special Policies and Strategies

The Chinese Government has consistently developed and legislated a series of supporting policies for the development of MMHP since the early 1950s. Currently, the key essence of these could be condensed to the usually called 'self-reliance' in all respects, particularly fund-raising. The **'three-selves'** policy, i.e., self-construction, self-management, and self-consumption' has been a well-known policy for MMHP development since the early 1960s, which means that local authorities/entities or local people (collective or private) who invest and construct the MMHP stations have the right to manage the stations and to utilise the electricity thus generated. In addition, 'self-consumption' also implies that there should be a MMHP market, i.e., MMHP stations should have their own distribution/supply area (concession area) instead of selling all the energy to the national grid for distribution. Another important principle of this policy is the cultivation or expansion of MMHP on the basis of existing MMHP; which means that the profits of existing MMHP stations can be used for further development of new MMHP stations in their own counties/regions (except for the necessary taxes). This policy has encouraged MMHP development over a long period.

Various Channels of Capital Investment

Under the guidance of the 'three-selves' policy, the sources of investment and modes of construction and management for MMHP are of multi-channels and multi-levels; including soft bank loans, government subsidies, and contributions from local households. In 1992, for example, the Central Government contributed about 6.2 per cent of the capital, the Provincial Government 6.4 per cent, and other levels (County, Prefecture) provided another 19.2 per cent. Bank loans accounted for 34.7 per cent of the investments and owners contributed 9.9 per cent.

Contribution to Rural Development/Electrification

After food problems had been mitigated, the local/rural industries started to boom and rural people now tend to receive more income from industry than agriculture. In 1983, the State Council rural electrification scheme was established as a significant issue concerning 800 million farmers. While the State developed large and medium-sized hydro plants, MMHP exploitation was to be actively carried out to realise rural electrification mainly by the masses at local level in the spirit of self-reliance, wherever resources were abundant. The State issued directives that 100 pilot counties would set up MMHP supply for rural electrification. Most of the 100 counties were located in State-aided areas. Rural electrification boosts the economy and enriches the cultural and material life as well. The experience proves that it is feasible to harness small or mini-hydropower to push ahead with the rural electrification programme in China in a unique Chinese style.

Diverse Utilisation of MMHP

Small river planning is conducted in accordance with county electrification planning and oriented towards cascade, trans-basin, and multipurpose exploitation. Meanwhile, MMHP stations are correlated with each other in the county grid. The multipurpose utilisation of MMHP resources and cascade development of small rivers has enabled the large-scale development of MMHP in China. There was close collaboration between water conservancy (mostly irrigation) projects and MMHP in the early stages when the electricity demand in rural areas was very low, while the demand for increased food production was urgent. Therefore, various hydraulic control structures, including dams, barrages, conduits, power-houses, etc, and all conventional types of layout schemes were constructed in many parts of China.

MMHP technology, including equipment manufacturing in China, has been developed indigenously. Therefore, it is a fully self-sustained technology. Although not as advanced as western technology, it is appropriate for developing countries, both technically and economically. The turbine-generator sets and their operations will continue to be investigated for achieving simplification, standardisation, and, automation, to reduce the cost, to improve the conditions of operation/management and the quality of energy supply, as well as to raise the utilisation hours of the equipment.

Different Ways of Management of Electric Power Supply/Distribution

More than 92 per cent of the MMHP capacity in China has been integrated and local (County) grids have been formed. A county grid ranges from 20 to 50 MW in general. One-third of the 23,000 counties in the whole country have set up their own grids, mainly based on MMHP. Therefore, a series of issues, both technical and managerial, relating to the small grids has emerged, some of which have been solved. The management of electric power supply/distribution is as follows.

For counties mainly supplied by MMHP, a unified generation and supply distribution system is adopted and managed by a county level entity, either the Bureau of Water Resources (BWR) and/or the MMHP corporation. They have a local grid with their own distribution system (usually 35/10-0.4 kV), and they are able to set up an independent tariff system. These local grids, if possible, are usually connected with the national grid to allow for the exchange of energy.

For counties directly supplied by the national grid, where all consumers receive electricity directly from the national grid through local substations (also run by the national grid), MMHP stations are run by county BWR or other small owners who only have the right of generation. All energy has to be sold to the NG for distribution and supply.

For counties supplied by the national grid through bulk selling to a local grid, although the local grid is usually run by the BWR, the main portion of the energy is supplied by the NG with a small supplement from the local MMHP stations.

End Uses in Rural Areas

Contrary to other developed and developing countries, China has always paid great importance to the productive use of electric energy, instead of livelihood use. Consequently, many productive end uses have been developed and promoted in China. For example, in 1992, 79 per cent of the energy produced by MMHP was consumed by rural industries, including agro-processing. Another 5.6 per cent was consumed by irrigation systems and lighting accounted for 13.2 per cent.

China has made great efforts to develop MMHP and to change the situation in hilly regions relying on MMHP. Though small MMHP is widely scattered, it is able to meet the demands in the absence of grids and plays a big role in enhancing rural production and in gathering local funds. Thousands of MMHP stations can vigorously promote the economy of quite a large area. Therefore it is reasonable to conclude that MMHP has become an important, rural energy source and an integral factor in boosting the rural economy.

2. THE INDIAN MMHP PROGRAMME - CURRENT INITIATIVES[2]

Principal Objectives

- To promote the speedy development of micro-, mini- and small-hydel schemes of up to a three MW capacity for power generation in order to use the available potential to its fullest extent.
- To achieve 600 MW of installed capacity of MMHP-SHP during the Eighth Plan (1992-97).

Other Objectives

- To make electricity available through MMHP to meet the cooking, lighting, and other domestic requirements of the people residing in remote hilly regions.
- To help in protecting and ameliorating the environment by checking deforestation and by inducing a change in the fuel usage practices of people residing in hilly areas by substituting electricity for firewood.
- To create suitable conditions for private-sector participation in setting up and managing MMHP projects, including framing promotional incentives for wheeling, banking, and purchasing power from the private sector.
- Standardisation of electro mechanical (E&M) equipment and simplification of civil design to achieve reduction in costs.
- Supporting R&D for new technologies suiting Indian conditions.

Acceptable norms for capital and generation costs for schemes in hilly regions/the North-eastern region should not be higher than Indian Rupees (IRs) 60,000/kW installed and Rs 3.5/kWh generated.

Avenues for Private Investment

- State Electricity Boards and other concerned State nodal agencies are allowed to lease out MMHP sites to the private sector for power generation for either captive use or public distribution.
- Terms and arrangements for wheeling, banking, and the buy-back of power are already announced by some States and under finalisation by others.
- Soft loans through the Indian Renewable Energy Development Agency Ltd. (IREDA)/World Bank.
- Ministry of Non-Conventional Energy Sources (MONES) subsidies for private-sector projects not qualifying for IREDA/World Bank loans.
- Encouragement to voluntary agencies and local communities to take over and manage MMHP projects in remote areas.

Soft Loans through IREDA

- All MMHP projects up to a 15 MW station capacity and a five MW unit capacity on irrigation dam/toe/canal drop based sites would be eligible for this loan.

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2. The Country Statement for India was presented by Mr. Arun Kumar who is associated with the Alternate Hydro Energy Centre, University of Roorkee, and Mr. P. Venkata Ramana of the Tata Energy Research Institute (TERI), India.

- The loan amount is limited to 75 per cent of the total cost of the projects or cost of eligible items under a World Bank loan, whichever is lower.
- The interest rate so far has been 15.5 per cent with a rebate of 0.5 per cent for timely repayments. It has been reduced to a flat rate of 12.5 per cent with effect from April 1994.
- The repayment period is ten years, with a maximum moratorium period of three years.

Incentives for Preparation of Detailed Project Reports (DPRs)

- For projects at canal drops/dam/toe sites, the fees would be IRs 40,000 for sites below 500 kW and IRs 75,000 for larger schemes.
- For run-of-the-river sites in the plains, the fees would be IRs 50,000 for sites under 500 kW and IRs 85,000 for larger plants
- For projects in hilly areas (especially the NE region) the fees to be paid are IRs 65,000 and IRs 100,000 for schemes below and above 500 KW respectively.

Similar fees are also payable to private surveyors/investigators of the sites.

Fiscal Incentives

- Power generation schemes involving capital outlays of up to IRS 250 million, can be taken up/sanctioned by the State governments without obtaining prior techno-economic clearance from the Centre.
- Tax holidays applicable (at least until 1997) for all power generation projects equally apply to MMHP projects.
- Concessional customs' duty @ 20 per cent can be granted for project imports for establishing MMHP projects.
- A hundred per cent depreciation in the first year under income taxes is under consideration, as it is already applicable to other new and renewable sources of energy (NRSE) systems.

Promotional Strategy (Some Supportive Inputs)

- Capital subsidy scheme
- Incentives for portable micro-hydel sets
- Scheme for survey and DPR
- Soft loans through IREDA
- Fiscal Incentives
- Customs' duty concessions
- United Nations Development Programme (UNDP)/Global Environment Facility (GEF) assistance
- Encouraging the private sector

Community-managed MMHP Plants in India

In Utter Pradesh (India), the Non-conventional Energy Development Agency (NEDA), the State nodal agency, is transferring micro-hydro projects to local societies (comprised of citizens of beneficiary villages) for operation, maintenance, and revenue collection. However, the major and special repairs are still being looked after by NEDA. Examples of such plants are Kempty Falls (12 kW), Sahastradhara (10 kW), Khokta (50 kW), Dior (50 kW), and Ramgash (50 kW). The performance of these power plants is closely monitored and the results may be available in one or two years. Similar efforts have been introduced in Arunachal Pradesh, Nagaland, and Mizoram.

Some Technical and Operational Problems Faced by the MMHP-SHP Sector in India

- Silting
- Damage to civil works
- Problems with the operation of sluice gates
- Lack of workshop facilities
- Inadequate institutional aspects
- Low level of people's participation

Constraints to MMHP Development

Constraints to MMHP development are mainly associated with the following

- Carrying out detailed survey and investigations and preparation of DPR;
- Land acquisition, allotment, and handing over of sites to developers;
- Delay in statutory State Government clearances;
- Inadequate State Plan Fund allocations;
- Lack of coordination among various agencies involved such as the State Nodal Agency/SEB, Irrigation Department, Power Department, Environment and Forestry Department, etc.
- Lack of transparent/uniform policies/incentives in different States to encourage private sector participation
- General tendency of SEBs to accord low priority to MMHP projects
- Poor infrastructural facilities and accessibility in North-eastern and other hilly regions

Suggestions Regarding the Outstanding Issues (delineated in the Synthesis Report)

- It is justifiable to initiate preferential propaganda in support of MMHP, except for small community plants in extremely remote areas (say up to 25 kW). Such schemes are not economically justified.
- In addition to commercial returns (private), benefits to the poor may also be justifiable as grid connection will improve the overall plant economy.
- Consumer/local entrepreneur-owned MMHP require preferential support.
- Support to private entrepreneurship is a MUST to get quicker installation. Also, government agencies must clear the projects clearly and quickly.
- In India, all State-promotion agencies are set up or under way (no need for an additional agency there).
- Stand-alone MMHP schemes need to be supported until they develop adequate load/economics.
- Priority training programmes are needed for decision-makers, village level influentials, actual beneficiary communities, and for owners/ operators in the maintenance of civil works, increase of load factor, and maintenance of equipment

- The plant factors of MMHP could be improved by linking them to water pumping systems and to community/government small-scale industries.
- Electronic Load Controllers (ELCs) for more than 50 kW are not satisfactory. Hydraulic governors are somewhat troublesome but the overall performance is okay.
- In order to alleviate repair/maintenance problems, the networking of repair workshops should be established/ supported in remote areas to provide annual maintenance contracts with penalties for non-compliance.

3. COUNTRY REPORT ON THE MINI-AND MICRO-HYDROPOWER PROGRAMME IN NEPAL[3]

Introduction

About 94 per cent of the total energy requirements in Nepal are met by traditional sources of energy which include fuelwood, crop residue, and animal dung. Fuelwood alone accounts for more than 78 per cent and electricity is less than one per cent of the total energy consumed. Nepal is a mountainous and hilly country with more than 90 per cent of its population residing in rural villages. A huge hydropower potential exists in the country. There are over 6,000 rivers and streams in the country originating from snow-covered mountains, glaciers, or, in some cases, from groundwater sources, which are perennial in nature and thus maintain some portion of flow even during the dry season.

Traditional water wheels for agro-processing have been in use for centuries in rural Nepal. Despite its limited power output (~1 kW) and low efficiency, it is estimated that there are about 25,000 such units still in operation in the country. The first modern hydropower plant in Nepal was installed in 1911 at Pharping (500 kW).

There is thus a great potential for the development and utilisation of hydropower, especially in the mini- and micro-range, which can be installed relatively easily in the remote and inaccessible areas. Low capital investment, short construction period, indigenous technology, manufacturing capability of Nepali manufacturers, simple operations, relatively low repair and maintenance costs, government incentives in the form of loan and subsidies, have all played an important role in the development and promotion of MMHP technology, especially in the private sector. There are about 37 MMHP installations in the public sector and over 900 plants in the private sector, mainly for agro-processing purposes in the remote and far-flung areas. These units are comparatively small, mostly in the 3-30 kW range, and are powering agro-processing units. In about 20 per cent of cases, add-on generators of lower capacities have also been installed. In addition, about 100 stand-alone units for electricity generation have been installed by the private sector. These installations are owned, managed, and operated by individuals, groups, or communities.

A number of government, semi-government and non-government agencies, international donors, private companies, and research institutes are involved in the development and promotion of MMHP technology in Nepal. MMHP technology has improved over the last 30 years in the form of improved water wheels (improved *ghatta*), multipurpose power units,

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3 The Nepal Country Statement was presented by Dr. K.B. Rokaya, Associate Professor, Institute of Engineering, Pulchowk Campus, Tribhuvan University, who also led the Nepal National Team in preparation of the Country Report.

cross-flow turbines, pelton turbines, and so on. There are at present about 11 indigenous manufacturing companies involved in manufacturing MMHP equipment, some of which are also engaged in research activities.

It is seen that the introduction of subsidies for micro-hydro installations and the delicensing of plants of up to a 100 kW in capacity by the Government played a significant role in the promotion of MMHP technology. In recent years, there has been a decline in the rate of micro-hydro installations. The scenario may improve in the coming years with the proper implementation and management of subsidies and the recently promulgated Hydropower Development Policy (1992) of His Majesty's Government of Nepal (HMG/N).

Cost Structure of MMHP Plants

The investment costs of indigenous MMHP installations in Nepal are found to be mostly site-specific. No straightforward relationships can be drawn between the size of the plant, end-use application, remoteness of location, and the total project cost. These costs vary between NRs 70,000 to 100,000 at present and usually include the cost of distribution lines. Similarly, maintenance and repair costs also vary greatly, ranging between NRs 5,000/year to 50,000/year.

Viability of the Micro-Hydro Programme

The micro-hydro schemes in Nepal have been found to be relatively viable options for meeting the energy needs of the rural population residing in scattered settlements in the remote and far-flung mountainous areas. Most of the factors that have contributed to the supposed non-profitability of some schemes are such that they can be improved considerably with moderate efforts. These are:

- some regulatory provision,
- clear and consistent government policies on the development and promotion of MMHP,
- regular monitoring and effective management of loans and subsidies,
- improvement in the training and management aspects,
- proper site selection, survey, and construction of the schemes,
- correct estimates of demand during feasibility,
- research and promotion activities in end-use diversification,
- reduction in repair and maintenance cost,
- coordination of the MMHP programme with other development activities, and
- establishment of a proper and competent institute, preferably in the private sector, to take overall responsibility for the development, promotion, standardisation, quality control, testing, financing, training, and coordination of the MMHP programme.

Most of the Nepalese turbine manufacturers and entrepreneurs have developed the technical capability to independently design, manufacture, install, and commission MMHP plants of up to a 100 kW capacity. Some manufacturers can even manufacture turbine and associated equipment of up to 12 MW in capacity while importing the turbine runner.

In spite of the technological capabilities of Nepalese manufacturers and the progress made in the development and promotion of mini-and micro-hydro technology, there are still many technical problems that need to be addressed in order for MMHP schemes to be technically viable. The owners of MMHP plants are struggling with many problems regarding the repair and, maintenance of their installations and, in the process, some of them have been forced to abandon their schemes altogether and are faced with having to pay back their loans from other sources. Lack of standardisation and lack of proper quality control, testing, and commissioning procedures seem to be a real problem. Another major obstacle in the effective dissemination of MHP plants is the unavailability of spare parts as well as of skilled/quality manpower.

Most of the plants visited in the course of preparing the Nepal Country Report were having various technical problems and the owners were spending a significant portion of their income in the repair and maintenance of their plants. The problems included worn-out turbine bearings, broken turbine shafts, water leakages, frequent damage to generator and control equipment, voltage fluctuations, and frequent damage to canal and intake structures.

3. HIGHLIGHTS OF MMHP DEVELOPMENT IN PAKISTAN[4]

- The recoverable potential of hydroelectric power is estimated to be nearly 21,000 MW out of which, only 3,330 MW have so far been exploited.
- The Water and Power Development Authority (WAPDA), an agency of the Federal Government, is responsible for the planning and execution of schemes of generation, transmission, and distribution of electrical energy. WAPDA mainly undertakes schemes of five MW and above.
- Among the primary energy sources, oil and gas contribute nearly 77 per cent of the total commercial energy, whereas the share of hydroelectricity is only 14 per cent. The non-commercial fuels, mainly biomass, currently supply nearly 40 per cent of the national energy demand.
- Per capita consumption of electricity is at a level of 296 kWh.
- The population of the mountainous areas of the North Western Frontier Province (NWFP) and the Northern Areas of Gilgit and Skardu is estimated to be more than two million. These remote, isolated mountainous areas cannot be provided with electricity from the national grid.
- The Government of Pakistan places a high priority on development of indigenous energy resources. The policy focusses on increasing the availability of electrical energy, eliminating load shedding, and electrifying all the villages.
- The Pakistan Council of Appropriate Technology (PCAT) and the Aga Khan Rural Support Programme (AKRSP) are engaged in the development of community-managed micro-and mini-hydropower in mountainous areas.
- PCAT, a federal government organisation, is engaged in development, adaptation, and dissemination of MMHP technologies for the benefit of rural communities. AKRSP is a private NGO established by the Aga Khan Foundation to help and improve the quality of life in the villages of northern Pakistan, and it receives funding from international sources. The main objective of the rural electrification programme of AKRSP is to develop and test the technological and managerial innovations needed for micro-hydel schemes.
- So far, nearly 160 schemes in the micro-range have been completed by PCAT, with a total installed capacity of nearly two MW, while AKRSP has installed 26 schemes, with an installed capacity of 600 kW.
- Cost-sharing is a key element in the MMHP programmes of PCAT and AKRSP. In the case of PCAT, the local community purchases the penstock pipe and distribution wires in addition to undertaking the entire civil works. In terms of money, the contribution of the community may be in the range of 40-50 per cent. In the case of AKRSP, the village organisations provide locally-produced materials, e.g., sand, stone, concrete, timber, and wooden poles in addition to providing unskilled labour. In some places, they have also provided distribution wires.
- The plants are designed, fabricated, and installed by making use of locally available materials and technology. Thus, they are less expensive and could be operated and maintained easily by the local community. A cross-flow/Banki turbine made in a small workshop is installed in most of the plants. Chinese-made electric generators are purchased from the local market. No sophisticated governing system is installed,

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[4] The Country Statement for Pakistan, was presented by Dr. M. Abdullah, a Professor at the NWFP University of Engineering & Technology, Pakistan, who also led the National Team for Pakistan in the preparation of the Country Report.

the flow of the water to the turbine is controlled by a gate-valve placed at the inlet to the nozzle.

- The capital cost of plant installation is in the range of Pakistani Rupees (PRs) 8,000 to PRs 15,000 per kW, which is fairly low compared to the cost of plants having imported machinery.
- The plants are installed to meet the expressed demand of the people, mainly for electricity for lighting purposes. Accordingly, most of the plants are run during the evening/night and supply the domestic lighting load of bulbs/tubes. In a number of cases, the motive power of the turbine is used during the daytime for agro-processing, e.g., flour grinding, rice husking, sawmills, cotton ginning, wooden lathes, and oil expellers. In a limited number of installations, the electrical energy is also used during the daytime for running washing-machines and food-processing units.
- The plants are managed by a committee of local people. After the plant is installed, it is handed over to a management committee which is responsible for operation, maintenance, and distribution. The tariffs are also determined by the Committee. Usually it is a flat rate per bulb, ranging from Rs five to Rs 15 per month. In some cases, energy meters have been installed and consumers are charged per kWh. The amount collected is barely adequate to cover the cost of operation and normal maintenance. In case of a major fault, or damage, additional amounts are collected from the consumers.
- Availability of electricity from the plants has considerably improved the life of the communities living in isolated and remote areas. Residents are able to save on the cost of kerosene oil. Family members, particularly children and women, can carry on their studies/work until late at night. Television has been installed. In some cases, the manual washing of clothes has been replaced by washing-machines, and this has brought relief to the women in terms of time and labour. In the case of those installations from which the power produced is used for running agro-processing units, owners are able to generate a substantial income and a few people in the village receive employment. Such installations do not create any adverse effects on the environment.
- The skill of MMHP operators is low at the village level. There is no formal training programme for the technicians responsible for operating and maintaining the plants. Since most people in the village have experience in building and maintaining irrigation channels, the water conveyance system of the plant is properly maintained and repaired if damaged during heavy rains/floods. However, the maintenance and repair of electro-mechanical equipment is weak. The on-the-job training provided to the local people during plant installation is not adequate. There is a need to organise training programmes for the operators and also for the installation staff working on the project.

Prospects

- Water in streams/brooks/springs is abundant, and adequate head is available due to the mountain terrain.
- The extension of grid electricity to remote localities is difficult and expensive.
- The domestic demand for electricity for lighting and running other household appliances is increasing rapidly.
- The private sector is more and more interested in establishing sawmills, flour mills, and fruit/vegetable dehydration plants.

- The tourism/hotel industry is expanding.
- A sound organisational structure has been developed by the AKRSP and the Village Organisations are now demanding micro-hydel plants instead of asking for irrigation channels and link roads.
- Elected representatives are also asking for MMHP in their constituencies.

Problems

- Proper management of MMHP requires a strong organisational set up. Problems may arise on issues, e.g., extending the distribution lines, deciding upon a suitable tariff, collecting from the consumers, generating funds for major repairs/ replacements, water and land rights, and use of water for power generation/irrigation/running traditional mills.
- Lack of funds is a major problem in most places. Since the local community is expected to share the cost of the installation, timely availability of cash is required. This poses a problem for the community and the projects are delayed. In some cases, turbine-generators have been installed, but the plant has remained closed as distribution wires were not purchased by the community. Raising funds to meet the cost of major repairs is difficult in most places.
- Due to the shortage of skill and technical facilities in the areas, even with minor problems, the plant may remain out of operation for several days. Components/parts and skilled technicians have to be brought from the town and then only can the plant be repaired.
- In areas where link roads are not available, the transport of plant machinery has to be carried out manually, which is difficult.

Suggestions

- Decentralised private MMHP technology should be recognised as a viable and preferred option for supplying electrical energy and motive power to meet the basic needs of rural communities residing in remote hilly areas. Energy policies and plans should promote the utilisation of hydropower on the micro- and mini-scale.
- The task of implementing MMHP schemes should be assigned to an appropriate agency at the provincial and district/local levels.
- An extensive survey needs to be carried out to identify the potential sites for MMHP installations.
- The PCAT and AKRSP should be further strengthened to improve their capabilities to provide technical assistance to implementing agencies, to undertake R&D work in areas related to MMHP, and to organise training programmes at various levels.
- An integrated programme of rural electrification and rural industrialisation should be implemented using MMHP as the source of energy. The private sector and banks should be encouraged to participate in these programmes.
- Local industries should be encouraged to undertake the design and fabrication of water turbines and generators. If necessary, such facilities may also be established in the public sector to give a boost to the programmes.
- Village organisations/local communities should be properly trained for the management of the plants.
- Repair and maintenance facilities should be established in central places in the towns of the North Western Frontier Province (NWFP, Pakistan) and the Northern Areas.

- Schemes for extension of the electricity grid and the installation of MMHP should be properly coordinated.

Suggested Subject Areas for the Proposed Training Programme for Decision-makers

- Information about the energy needs of rural communities living in isolated mountainous areas; the current situation in respect of supply of energy resources and their end uses.
- Need for rural electrification, options available for supplying electricity to these areas and their technological and economic considerations.
- MMHP as a viable option; technological aspects, capital and running costs, economic feasibility, environmental considerations, evaluation criteria, socioeconomic benefits.
- Financing of the MMHP programme, multilateral sources, regional aid organisations, development banks, commercial banks, NGOs, private sector.
- Electricity tariff, Cost of energy supply, paying capacity of the community, and end-use promotion.
- Management, operation and maintenance of the plant, training needs.
- Institutional aspects of the MMHP programme, single utility, separate Central Rural Electrification Authority, autonomous MMHP authority.
- Integrated programme for rural electrification and rural development.
- Case studies
- Site visits.

Annex 2: THE SYNTHESIS OF COUNTRY EXPERIENCES[5]

A summary of the Synthesis Report "Mini- and Micro-Hydropower Development in the Hindu Kush-Himalayan Region - Status, Prospects, and Problems"

Introduction

The Himalayan range, including the Hindu Kush and the Karakoram, is the largest range in the world and home to about 120 million people. It is divided into eight countries from Afghanistan in the west to Myanmar in the east and has a total area of about 3.4 million sq.km. This area is inaccessible, undeveloped, and poor. Consequently, the energy situation (availability, supply, and distribution) is also considerably problematic. Wood and other biomass are used for fuel in a proportion of 90 per cent and above, since these are the only available fuels in many areas. However, this traditional fuel system is now becoming scarcer in many areas because of deforestation. At the same time, the overall consumption of energy is increasing at a rate ranging between five and 10 per cent.

In most of these mountain areas, a sizeable and viable source of energy, i.e., hydropower especially mini-and micro-hydropower (MMHP), exists which could easily be developed to meet local energy needs, including electricity.

Although the whole of the hydropower spectrum (from micro-to large plants) is considered to be less damaging to the environment than most other fuels, the mini- and micro-hydropower (MMHP) range has considerable advantages over the larger hydropower schemes and other fossil or biomass fuels. Some of these advantages are:

- sizeable potential; in China, for example, the potential of MMHP is estimated to be around 70,000 MW;
- the plants are comparatively more viable for remote and inaccessible areas than other commercial fuel systems;
- they are easier to design and manufacture locally;
- sophisticated and expensive instrumentation and control systems can mostly be avoided;
- the plants are cheaper to manufacture and install by a factor varying from two to five compared to imported plants, and they can be easily repaired with local facilities;
- the problem of transporting other fuels to such difficult areas can be greatly offset;
- the O&M costs of privately-owned/operated plants are also quite low;
- indigenous design and manufacture of such plants contribute towards the development of the local industrial base, including technical expertise, and this is useful for other development work;
- adverse environmental effects are minimal; and
- MMHP is also more suited for decentralised development, including design, manufacture, installation, and operation/management.

5 This is a summary of the Synthesis Report based on five Country Reports, prepared by Dr. A. A. Junejo, Project Coordinator for the NORAD-Sponsored Project, "Design & Testing of a Regional Training Programme on Mini-& Micro-Hydropower for Mountain Development in the HKH Region".

Unfortunately, only a small fraction of the viable potential has been used so far. The overall situation of the Hindu Kush-Himalayan Region warrants a cheap, indigenous, and non-polluting generation of energy and mini-and micro-hydropower has these advantages.

Brief History of the MMHP Programmes

MMHP plants were introduced in the region by the Government Electricity Departments. In Nepal the first MMHP plant was installed at Pharping in the Kathmandu Valley in 1911 with a 500 kW capacity. It just went out of operation a few years ago. The first MHP plant was installed in Darjeeeling, India, in 1897 with a 130 kW capacity and in Kunming, China, in 1912 (480 kW). The story of MMHPs in the other countries is not too different and many had MMHP installations in the 20s and 30s. However, there was no particular distinction between the larger and smaller plants. The basic equipment was the same, and it was almost always imported. Therefore, the MMHP plants tended to be costlier than the larger ones on the installed cost per kW basis, as well as on the operational cost per kWh basis. It was during the fifties in China, and in the sixties and seventies in the other countries of the region, that a new approach emerged; i.e., indigenous development and decentralised installation of micro-hydropower plants. This new approach reduced the capital costs considerably and introduced informal management and operational practices. Consequently, the rate of installations increased substantially, and some really remote and inaccessible villages witnessed the advent of electricity which would have been unthinkable under a government planned and managed system. These micro-hydropower plants, mostly in the three kW to 40 kW range, are usually subsidised by a government development agency, or an NGO, as in Nepal and Pakistan. In China, similar but larger plants are financed by a combination of government agencies (central, provincial, or local). After the installation, the local communities own, operate, maintain, and organise the repair of these plants. In a way, the new-approach MMHP plants were considered to be the extension of the traditional *ghatta*, or *gharat* (water wheel), technology which has been used in the region for many centuries, mostly to operate small, agro-processing units.

More recently, the funding and management systems of MMHP have been diversified to achieve differing objectives, as delineated below.

1. Community-owned and formally-managed plants installed with the main objective of providing electricity to the rural and remote areas (mainly Nepal).
2. Local community- or individually-owned electrification MHP plants managed informally, mainly to provide electricity (Nepal & Pakistan)
3. Decentralised plants initiated and installed by communities, or the lowest level, local administration, the main objective being to provide electricity to the rural areas (mainly China).
4. Local community- or individually-owned milling only, milling plus electricity, or electricity only MHP plants managed informally; the main objective being to earn profits (Nepal and Pakistan).
5. Investor (local or outsiders)-implemented electrification plants managed formally, mainly for the sale of bulk electricity to the grids or government agencies; the main objective being profit (efforts taking place in India, Nepal, Pakistan).

The private MMHP plants have distinct advantages over the larger public sector versions. Therefore, although the larger, government-owned MMHP plants are not excluded from the programme, and their improved performance (economic as well as technical) is very much a concern, the main focus would be on micro-hydropower plants installed and managed by the private sector or by the communities.

MMHP Installations in the Region

There has been considerable progress in the five countries of the region in terms of the number of installations in the MMHP range, although the actual contribution towards the energy requirements of the mountain areas is still minimal. Details of the MMHP installations for the participating countries, both in the public as well as in the private sector, are given below.

At present, there are 19 MMHP plants in **Bhutan**, with a total capacity of 3.40 MW, all installed by the Royal Government under various aid agreements, mainly with India and Japan. There are only three other hydropower plants installed in Bhutan, i.e., the Chukha (336 MW), Gyetsa (1.5 MW), and Gidakom (1.25 MW). About 80 per cent of the electricity generated by the Chukha plant is currently being exported to India. About 20 per cent of the population has access to electricity. Most of the electro-mechanical equipment has been imported, mainly from India or Japan. The plant design and installation are undertaken by foreign consultants. Most of the funding (loans or grants) has been provided by foreign agencies. Ten MHP plants, varying in capacity between 20 kW to 70 kW, were handed over to the user communities recently for operation, maintenance, and distribution of electricity. The communities also fix tariffs and collect revenues. This experimentation has been introduced mainly because the government agencies were finding it very difficult to operate and maintain the plants. The responsibility for the repair of these plants, however, still lies with the Department of Power. The government agencies regard MMHP plants to be very expensive and not economically viable, and they have no plans to promote them in the near future.

In **India**, there are 145 existing MMHP/SHP plants (up to 3 MW) with a total capacity of about 106 MW installed by various government agencies, while 159 additional plants, with a cumulative capacity of 198 MW are under construction. Out of the above, about 100 existing plants are located in the Northern Himalayan range, with an installed capacity of about 70 MW. All these plants are being managed by the State Electricity Boards or by the Department of Power in Arunachal Pradesh. In most cases, the tariff being charged is the same as the general State tariff for the grid system, except in Arunachal Pradesh.

More recently, some NGOs have also started to install micro-hydro plants in Ladakh and Uttar Pradesh. The plants, once installed, are handed over to the communities for operation and use.

In **Nepal**, 35 MMHP plants were installed by the government sector with a total installed capacity of nine MW, which are owned by the NEA, and five of them are grid-connected. During 1993, five of the above plants, at Darchula, Bhojpur, Kandhabari, Jomsom, and Bajhang, were leased out to private commercial companies. The new companies are to be responsible for operation and maintenance of these plants, as well as for the distribution of electricity. They are also authorised to fix tariffs and collect revenue from the consumers. However, the tariffs fixed by them must not be higher than the prevailing NEA tariffs. This is a new initiative adopted by the NEA in order to cut down its losses from mini-hydropower plants. It is expected that other MMHP plants will also be leased out by the NEA to private establishments.

There are other MMHP plants in Nepal, managed and operated by private establish-ments, which also undertake distribution and revenue collection. These establish-ments are not following the NEA tariffs and have introduced novel systems to promote more uniform use of electricity and avoid sharp peaks in the demand. The largest and the most important of these plants is the 400 kW, Salleri Chialsa Power Plant, completed in 1988. Distribution of electricity is also undertaken by the company. The tariff has three main components. First is the initial connection fee, which increases with maximum power allowed from NRs 250 for a 100 W connection to NRs 1,500 for loads higher than 4,000 W. This connection fee is automatically transformed into company shares. Secondly, there are fixed rates for admissible power, subdivided into eight levels: rates vary from NRs 50/month for the first level of a 100 W connection to NRs 500/month for the eighth level. Thirdly, except for the first two levels, an energy charge per kWh is also made which ranges between NRs 0.90 to NRs 3.00.

Another interesting MHP plant is the 50 kW Ghandruk power plant. Here also, fixed but different, flat-rate tariffs are charged for different permissible levels of power consumption. A power cut-off device is installed in the connections to switch off power if the prescribed limit is exceeded. Other similar plants are also under construction, or are being planned. These new trends, although not perfect for solving the problem of sharp peaks and non-uniform usage, have come a long way from the energy (kWh)-based tariffs.

Considerable assistance has been provided by many international agencies in R&D, promotion, installation, and monitoring and evaluation of the private MHP plants in Nepal. Foremost amongst them are SKAT (Switzerland), ITDG (U.K), German Appropriate Technology Exchange (GATE)/German Agency for Technical Cooperation (GTZ, Germany), and Association for Promotion of Appropriate Technology (FAKT, Germany). In addition, the United Mission to Nepal (UMN), a missionary organisation supported by many developed countries, is also arranging assistance from other parts of the world.

There are between 900 micro-hydropower turbine units in Nepal, owned and operated by individual entrepreneurs, mostly for powering the agro-processing equipment. Out of these, 13 are stand-alone electrification plants, and about 100 other agro-processing units also have add-on generators. In addition, about 70 peltric sets, having an average power output of about one kW, have also been installed all over Nepal for electricity generation. Another interesting endeavour is the improvement of the *ghatta* or traditional water wheel. So far about 200 *ghatta* have been improved by replacing the traditional wooden runner with a steel one, with buckets similar to Turgo turbines. In this way, the efficiency is reported to be doubled, at a very nominal expenditure of NRs 5,000 (US$ 100). During the 80s, a new design of turbines, similar to the improved *ghatta* but having all the components made of steel, the Multi Purpose Power Unit (MPPU) was also installed.

The bulk of these private MMHP plants were installed during the eighties when the Government removed the requirement for licenses for MMHP installations up to a 100 kW and provided funding facilities through loans and subsidies. Subsidies of 50 per cent to 75 per cent were available only for electrical equipment, whereas loans were available for mechanical equipment and civil works. The concentration of MMHP installations is much higher in the districts nearer to the two production centres, i.e., Kathmandu and Butwal.

The first manufacturer of MHP turbines in Nepal was the *Balaju Yantra Shala* (BYS) in Kathmandu, established in 1960, with technical and financial assistance from the Swiss Government. After initial experimentation with the axial propeller turbine, the BYS settled on manufacturing cross-flow turbines in the seventies, which is its specialty still today. Soon after, the United Mission to Nepal (UMN) sponsored the Butwal Technical Institute (BTI) and started the manufacture of cross-flow turbines. Subsequently, a number of different companies were established to undertake site survey, layout design, plant design, manufacture, and installations under the overall umbrella of the UMN. At present, there are ten such companies based in Butwal and Kathmandu involved in manufacture and other technical aspects of MHP. At present, the production capacity of MHP equipment in Nepal is around 1.00 MW per year; although the generator and instruments are being imported from India.

Over the past two decades, R&D on a number of other devices have also been undertaken in Nepal, mostly for the control systems or end uses. The *bijuli dekchi* is an efficient cooking pot, heated by an electrical element, and incorporating a thermostat. The wattage range may vary between 200W to 500W for pot sizes ranging between 2.5 litres to 20 litres. In air-heat storage cookers, a bank of packed pebbles is heated through a 250 W element and the heat is stored up at about 500°C. For use, air is circulated through the pebbles and supplied to the cooking chamber where it heats the pan. The *bijuli dekchi* is currently being distributed in some areas under a subsidy programme, and the storage cooker is undergoing field trials. The electronic load controllers (ELCs) automatically divert excess power not utilised by the consumers to ballast heaters. Thus, they maintain a predetermined constant (maximum) load on the turbines and keep the supply voltage, as well as frequency, constant. The ELCs, originally developed in the U.K. and elsewhere, are being assembled locally in Nepal; the main components, including the circuit board, however, are being imported.

Installation of MMHP/SHP plants in China started in the 50s. The installed capacity of MMHP/SHP reached 1,200 MW in 1979, which was about 48 per cent of the total hydropower. At present, China has 51,389 MMHP/SHP (up to 10 MW capacity) power plants with a total generation capacity of 14,420 MW; the annual generated energy being 44.2 TWh. Out of this, 48,888 plants are in the mini-and micro range (up to 500 kW). About 1,567 out of the total of 2,300 counties in China have significant MMHP/SHP potential and 777 counties mostly rely on electricity from the MMHP. About 35 per cent of the plants are grid-connected; however, in terms of capacity, 93.5 per cent of the power from MMHP/SHP plants is connected either to the national or local grids.

Most of these plants are introduced, constructed, and managed in a decentralised manner, based on the policy of 'self-construction, self-management, and self-consumption'. The plants are managed and operated by local governments, including village, township, or county administrations. Funding for the plants is obtained from various sources, including the Central Government, provincial governments, and many other administrative systems. About 35 per cent of the funds were also arranged through bank loans on interest. The owners (individuals as well as communities) also contributed about 14 per cent of the costs. The energy charges collected from the consumers are fixed by the administration. However, the rates for sale to the national grid are government rates. At present, these rates vary between 0.05-0.08 *yuan*/kWh (less than one US cent). The other rates are somewhat higher but are not known. Technical assistance for design and installation, and training for operations and maintenance are provided by bureaux established for this purpose at various levels.

Like most other countries, the main government agency in **Pakistan**, WAPDA, has found it difficult to implement and run smaller projects below the five MW capacity. Therefore, the power houses installed already were handed over to the Irrigation Departments of the NWFP and the Punjab. More recently, other organisations have also been created or upgraded to undertake installation and maintenance of the MMHP/SHP plants. In the Northern Areas (Gilgit and Baltistan), the task of MMHP plant construction and operation is assigned to the Public Works Department; whereas, in the NWFP, a new organisation, Sarhad Hydel Development Organisation (SHYDO), has been established under the provincial government; and the older MMHP plants have also been handed over to SHYDO. There are 64 MHP plants with a total installed capacity of about 17 MW being operated by various government agencies.

Two organisations in **Pakistan**, engaged in promotion of MMHP in the private sector, are the Pakistan Council of Appropriate Technology (PCAT) and the Aga Khan Rural Support Programme (AKRSP). Both of these organisations arrange installations in the hilly mountain areas, carry out surveys, and lay out plans. They also provide sizeable subsidies for the plants. All the plants installed by these two agencies are electrification schemes which are handed over after installation to the recipient community for operation, maintenance, and repair.

The PCAT, at present, provides subsidies at the rate of about 40 per cent on the cost of the plant and installation. The villagers pay for and complete the civil works, pay for the transmission/distribution system, and provide all the labour and transport. Of late, the recipients also provide about 50 per cent of the cost of the penstock. In the case of the plants installed by the AKRSP, the subsidy varies from about 20 per cent to 80 per cent, including the transmission lines. In some cases the villagers have contributed in cash also. In one case, about 80 per cent of the project cost was arranged by the villagers through contributions. On the other hand, another plant was almost entirely financed through funds provided by the Canadian High Commission.

Since the introduction of its MHP programme in 1975,the PCAT has, so far, installed about 160 plants with a total generation capacity of about two MW and an average plant capacity of about 12.8 kW. About 90 per cent of the plants are within a 5-20 kW range. Only 10 plants (6%) have a capacity of less than five kW and seven plants (4.5%) have capacities higher than 20 kW. All the plants use an old cross-flow turbine design and supply electricity to a rural mountain population of about 10,000 in 160 villages. In about 20 per cent of cases, some add-on agro-processing, or similar, units are also powered by the plants. To date, all the funding has been provided by the Federal Government. More recently, however, some funds have also been allocated by the provincial government of the NWFP as well as by members of the National Assembly. The cost per kW of the installed plants ranges between PRs 10,000-15,000 (US$ 330-500).

A number of improvements has been achieved during the past few years in plant quality and performance. Plant failures have also decreased. However, unlike Nepal, basic technology and design have not changed much. The PCAT still uses the original version of the cross-flow design, straight penstock, and gate valve. No electronic load controllers or other such devices are being used at present.

It has been observed that the plants are quite successful in some districts; especially, Swat, Dir, Chitral, and Kohistan, and the local technicians seem to have gained considerable experience in the repair and maintenance of MMHP plants, which is helpful for extending plant life and providing better service. However, all the plants are operated and managed as non-profit making enterprises. Therefore, the revenue generated is small and usually just about enough to meet the routine operation and maintenance costs. If there is a serious breakdown, the principal person in charge meets the expenditure from his own pocket to get the repairs done. He may, however, organise a collection for this purpose before or after the repairs have been completed. Also, no serious attempts have been made so far to increase and/or diversify the end uses, mainly because profit-making is not the objective and the manager/in-charge does not benefit directly from enhanced power generation and additional working hours.

Since 1986, the AKRSP has installed 26 MMHP plants with a total installed capacity of 600 kW (average plant size 23 kW), supplying electricity to about 1,100 households. Unlike the PCAT, the AKRSP has installed various types of turbines for their plants, including cross-flow, tubular (propeller), Pelton, and Francis. All the equipment is manufactured locally, except for the generators.

At present, the cost of MHP plants installed by PCAT and AKRSP varies between PRs 8,000 to 15000 (US$ 260 to 500), including the cost of transmission lines; which is about one third to one quarter of the costs being incurred by the Northern Areas-Public Works Department (NA-PWD, Pakistan), a Government agency working in the same area but importing the main items of equipment. There are ongoing efforts to use electricity for processing (drying) fruits and vegetables in the area. However, the plants are not being managed as commercial ventures; they are rather a social service for the community, especially for those who have contributed actively towards the construction of the plant. The recipients, therefore, are charged rather nominally, i.e., between PRs five to 15 per bulb per month.

Main Features of Indigenous MMHP Technology

In the case of the private sector micro-hydropower plants, the most important turbine is the cross-flow. In Pakistan, for example, out of 182 turbines installed in the private sector (by PCAT and AKRSP) 177 are cross-flow. Only a few turbines installed by AKRSP are Pelton or other types. In Nepal also, about 76 per cent of the turbines are cross-flow, followed by 20 per cent MPPU and three per cent Pelton. During the past three to four years, Pelton wheels are also being designed and manufactured locally, especially, the smaller version the (~1kW) peltric set. These sets are standard designs in which the generator and turbines are mounted on the same vertical shafts. Their advantage lies in their small size, which can be easily transported, and ordinary pipes are used as penstocks. In Nepal, the technology for casting the Pelton buckets seems to have been mastered reasonably well. However, it is difficult to say whether the degree of quality and precision has been achieved to provide the desirable efficiency and durability.

China has a very broad base for manufacturing different turbines, including the Francis, Propeller/Tubular, Turgo, and Pelton. Interestingly, the cross-flow turbine does not seem to be very popular in China. China also exports MMHP equipment to other countries within the region, as well as outside. Chinese synchronous generators, for example, have been used in Pakistani MHP programmes since the inception and have given reasonably trouble-free service.

In the case of private sector MMHP installations, almost all of which are locally manufactured, reports about the quality and performance assurance have been mixed. Most of the turbines and the other auxiliary equipment have performed well in Nepal and Pakistan. However, at present, there does not seem to be a proper system for evaluating either the quality or performance. At the time of commissioning also, it is not normal practice to measure the power output or to check the maximum or rated power.

In one of the surveys undertaken in Pakistan, it was found that 54 per cent of the plants installed by PCAT were non-operational at the time of the survey. The situation seems to have improved considerably now and, according to the current estimates, about 10 per cent of plants were non-operational out of the total installed since 1988. In the case of Nepal, no such study has been undertaken so far. There have been some reports of serious breakdowns such as burst penstock pipes, broken turbine shafts, excessive wearing out of bearings, and serious leakages. However, this must be expected to some extent, since the capital cost is less for indigenous equipment.

Almost all the locally-produced equipment in the four countries has been considerably cheaper than the equipment imported from abroad. Even the better quality Chinese equipment is cheaper by a factor of from two to four, compared to European or Japanese equipment. The cost of privately-installed plants in Nepal at present varies between NRs 40,000 to 10,000 (US$ 800-2,000), whereas, in Pakistan, the cost is around PRs 10,000-15,000 (US$ 300 to 500). Chinese and Indian equipment also fall within the same cost range. It is believed that if right inputs and guidelines can be provided to the manufacturers in the region, so that quality and performance could be improved, not only could the local requirements be met satisfactorily, considerable exports to nearby countries in South/Southeast Asia and the Pacific could also be made. Costs of the equipment might go up due to such improvements; nevertheless, they would still be much lower than the products imported from developed countries.

In the case of privately-owned informal plants, total management is almost always in the hands of the owners in Nepal and Pakistan. Most of these plants in Nepal have been installed for agro-processing or added on generation of electricity. The owners employ operators and oversee their working. Sometimes the owners or their relatives may also operate the plants.

In the case of community-owned plants, the management is assigned to one or two persons, sometimes on a continuous basis, but not always and usually on nominal or no payment. Such a manager may, however, be allowed free use of electricity for his house. Most plants installed by the AKRSP are managed in this way, so are some community-owned PCAT plants in Pakistan and the community plants in Nepal.

Policies Concerning the MMHP Programmes

All the five participating countries have given some kind of support for hydropower installations, including the MMHP/SHP. They have also declared rural electrification as their priority area. China, India, and Nepal have also given priority to the installation of

MHP/SHP installations for remote and isolated areas. The approach, however, is considerably different. In India, for example, the recent policy of privatisation aims to induce the private sector to start generating electricity as a supplement to government effort through various incentives, and then to supply this electricity to the public sector grid system. It is more likely that, since private sector entrepreneurs establish installations primarily for profit, they would tend to go for larger installations which could be easily connected to national/regional grids. Thus, the main benefits of such private sector efforts would accrue to the mainstream, mostly urban/sub-urban consumers.

On many accounts, Nepal is ahead of most of the countries of the HKH Region in evolving and adopting policies and plans that affect the renewable energy sector in general and MMHP/SHP in particular. A number of initiatives taking place in Nepal during the past 15 years is briefly discussed below.

Provision of soft loans in 1977 allowed for up to 80 per cent of the project cost. The interest rates, at present, are 17.5 per cent. Delicensing of the MHP plants in 1984 was perhaps the most important supportive legislation to affect the proliferation of the MHP plants in the remote rural and inaccessible areas.

Subsidies for electrification through private MHP plants to the extent of up to 80 per cent is allowed for the plants in remote districts and up to 50 per cent in more accessible districts; these were handled by the Agricultural Development Bank Nepal (ADB/N). Both the amounts under subsidies and loans are payable only to the installers/manufacturers.

The Hydropower Development Policy enacted in 1992 emphasises the need for installation of MMHP/SHP plants to meet the demand of remote and inaccessible mountain regions. Also, the participation of the private sector, including foreign entrepreneurs, has been actively solicited through provision of permission to transfer profits and through provision of tax holidays. The policy also places special emphasis on local manufacture, as far as possible, and allows a number of concessions in this respect. It also allows the investors to generate electricity and distribute it, fix tariffs, and collect revenues from the consumers. No license or any kind of approval is required for installations up to 100 kW. In the case of MMHPs in the range of 101 to 1,000 kW, notice should be given to the concerned (Government) agency.

The main highlights of the Water Resources' Act 1992, concerning MMHP, are the priority given to various water uses. Utilisation of water for the generation of hydropower has been listed after drinking/domestic use, irrigation, and other agriculture-related uses in terms of priority. Another aspect worth noticing is restrictions on pollution of water resources.

In addition, the various five-year plans have proclaimed support for various aspects of the MMHP installations, including rural electrification, rural industries, private as well as community MMHP installations, and so on. Rural electrification is accorded special attention in these plans.

The Governments of China and India have also given special recognition to the MMHP/SHP in their planning and policy documents to meet the energy needs of some areas. The Government of India has now allowed private sector MMHP/SHP installations and has also announced special incentives, loans, subsidies, and tax breaks for such installations.

However, it remains to be seen whether these efforts will help to establish sizeable programmes in the mini- and micro-range, especially for plants owned by communities or local individuals. A number of clearances have also to be obtained from State Governments for water use (about 10% royalty may also have to be paid), environmental protection, and forest protection.

In Pakistan also, many announcements have been made in support of rural electrification, and support for renewable energy, including small hydropower and its achievements, is considerable. About 30-40 per cent of the rural population now have access to electricity; both through grid extension as well as installation of stand-alone plants. However, there are still vast remote areas which can be electrified through privately or community-owned mini- and micro-hydropower plants. Unfortunately, in this respect, the Government of Pakistan has not declared any policy or tangible initiatives for private MMHP installations. The only notable programme supported by the Government is being implemented by the PCAT, but it is a very minor effort and not recognised by the concerned government agencies.

Although incentives and policy support mechanisms have been promulgated in many countries, judicious implementation was reported to be lacking. In Nepal, for example, the availability of funds for loans and subsidies was not consistent.

Planning and Implementation

Until very recently, planning for public sector MMHP installations was neither comprehensive nor long term. More recently, however, some efforts have been made in almost all the countries to prepare a Master Plan, or an inventory of the sites and available data. For example, the Small Hydropower Department (SHPD), Nepal, in collaboration with GTZ, has prepared a Master Plan for MMHP sites having power potentials in the range of 100 kW to 1,000 kW. Similarly, the Water and Energy Commission Secretariat (WECS), Nepal, is preparing an inventory of 10-15 most viable MHP sites in each of the 63 districts in Nepal where MHP potential exists. Preparation of a similar Master Plan has also been undertaken by SHYDO (Pakistan). However, most planning efforts are usually concerned with larger mini- and small plants and not with the micro-plants. As far as is known, no comprehensive planning effort has been undertaken for an area or part of a country to specify that such and such a part would be electrified through decentralised MHPs, this part through extension of the transmission line from a SHP plant, and these parts through extension of the main grid system. Sometimes, the MHP plants originally approved and financed by the government agencies would be allowed to go out of operation when the national grid was extended in that area. Many MHP plants have been abandoned in this way, even in the public sector, partially or completely.

In China, most of the planning concerning decentralised MMHP/SHP is carried out at the central as well as at the provincial government level.

In the case of informal, private MHP plants owned and managed by individuals or communities, the villagers or recipients usually identify a potential site and the water source. They then approach an implementing agency, such as PCAT (Pakistan) or ADB/N (Nepal), to arrange for the installation. Usually, in such cases, proper assessment of the demand for the village or area is not carried out; the result being that demand may exceed the capacity quite quickly and the villagers may start looking for bigger plants. In many cases, the opposite has also been reported. In Pakistan, as well as in Nepal, comprehensive planning may not be crucial at this stage, especially since the exercise may be quite expensive. More important is the need to integrate the private MHP programmes into the comprehensive electrification schemes drawn by the government agencies, either for electrification or for energy applications leading to rural development (industries, employment, other energy needs), which does not seem to be the case at present.

PCAT and AKRSP in Pakistan also hold considerable discussions with recipients and their main representatives to appraise them of their contributions as well as of their responsibilities. These discussions also assist the appraisers in assessing the capabilities of the villagers to manage and operate the plant successfully and also to enable them to learn about any potential communal problems in the project area which may affect plant operations in future. More recently, agreements have been signed with the representatives of the recipients. Usually, the villagers are also asked to complete the civil works first, which is their share of the contribution, before transfer of the electro-mechanical equipment to the site. The main objective is to involve the recipients fully during all the phases of planning, installation, and operation and to persuade them to make significant contributions towards the expenditure for the plants. In Pakistan, the main drawback is the lack of development of the more productive end uses of electricity which could bring about significant economic returns for the plant owners leading to their being able to fund their plants entirely one day.

Funding Sources and Procedures

Funding for public sector MMHP installations is usually arranged by the Governments through their own resources or through international sources (banks, donors). In the case of private plants, various types of funding systems have been introduced in China, Pakistan, and Nepal and these are described briefly here.

Grants for installations have been provided by donor organisations in some cases. Such grants are not a regular feature and usually do not make much impact on the overall programmes.

Subsidy funding is the main resource in Pakistan and, to a lesser extent, in Nepal. The level of the subsidy has gradually decreased from 70 per cent to a current level of around 40 per cent. As described elsewhere, subsidies are also provided by the Agricultural Development Bank/Nepal (ADB/N) for the electrical equipment of MHP plants in Nepal. The AKRSP, on the other hand, provides varying amounts of subsidy.

Loans for private MMHP installations are provided in Nepal, China, and India. There is an interesting combination of loans and subsidies being implemented in Nepal, and these are mainly managed by the Agricultural Development Bank (ADB/N). The turbine equipment used for agro-processing, electrification, and the agro-processing units qualify for loans at slightly cheaper rates than the commercial loans. Loans of up to 80 per cent of the total cost may be provided. The ADB/N had invested more than NRs 100 million as loans and subsidies in the MHP programmes up to 1992. However, at one time, the ADB/N was charging a 15 per cent interest rate which increased to about 19 per cent (including a 1% service charge). At present, the total rate being charged by the ADB/N is 17.5 per cent, and this includes a one per cent service charge. Subsidies are available for electrical equipment only.

Serious problems of loan defaulting have been reported by the ADB/N. A study conducted in this respect pointed out many causes for loan defaulting by mill owners. The main cause, however, was stated to be the poor economic returns of the mills arising from poor financial management; poor technical operations, inappropriate sites, water problems, and market saturation were also identified as other contributory factors. One of the ICIMOD case studies has pointed out that some borrowers were not paying back loans even though they had received significant incomes from the mills.

As described earlier, the Government of India has announced various economic incentives for private sector MMHP/SHP plants of up to a 15 MW capacity, including loans and subsidies. Loans of up to 75 per cent of the total plant cost, at a simple interest rate of 15.5 per cent, have been offered. The maximum amount of the loan varies with the credit ranking and type of security of the borrower; the current maximum limit being IRs 254 million. In addition, the Ministry of Non-Conventional Energy Sources (MoNES, India) also offers a 25 per cent capital subsidy for grid-connected plants, and 50 per cent for non-grid connected or hilly region plants of up to three MW in capacity. These funding systems, however, are more likely to be of benefit to profit-oriented enterprises mostly going in for large plants.

Plant Management, Operation; and Repair

Private sector plants can be generally divided into two main categories; i.e., those being managed in a formal manner with the employees working fixed hours in some semblance of a regular service structure. Two of the most important existing MMHP plants were described earlier. The Salleri plant currently has eight employees[6], while the 50 kW Ghandruk plant has three employees (one manager and two operators). The staff and the manager maintain the incomes and expenditure ledgers. In the case of Ghandruk there is a net income of about NRS 240,000 per annum (~6% of total capital cost), however most of it has gone towards the loan repayment which has been repaid completely. During 1992-93 there was a net income of NRs 472,000 (~2.4% of the total investment) from the Salleri Chialsa plant when only one turbine (200 kW) was operational. This situation has improved considerably now that both the turbines are operational. Thus, these plants are doing much better than the NEA-managed plants, which are losing money even on the current account basis. Overall, the operating and managerial staff are fairly competent and trained. The staff also receives continuous training and guidance from experts, some of whom are expatriates.

In the case of informally-managed plants, the owner or a prominent person from the community looks after the plant as an owner/manager, overseeing the operation and maintenance and handling financial matters. Generally, the owner/managers are not well-educated, if at all. Also, they may have received no training, either technical or managerial. In many cases, they may not have commercial instincts. Therefore, it is not surprising that poor management has been cited as one of the main reasons for the financial troubles of the mills. In some districts of Pakistan, the MHP plants are more successful than in other areas. These areas also happen to have a large concentration of plants. The general feeling is that in these areas the people and the technicians have learned enough about the plants. Therefore, they are able to organise and carry out the maintenance and repairs on their own

6 One General Manager, one Admin/Accounts Officer each, three operators and, two helpers.

without much difficulty. Similarly, in some districts of Nepal also (e.g., Dhading District), where plant concentration is high and they happen to be quite near and accessible to industrial centres, the plants tend to be more successful than in the more remote parts of the country. Here also, the managers seem to have improved their capabilities over the years, mainly through trial and error, whereas in the remote districts, such as Darchula, the plants face more serious problems and have less income.

Many studies, including some ICIMOD case studies, have generally pointed out the inadequacy of the capabilities of the owner/managers and the operators. In Nepal, book-keeping of any kind was lacking and management of cash was also inadequate; no amounts were being put away for loan repayment or routine maintenance. Similarly, the operators were not sufficiently trained to notice signs of impending trouble and take appropriate action to avoid a severe breakdown. Usually, the salaries of the operators were quite low, prompting them to change jobs quite often. These reasons may be partially responsible for more frequent and severe breakdowns.

In most of the mountain areas, including Nepal and Pakistan, the organisation of the repairs is a difficult and time-consuming endeavour. This may be aggravated due to incapable management. Sometimes, the damaged part has to be identified, disassembled, and transported to an appropriate repair centre. Alternatively, a mechanic has to be brought from the repairing establishment to undertake repairs or assembly/disassembly. All this necessitates a considerable level of organisational capability, which may not be available.Performance of a given plant can be considerably enhanced through various optimal operational and maintenance practices, which may also lead to increased plant life and less breakdowns. Unfortunately, significant and reliable data are not available on this aspect.

In Nepal, it has also been noticed that the add-on electrical equipment goes out of operation quite often and the repairs and recommissioning take quite a long time. This could be because of the low returns from the electricity, or there may be problems with repairs which require more sophisticated equipment or manpower. In this case also, adequate data are not available. Some problems have been reported concerning collection of the electricity revenues from consumers. In some cases consumers may connect more loads (bulbs) than they are paying for. Some consumers are reluctant to pay the full bills because the electricity supply is irregular and unreliable. In some cases, the owners or their relatives were reported to be operating the mills as a secondary occupation. In such cases, the service is unlikely to be reliable, since these operators have to perform other duties also. This might affect consumer confidence, and they may be reluctant to bring their business there.

Overall, it can be concluded that the plant performance, service reliability, and economic returns can be significantly improved by improving the management, operation, and maintenance practices.

Plant Capacity Utilisation and End Uses

Utilisation of plant capacity and the plant factors tend to be quite low for both public and private sector MMHP plants. Plant factors ranging between 10 per cent and 20 per cent are quite common for electrification schemes. Reliable data are not available for the plant factors of agro-processing units. However, there also, the values are anticipated to be quite low;

say between 10 per cent to 30 per cent. Since all the plants are run-of-the-river type, having negligible water storage capabilities, the unused, available energy simply goes to waste. Therefore, low load factors for MMHP plants are a serious drawback financially.

As discussed earlier, private/decentralised, formal electrification plants are doing relatively better in Pakistan and in Nepal than informal plants in the sense that their income is higher than their yearly expenditure. This suggests that these plants are using their plant capacity relatively well and chances of improvement of the plant factor are considerable through innovative tariff systems and promotion of other end uses, including cooking, during the off-peak periods. Prior to the installation of the new turbine at Salleri Chialsa, the plant (station) factor was about 41 per cent whereas the plant factor for the Ghandruk plant is about 42 per cent. Similarly, the plant factor for the Purang MHP plant in Mustang District is about 42 per cent. These values are quite reasonable for small, stand-alone plants. However, to some extent at least, fixed power connections may also encourage users to leave appliances, such as bulbs, on when they are not needed. Many reasons have been reported for the low level of plant capacity utilisation of private informal plants. For example, the areas were usually remote and undeveloped, and the people were poor. Therefore, they used electricity for lighting only for three to four hours. Secondly, the supply was not so reliable, or sufficient, for industrial use during the day. Where MMHP plants power agro-processing units, the reasons for low plant factors may be insufficient business, inadequate capability on the part of the operators to connect various units simultaneously, or poor plant performance due to a serious defect or improper maintenance/repair. Generally speaking, many plants are observed to be running at a less than optimum capacity.

In China, plant factors have improved considerably, as larger more reliable plants have been installed, replacing the older ones. Plant factors have also improved due to grid connections. As cited in the Chinese Country Report, considerable diversification of the end uses has also taken place. Electricity is being used for irrigation, agro-processing, rural industries, and so on. In this way, about 85 per cent of the electricity is for productive uses in the rural areas. However, low plant factors are still being cited as a serious handicap, especially for isolated MMHP plants.

Enhancement and diversification of the end uses is considered to be a thrust area for making the MMHP more financially attractive for private entrepreneurs. Some of the areas identified for the other end uses are domestic cooking and heating, commercial uses in shops and lodges, and small-scale industrial applications. Obviously, commercial and industrial applications of electricity are likely to be more attractive for consumers than domestic applications, since the latter are likely to be more financially rewarding.

Some ground-breaking work has already been undertaken by the management of the Ghandruk, Salleri-Chialsa, and Andhikhola power plants by introducing novel tariff systems, which may promote more uniform utilisation of the connected power. Work has also been undertaken to develop and promote low power (wattage) devices such as cooking utensils and stoves. The *bijuli dekchi*, which has been around for a few years, and has been promoted in some rural areas under various levels of subsidy, does not seem to have made any real impact as yet, in the sense that demand has not really increased. Also, the cost of these low-power devices tends to be quite high, a five litre *bijuli dekchi*, for example, costs NRs 1,326, and the air-heat storage cooker costs around NRs 3,000.

However, it is generally observed that use of electricity, or any other utility/technology for that matter, is adopted more easily or willingly when there are direct economic returns from the endeavour; for example, a welding machine or an electric iron used by a washerman, etc. In this respect, making electricity available to a given area is not enough. More efforts are needed to promote such industrial/commercial uses of electricity in the poorer rural areas of the region. The most important aspect would be assurance of a reliable, uninterrupted and affordable supply of electricity. In addition, the necessary appliances and gadgets have to be available, preferably through normal commercial channels. So far, efforts to enhance industrial use of electricity have been negligible. The AKRSP has suggested the use of the electrical driers for fruits and vegetables, or for wood working. There are many other possibilities.

More R&D needs to be carried out to develop and test appropriate appliances for industrial applications as well as cooking. Also, an adequate network of workshops and trained personnel has to evolve to maintain and repair the MMHP plants and accessory units in order to reduce repair time and costs, as well end-use appliances. Such repair centres need to be established in convenient localities, especially in the more remote areas.

Impact, Benefits, Acceptance, and Demand

The main benefit of the electrification schemes is a better method of lighting one's house or place of work. The quality of light is obviously better and the rural households generally spend less on electricity than on kerosene. However, the level of impact varies from country to country. In China, electrification progressed quite well, achieving an installed capacity of 14,400 MW, which is about 37.2 per cent of the total HP-installed capacity. Electricity is now available to about 87 per cent of the population. China has exploited the largest proportion of MMHP potential in the country and the pace of additional installations, as well as replacement of small, less efficient, and unreliable plants, has been increasing steadily. On both accounts (% of potential exploited and % of people benefitted) the impact is remarkable. The study and adoption of the Chinese experience and achievements in the promotion of MMHP could be very beneficial for the region, and even beyond.

Decentralised public sector MMHP plants have provided the considerable benefits of electrification to the remote mountain areas in other countries also. Some decentralised efforts, such as the MMHP installations in Gilgit (Pakistan), seem to be more economically attractive than the earlier efforts made by centralised agencies such as WAPDA. Here the tariffs are lower than the mainstream rates, and generation cost is also lower. However, even then, operational costs are higher than revenue, but not as bad, for example, as the NEA-managed plants, for which it is reported that, on average, only about 20 per cent of the recurrent expenditure is covered by the income.

Impact of Private Sector MMHP Plants

China has achieved maximum benefits from the decentralised MMHP/SHP installations and the increased end uses. In many counties most of the energy used comes from this source. Surplus electricity has also been used for heating, lift irrigation, and industrial applications such as agricultural production and processing, including tea and tobacco drying, with the result that, in about 100 counties earmarked for prioritised exploitation of MMHP, the agricultural output more than doubled, while the industrial output more than quadrupled. In many cases, electricity was also sold to the national or regional grid, thus earning an additional income. In the case of Dehua county, Fujian Province, the share of electricity generated from MMHP/SHP rose from 7.7 per cent to 68.5 per cent of the total energy used during the past decade or so, while the share of fuelwood decreased from 66.5 per cent to 12.5 per cent. The level of income per capita has also doubled.

The MHP plants installed in the private sector so far have a very small overall capacity, both in Nepal as well as in Pakistan; about five MW in Nepal and about 2.6 MW in Pakistan. The share of electrification in Nepal is much lower; around 1.6 MW. Nevertheless, considering the fact that the financial inputs for both of these programmes are not large, compared to government-installed, imported plants, in terms of subsidies as well as in terms of soft loans (in the case of Nepal), the achievements are quite significant.

In the case of Pakistan, the total amount spent by the Government is around PRs 15 million. An additional amount of PRs five million has been spent by the AKRSP for installation of 26 of their plants which have a total installed capacity of 600 kW. The benefitting communities have also contributed about PRs five million, mostly in kind. As a result, electricity has been provided to about 11,000 households, and about 200 jobs have been created in the most remote and inaccessible areas. Some business was generated for manufacturers and installers who also benefitted technically since they were able to undertake manufacturing indigenously. Additionally, business was generated for the milling units and other small industries. There have been some benefits for the environment in the sense that the kerosene used for lighting has been replaced by electricity. Therefore, the benefits, although very small in terms of percentage of population affected or energy used, are quite considerable for the actual beneficiaries. Above all, the potential for substantive improvements in living conditions, including reduction of drudgery and earning opportunities, is sizeable. The people in these areas are quite familiar by now with the technology and have gained enough confidence to manage and operate these plants. The main impact, however, is the increasing demand from the people and their willingness to make large contributions, both in cash as well as in kind.

In the case of Nepal also, the overall impact of private sector MMHP plants is comparatively small in terms of electrification. However, there have been many other benefits and their impact is quite significant. For example, a number of new industries was established for the sole purpose of developing/manufacturing MMHP plants during the 70s. Considering the fact that Nepal, especially at that time, was far behind in engineering and technology, especially indigenous manufacturing, this is an important contribution. Many of these industries diversified their businesses later on, thus creating jobs and enhancing their capabilities in the manufacturing sector. Another important aspect of private sector MMHP in Nepal is that the plants are meant to be installed and operated as commercial ventures. Many such agro-processing plants have exhibited that financial returns on investment can be quite lucrative; even though the problems facing these plants have not been overcome as yet. The electrification schemes are admittedly not performing as well financially, even then they are a better alternative to the government-installed and operated plants which are losing money on a current account basis. There are also good prospects for improving the plant factors of private plants, thus enhancing the economic returns, and some significant novel approaches are already being tested out. Innovative tariff systems, introduced to promote other end uses, have contributed significantly to improving the load factors.

Efforts to develop appropriate end-use devices, especially for cooking, have also been significant in Nepal. Although the impact of these devices has been small so far, the scope and potential are considerable, and the initial efforts indicate possibilities of breakthrough in the foreseeable future. Other innovative end uses, such as hot showers for tourists, are also making an impact, both in terms of income generation as well as in terms of the availability of a service. There is also considerable scope for using the available electrical power for other productive activities, such as lift irrigation, and small-scale industries such as paper making. Efforts or achievements in Pakistan, however, are negligible in this respect.

An important contribution of MMHP agro-processing plants is the alleviation of drudgery for women from cereal grinding or the dehusking of rice. Additionally, oil-expelling operations are almost exclusively performed now through oil-expellers powered by MHP plants and the *kol* (a traditional, manually-operated expeller) is no longer used. This is because the oil yield from modern expellers is up to 50 per cent higher than from traditional *kol*.

The demand for the installation of MMHP plants has been growing steadily in the region, mainly for electricity. In China, for example, the installed capacity of SHP plants has been growing rapidly and has doubled during the past decade. Similarly, in Pakistan, the requests for installations have been increasing and the number of pending applications has been multiplying. Sometimes, political pressure or influence is also used to get approval for plant installation. Similarly, funds are now being provided by the members of national and provincial assemblies for installations in their areas. This clearly indicates the preference of the people for such installations.

The situation in Nepal, however, is a little more complicated. Although the electrification of rural areas has also increased considerably, through public as well as through private-sector installations, so has the demand; the rate of micro-hydropower installations has declined. It has been suggested that the main reason for this decline is the non-availability of funds for loans and subsidies. It seems that there are other problems as well, such as non-repayment of loans, the financial difficulties faced by some owners, and, in some areas, non-availability of business. A large number of add-on electrification generators have also gone out of operation. One example of the complexity of the situation is that diesel engine plants seem to be competing well with MHP plants. This calls for some rethinking in terms of funding procedures as well as for the addressal of other serious problems.

Current Training Arrangements and Needs

Training for the personnel of government-installed and operated MMHP plants is carried out by the agencies themselves, sometimes through full-time, formal programmes but mainly through on-the-job training.

Training provided to managers as well as to operators of formal plants, such as those in Salleri and Ghandruk, is quite substantive. Even now, after the plants have been commissioned for years, expatriate experts are providing assistance in the management, operation, and maintenance of the plants.

In the case of informal MHP plants, however, the situation is more difficult. Some information and training are provided to the owners and operators during the installation and commissioning phase. In Pakistan, this phase lasts for a few days since the trainers are paid by the PCAT or AKRSP from separate funds available for this purpose. In Nepal, however, the manufacturers, who also undertake the installation, bear the expenses for the testing/commissioning of the plants as well as the associated training. Therefore, the extent of training provided may not be satisfactory. Training for managers is even less satisfactory in both countries. They might be provided with some information regarding the various components and subassemblies. However, they are not provided with any written materials (manuals) concerning loading, speed of various agro-processing units, book-keeping, or management of the earnings. In fact, the lack of training in this aspect may lead to technological and economic problems. In Nepal, some regular programmes have been organised by the Development and Consulting Services and Butwal Engineering Works (DCS/BEW) for managers/operators about once a year. This training, arranged at their premises in Butwal, is quite extensive and some written material is also distributed. Similarly, the BYS organised a year-long training programme with funding provided by a donor. However, it is not known what percentage of the really needy operators or managers have benefitted from these programmes.

Most of the training needs of two main manufacturers, BYS and BEW/Nepal Hydro Electric Co. (NHE, Nepal), are met through inputs from international experts who interact with these companies on a regular basis. Training concerns plant design, including the layout, civil works, E&M equipment design, manufacturing methods, quality control, and installation procedures. A number of regional as well as national training programmes has been organised by international organisations, such as ITDG and SKAT, which also have some relevance for manufacturers and other groups such as planners, designers, surveyors, and managers. Similar, regular training programmes are also organised by the Hangzhou Regional Centre (Asia-Pacific) for Small Hydropower (HRC-SHP, China) for the participants from the Asia-Pacific Region. It has, so far, organised 25 training workshops which have been attended by 250 international participants and about 2,000 national professionals. The Small Hydropower Educational Centre, Chengdu, also organises regular training programmes for technicians and operators. The ITDG also organised a training programme on the manufacture of Pelton turbines in Nepal in 1991, which was especially relevant for the manufacturers. However, most of the other smaller manufacturers, who happen to be handling the bulk of MMHP manufacturing at present, are not sufficiently exposed to training in design and manufacture. The situation in other countries, such as Pakistan, is even more problematical with regard to manufacturing.

Since the main thrust for MMHP is decentralised, indigenous, community/ user-operated and managed private installations, a number of different groups have to be provided with training in various aspects of MMHP programmes. Training programmes for the following groups are likely to be useful.

a) Decision-makers - including planners, financiers, energy administrators, etc - need to be made aware and convinced of the usefulness and viability of MMHP for the remote, isolated, inaccessible and scattered population of the mountain areas. They should also be made aware of various options in technology, funding systems, and implementation methodology as well as of the advantages/limitations thereof. Some prominent donor organisations, such as UNDP, the United States Agency for International Development (USAID), and GTZ may be invited to participate also.

b) Communities and their leaders have to be informed about the benefits and limitations of MMHP installations, plus their responsibilities and desired actions in this respect.

c) Surveyors and assessors of the potential and available power from a given site have to be trained in the techniques of flow and available head measurement and location and layout of various civil works and equipment. The surveyors/designers have also to keep in mind and cater for geological constraints, floods, landslides, and other such eventualities.

d) Technical personnel with a strong, civil engineering background should be trained in the design, construction, and supervision of the civil works referred to above.

e) Mechanical engineers from relevant agencies have to be trained in design and/ or selection of electrical/mechanical equipment such as penstocks, valves, turbines, governing/control systems, coupling/transmission, generators, instrumentation, supply panels/switches, etc.

f) Manufacturing personnel need to be trained in appropriate methods for manufacturing various components as well as quality control and dimensional accuracy.

g) Engineers and technicians need to be trained in installation procedures for the equipment as well as for performance testing during the commissioning phase. The concerned engineers may also have to be trained in design and construction of transmission and distribution systems, including transformers if required.

h) Owners/managers should be trained in various aspects of plant operation, including load management; operational procedures, including speed/frequency maintenance; watching out for signs of malfunction (noise, power loss, vibrations, overheating); book-keeping; organisation and scheduling of maintenance and repair; public relations; and so on.

i) Operators should be trained in operation and maintenance procedures.

j) Mechanics/technicians (from nearby workshops for example) need to be trained in various aspects of plant machinery, its functioning, and assembly so that they are able to undertake repairs easily. They should also be trained in the appropriate repair procedures.

k) In addition, personnel from local banks, or financial institutions, could be trained in assessment of plant feasibility and performance and assessment of economic as well as technical feasibilities, especially technical performance and power output, operational problems, etc.

l) Increased use of electricity, wherever reliably available, is another important area for training or awareness-raising among end users, especially among community leaders. Printed material could also be used for this purpose, in addition to lectures and movies/video documentaries, which could be prepared and shown.

Major Problems of Private MMHP and Redressals

Many problems are being faced by private MMHP installation programmes. The more serious problems and suggested redressals are discussed below.

- The present funding level is low and inconsistent. It is realised that private MMHPs need funding support in the forseeable future. The current level of funding for the whole renewable energy sector, from most governments in the HKH Region, is one per cent or less. Adequate amounts of funding would be needed for R & D to improve MMHP equipment, civil works, end-use appliance development, installation subsidies, evaluation, and monitoring.

- More effective methodologies have to be evolved in order to decide about the level of subsidies and their effective administration, on a long-term and consistent basis, in order to avoid problems such as non-repayment of loans, declining rates of installations, and so on.
- Prevalent interest rates in Nepal are too high. They may be reduced considerably.
- Proper feasibility studies to evaluate loads in a given area, should be undertaken, based on wisely-developed methodologies, so that underestimations/over-estimations can be avoided.
- The cost of indigenous MMHP plants has been going up, especially in Nepal. Efforts in terms of R & D and studies should be undertaken to discover the reasons for the rise in costs, and other efforts to reduce/stabilise them should be introduced.
- Economic returns from MMHP plants, in general, and electrification schemes, in particular, are very low. Adequate steps need to be taken to enhance end uses and collect revenue.
- Frequent breakdowns are a very severe drawback of indigenous MMHP plants, giving a bad name to the technology and causing severe problems to the owners. While this problem may be caused by many factors, including poor equipment quality and incompetence of managers/operators, its seriousness cannot be overemphasised. Adequate measures have to be developed and implemented to offset these problems. Some of the efforts suggested are:

  - improvement of equipment quality,
  - adequate training of plant managers, operators,
  - adequate post-installation monitoring of the performance of a plant and advice to the owners,
  - adequate design and construction of civil works, and
  - development of repair centres, in some specific locations, etc.

- The problem of water availability and usage is becoming increasingly serious, and its availability for the MMHP plants may be hampered due to local conflicts and other preferred uses, such as irrigation: policy decisions and legislative measures are needed to deal with this problem.
- Lack of coordination among the agencies implementing electrification in the rural areas has been reported. The government implementing agencies do not give adequate recognition to the private MMHP. When grid electricity is supplied to a locality in which an MMHP is already functioning, no consideration is given to what becomes of such a plant. There is a need for coordination and for safeguards for existing plants. For example, Master Plans should be developed indicating areas where decentralised MMHP is the most suitable option; other areas can be earmarked in which private MMHP may be developed but extension grids are also possible; a third category in which an extension grid is proposed in the near future can also be induced. Some kind of compensation may be allowed to plant owners whose plants go out of operation due to grid extension. In some cases such a provision exists but is not being practised.
- The rule of not allowing finance for another MMHP plant within a four-mile radius should be applied strictly and judiciously.
- The level of competence assessment for applicants for MMHP should be evolved and

implemented, since it has been reported that many owners were simply not in a position to manage the plants properly.

- Delicensing of MMHP plants (say up to a 100 kW) may be introduced in countries, such as India and Pakistan, as this seems to be the singlemost important policy decision made by HMG/Nepal which contributed to the proliferation of MMHP in remote, rural areas.
- The management capabilities of most MMHP plant owners are reported to be inadequate. Training programmes should be developed and implemented for owner/managers, especially in load management, book-keeping, and organisation of repairs. Suitable training manuals may also be developed for this purpose.
- Similarly, proper training for operators should be organised. Training materials should also be developed for this purpose also.
- An adequate level of plant capacity use is the basis for the economic success or failure of a plant. In order to achieve this, the following activities may be helpful - proper assessment of business and load during the feasibility stage; promotion of end uses, especially the more productive ones; and some training of the management.
- It has been suggested that an independent institution is necessary to organise the development and promotion of private MMHP, including provision of inputs such as training materials and guidelines, training programmes, and plant performance evaluation. The need to establish such a centre has been discussed in Nepal especially.
- Guidelines/standards need to be developed for assessors, surveyors, manufacturers, installers, and supervisors of civil works.
- Adequate training programmes should be developed and conducted as outlined earlier, especially for owners/managers, operators, repairers, etc.
- Some social conflicts have been observed within the communities which can affect the success of a plant. These conflicts might cause problems with water availability, business availability, collection of revenues, and so on. The best precaution would be to look for such conflicts at the time of surveys/feasibility studies and some measures may be taken, such as formation of a committee or advice to the owner as to how to deal with it. However, if the matter was more serious, sanctioning of the plant (say by ADB/N or PCAT) can be reviewed.
- The situation regarding the quality of indigenous equipment and associated instrumentation and controls needs to be reviewed; for example, how reliable the equipment should be for a given site and so on. Some countries, such as Pakistan, are still continuing with minimal rudimentary equipment without any automatic controls. This situation is obviously not helpful in the long run and needs to be reviewed.
- Similarly, the charging of minimum tariffs, scarcely enough to cover operational costs, also needs to be reviewed, so that the plants have some net income for major repairs, or to cover depreciation, etc.

A. TRAINING FOR DECISION-MAKERS

The proposed name for the training programme is:

'Familiarisation Seminar on the Role of Mini- and Micro-Hydropower in Development and Electrification of the Rural Mountainous Areas of the HKH Region'.

1. Objectives

Overall Objectives

1.1. **Familiarisation of participants with MMHP in mountain areas as a significant and viable contributor to rural development and rural electrification.**

Subsidiary Objectives

1.2. The participants will develop a capability to evaluate MMHP feasibility in a given area.

1.3. The participants will become familiar with the assessment and comparative advantages of different energy options.

1.4. The participants will develop an awareness of the optimum division of responsibilities between parties involved, particularly with respect to the most effective division of roles between the government and the private sector.

2. Participants

Maximum number 20 (although nearer to 15 than 20).

Participants

2.1 Senior government officials from concerned ministries, including Rural Development, Rural Electrification, Planning, Finance, and Environment.

2.2 Senior officials from implementing ministries/agencies,

2.3 Senior officials from donor agencies and national development banks.

2.4 The participants should be second-level officers from the executive level concerned with the subject, preferably professionals who are not normally transferred.

2.5 The participants should preferably have qualifications/experience in economics, rural development, energy/electricity, etc.

3. Duration and Location

Five days (maximum). The participants should have access to demonstration sites and be trained in a stimulating environment with adequate facilities.

4. Contents

Twelve themes are outlined in the following passages.

4.1 Role of appropriate energy systems in rural development. Rural electrification as a contributor to rural development - integrated approaches. Options available for supplying electricity. Adoption of an unbiased approach; for instance listing the merits of diesel sets and recognition of the site-specificity of MMHP. Current prevalent policies.

4.2 What is MMHP? Current status, policy support, and achievements.

4.3 Institutional arrangements for MMHP. Five current approaches to decentralised/private MMHP.

4.4 Demand: assessment/forecast, energy efficiency, uses, future.

4.5 MMHP- economic feasibility (includes social benefits, indirect economic benefits, and long-term national interests), financial feasibility and constraints, evaluation criteria and methodology. Economic analysis. Comparison with other energy systems.

4.6 Funding sources for MMHP (e.g., multilateral sources, regional aid organisations, development banks, commercial banks, NGOs, private sector, etc). What are their policies and practices? Methodology, institutions involved, individual installations. Other policy support.

4.7 Planning and Implementation issues, importance of decentralised planning and community participation, agencies other than main national agencies.

4.8 Technology: indigenous manufacturing and technology options, civil works, constraints, and issues. Standards and guidelines for quality assurance.

4.9 Significance of management of MMHP installations (includes operation and maintenance issues). Inducements for reliable operation, monitoring of kWh produced.

4.10 Concept of special tariffs. Methods of tariff setting.

4.11 End uses and optimum plant use.

4.12 Two guided discussion groups focussed on reviews of prevailing policies and institutional arrangements:

(a) mini-hydro (power supply concerned participants) and
(b) micro-hydro (rural development concerned participants).

Plenary presentations from both groups and discussions.

5. Structure and Techniques

The structure and techniques are chosen to keep attention, engage, and interact; the result should be an enjoyable and illuminating briefing.

The course will be taught by various methods, including poster display and exhibition, working models (if of a sufficiently high standard), synchronised audiovisual aids (video, slides, OHP), and good illustration materials such as easy-to-understand pictures/cartoons, case studies, and site visits. If requested by participants, distribution of pre-prepared executive summaries. A more detailed curriculum text will also be prepared and distributed.

The numbers below correspond to the numbered themes listed above. The suggested programme is tentative and may be revised when a detailed curriculum is prepared.

FIRST DAY: Registration, Inauguration, Introductions.

5.0 Introduction to the Subject, Objectives, and Scope of the Seminar.
5.1 Introduction to the role of..... (as 4.1 above). Taught by synchronised AV presentation using illustrated concepts ("a picture is worth a 1,000 words")

LUNCH

5.2 What is MMHP? (as 4.2) - Introduce a working model, if it is of a high standard, briefly; otherwise AV. Take questions, briefly. Explain that an opportunity for writing with the model will be available later; more questions then.

5.2.1 Current status, potential, and achievements.
5.2.2 Ideal scenario exercise. For instance: An MMHP station revitalises a village and draws sufficient revenue for funds to be invested in commissioning a similar scheme in a neighbouring village.
5.2.3 Interactive session. Work with the model, if one is being used. In addition, or instead, look at cut-away models, cardboard mock-ups, etc, posters, exhibition.

Evening Cultural Event/Reception

SECOND DAY

5.3 Introduction to institutional arrangements/five approaches - synchronised AV presentation

5.3.1 Case study of a real site, video and discussion to illustrate one of five current approaches, and to explain various aspects (technology, management, water rights, income, location, breakdowns, etc).

5.4 Introduction to demand. Demand for energy and electricity; forecasting for future current use and future requirements for improved economic as well as living conditions.

Discussion with participants to learn about their expectations. Some participants may be allowed to make formal but brief presentations if they wish. Review meetings and consultations by lecturers to refer to course contents regarding these expectations. Preparation of some additional material.

LUNCH

5.5 Introduction to economic and financial feasibility with distinctions drawn. Methodology and components. AV and discussion.
5.6 Introduction to funding sources taught by synchronised AV.
5.7 Planning and implementation issues.

EVENING: Optional access to relevant video films. Possibly a light presentation from an outside speaker on an interconnected topic such as mountain cultures, afforestation, income-generating projects, etc.

THIRD DAY

5.8 Technology issues; reliability vs low cost, indigenous vs imported, quality vs regulation, options and constraints.

5.8.1 Site selection: methodology, constraints, civil works, various options, GIS, costs.

5.9. Management issues for MMHP: participation in installation by the community operation, load management, routine maintenance, financial management, organisation of repairs; institutional support, expense management, reliability issues, and training aspects.

5.10 Concept of special tariffs as opposed to national grid tariffs taught by game or by interactive exercise, e.g., competition between small groups to design the scheme with the lowest tariff using business revenue, connection charges, wattage connected, etc as parameters (use of computer by game-master as a tool for rapid calculation). Ideally a multiple-window system to allow each group to work simultaneously. The programme should be very simple and transparent to the participants, hand-outs will explain the basic one-line equation of the programme).

LUNCH

5.11 End uses; uniform and optimum plant use; productive end uses.

General discussions: Are the expections met? Have new questions emerged, etc.

FOURTH DAY

SITE VISIT: assisted by site brief and question and answer sheets (one complete day).

FIFTH DAY

5.12 Guided group discussions.

Current policies: similarities and differences. Formulation of a package of policy support and incentives for MMHP:

- for private consumer-owned/managed isolated micro-plants, and
- for private, commercial stand-alone or grid-connected mini-plants.

LUNCH

CONCLUDING SESSION

Presentation of the draft conclusions.

a. Support and incentives for isolated community micro-plants.
b. General provisions and coordination for commercial MMHP plants.
c. Comments of a participant about MMHP, seminar, and energy situation.
d. Comments by a resource person.
e. Chairman's concluding remarks.
g. Closing.

Exact titles of the lectures and contents will be finalised and announced after preparation of the curriculum.

B. MEETING CONCLUSIONS AND RECOMMENDATIONS

A principal concern expressed by policy-makers in the HKH Region is the need for sustainable social and economic development of remote areas to reduce rural poverty, alleviate the burden on women, and reverse environmental degradation of the mountain region.

One solution to these problems lies in the creation of employment opportunities in the region and the provision of mechanical, electrical, and thermal energy to meet the energy needs of agro-processing, cooking and space-heating, and employment-generating end uses.

The countries of the HKH Region are well endowed with hydropower resources and there are significant advantages of harnessing this indigenous energy resource to fuel socioeconomic development.

Regarding the use of MMHP technology, several decades of experience in harnessing hydropower resources through the use of micro- and mini-hydropower plants have clearly established the fact that projects designed to furnish energy for agro-processing; namely rice hulling, grain milling, and oil expelling; are financially viable and have begun to contribute to addressing the concerns of the policy-makers: generating some economic activity in the rural areas and reducing some of the drudgery faced by women in agro-processing.

However, the major obstacle facing the implementation of private isolated MMHP projects for the generation of electricity to contribute further to addressing the concerns noted above is the difficulty to ensure the financial viability of such projects. Although many such plants can also be considered to be economically viable when other benefits (social and environmental) are accounted for.

The general conclusions of the meeting, concerning the factors which will have to be addressed to ensure financial viability, are the following.

Low Load Factor

Isolated, small electricity-generating plants are prone to a low load factor because the main use is for lighting for a few hours during the evening. Such a low load factor limits the financial returns from energy sales, making it difficult to meet the costs for operation, maintenance, and loan amortisation.

The enhancement of end uses is the answer to the low load factor problem: there are three categories of end uses considered to have the highest potential:

- agro-processing,
- pump irrigation, and
- grid interconnection.

For each of these, a number of recommendations has been prepared.

Policy, Legislation, and Institutional Support

Existing policy, legislation, and institutional support may or may not be conducive to the development of MMHP.In some of the member countries, the formulation of laws, rules, and regulations has been conducive to private sector involvement. However, it appears that many questions remain to be answered to really facilitate project implementation.

Policy and legislation also influence the economic or financial viability and the attractiveness of the MMHP option. The tariffs in any national grid are heavily subsidised. Without any subsidies on the electricity supplied, especially on the power generation plants and the high voltage transmission line, the unit (kWh) cost would be two to three times more. Equally, diesel and kerosene are subsidised to a varying extent. Under these circumstances, the electricity of an isolated plant cannot be sold at tariffs which make the installation viable or profitable, nor can the electricity of a grid-connected MMHP installation be sold at reasonable tariffs.

Technology Issues

The load factor can be improved on a sustainable basis only if power is available with high reliability. Reliability in turn is dependent, to a large extent, on the level of technology used. The objective is therefore to design and build for reliability. Costs of reliable technology can be reduced only with experience. It is important not to limit reliability aspects to the electro-mechanical equipment. Civil engineering works are just as critical. The level of reliability should also be site-specific. For example, a more remote and inaccessible site should have more reliable technology.

Institutional Set-up, Management, Operation, and Maintenance

How the organisation of MMHP schemes is set up, and how effective management is, has a strong impact on the operation costs and power availability and thus on economic viability. Decentralised MMHP schemes require decentralised concepts of institutional set-ups to be cost-effective.

Management, operation, and maintenance need to be based on the clear assignment of responsibilities, as the only means to assure sustained and effective plant operation. Since an improved load factor is a clearly identified objective, an incentive scheme based on kWh produced and sold is suggested, in addition to the other load-factor enhancing measures.

Socioeconomic Environment

Many governments in the countries in the HKH Region have been attaching high priority to the social and environmental aspects of MMHP, rather than relying on economic viability alone to justify their promotion. Due to increasing population pressure and the excessive use of fuelwood as the only available energy resource, the countries in the HKH Region have been facing serious ecological problems and the process of desertification has already commenced in some areas. The exploitation of locally available hydropower resources, especially in the mini- and micro- hydropower range, seems to be a viable option for alleviating this situation under most circumstances. Electricity from MMHP also has many social benefits such as facilitating formal and non-formal education, provision of health services through the use of refrigeration, reducing the drudgery of rural women, etc. Provision of electricity is also understood to have a psychological effect on the rural population and may contribute to reducing the impetus to move into the urban areas.

A course of action is suggested as follows:

- exposure of decision-makers to the merits and problems of MMHP;
- training of planners, implementors, and managers in the course of project execution;
- identifying remaining political inconsistencies and legal issues not clarified;
- identifying implementation-related barriers and the working out of solutions;
- establishing guidelines for potential investors to facilitate market entry to the private sector;
- establishing institution(s) to take responsibility for; proposing initiative, locating funding, contracting appropriate existing organisations or individuals to implement the above-mentioned actions, and coordinating the efforts of various agencies. However, caution with regard to establishment of new institutions should also be expressed, especially in the government system: instead, some suitable key existing institutions could be strengthened if they existed;
- establishing a regional network for the exchange of experiences and information in MMHP developments within the countries of the region and indifferent areas within the countries;
- organising proper feed-back mechanisms;
- preparing and implementing guidelines to improve local equipment; and
- a significant role could be played by ICIMOD by building on its strengths.

Annex 4: COMPOSITION OF THE DISCUSSION GROUPS

GROUP 1 Technology	GROUP 2 Economics, Funding, and Viability	GROUP 3 Implementation, Operation and Management	GROUP 4 Enhancement of End Uses	GROUP 5 Planning Policy and Institutional Support
Dr. M. Abdullah	Mr. D. Adhikari	Dr. Tong Jiandong	Mr. R. Metzler	Mr. V. Ramana
Dr. Ueli Meier	Mr. M. Bach	Mr. L. Perera	Mr. A. Inversin	Mr. A.K. Varshney
Mr. Xu Honghua	Mr. Alex Arter *(moved to Group 5 in the afternoon)*	Mr. K.P. Rizal	Mr. D. Nafziger	Dr. Adam Harvey
Mr. S. Devkota *(moved to Group 4 in the afternoon)*	Mr. Suresh Sharma	Mr. Wahaj us Siraj	Mr. B. Ranatunga	Mr. M. Saleem
Mr. Arun Kumar *(moved to Group 3 in the afternoon)*	Mr. Y.B. Thapa	Mr. B.M. Sherchand	Mr. S. L. Vaidya	Dr. K.B. Rokaya
Mr. J. Thake	Mr. S.B. Shrestha			Mr. K. Rudolph

Annex 5: CONSULTATIVE MEETING PROGRAMME

DAY ONE (Monday, 13 June 1994)

Programme	Time
Registration	9:00-10:00 a.m.
Session 1. Inauguration	10:00-11:00 a.m.
Introduction and Background	Dr. Anwar Ahmed Junejo, Project Coordinator, MMHP, ICIMOD
ICIMOD's Energy Programme	Dr. Mahesh Banskota, Director of Programmes, ICIMOD
MMHP Perspective and the Relevance of the Norwegian Experience to the Countries of the HKH Region	Mr. Odd Hoftun, Consultant, Butwal Power Company, Nepal
Keynote Speech on Prospects, Achievements, and Problems of MMHP	Dr. Ueli Meier, Executive Director, Entech AG, Switzerland
Chairman's Remarks	Honourable Dr. Binayak Bhadra Member, National Planning Commission, His Majesty's Government, Nepal
Vote of Thanks	Dr. Anwar Ahmed Junejo, Project Coordinator, MMHP, ICIMOD
Tea Break	

Session 2: **Statement of Objectives and Anticipated Achievements** 11:30 a.m.

The Goal: Accelerated and Sustainable Promotion of Micro-and Mini-hydropower

Chairman: Dr. Tong Jiandong
Rapporteur: Mr. Bikash R. Panday

The Objectives

General	-	To come up with suggestions leading to solving the problems of MMHP in the region and thus accelerating the programmes.
Why MMHP ?	-	Cleaner, indigenous, small-scale, cheap, more suited to far-flung/inaccessible areas, having scattered populations. Replaces other more harmful fuels. Enhances energy usage to improve lifestyles.

How ?	-	Through making it technically and economically viable, and by promoting it through using appropriate methodologies.
The Target Group	-	Most appropriate entrepreneurs who can manage the plants viably. The rural population, in general, is likely to benefit indirectly.
Four Main Aspects	-	Improve performance Improve returns Improve methodology (planning, funding, implementation) Enhance end uses

Specific Outputs: **To design outlines of a training programme for the decision-makers**

- Future programme outlines

Inputs: - Synthesis Report, five Country Reports, and some other Reports

LUNCH 1:00 p.m.

Session 3: Statements by Country Representatives 2:30 p.m.

Chairman: Dr. M. Banskota
Rapporteur: Mr. Suresh Sharma

China, India, Nepal, and Pakistan

TEA 3:45-4:15 p.m.

Discussion on Country Statements 4:15 p.m.

Conclusions 5:00-5:30 p.m.

DAY TWO (Tuesday, 14 June 1994)

Session 4: Review of Synthesis Report (and Country Reports) 9:00 a.m.

Chairman: Mr. U. Meier
Rapporteur: Mr. Sridhar Devkota

Presentation 9-10:30 a.m.

TEA 11-11:30 a.m.

Discussion 11:30 a.m - 1:00 p.m.

LUNCH 1:00 p.m

Session 5: Discussion on Important Issues 2.30 p.m. - 5.30 p.m.

Chairman: Dr. M. Abdullah
Rapporteur: Mr. Arun Kumar

- Policies & Other Government Supports - Alex Arter
- Indigenous technology Issues - Allen Inversin
- Plant Utilisation and Economics - Reinhold Metzler
- Various Training Aspects - Adam Harvey
- Plant Management & Repair Issues - Lahiru Perera

DAY THREE (Wednesday, 15 June 1994)

Session 6 : Group Discussions 9 a.m.

- Tea Break 11.00 a.m. - 11.30 am.
- Plenary Session 11.30 a.m. - 1.00 p.m.

Chairman: Mr. K. Rudolph
Rapporteur: Mr. A.A. Junejo

- LUNCH 1.00 p.m. - 2.30 p.m.

- Finalisation of Discussions within the Groups 2.30 p.m. - 3.45 p.m.
- Tea Break 3.45 p.m. - 4.15 p.m.
- Finalisation of Discussions within the Groups (contd) 4.15 p.m. - 5.30 p.m.

STRUCTURE OF THE GROUP DISCUSSIONS

Group 1. Technology

Some Suggested Aspects

- Standardisation
- Interchangeability
- Quality control
- Performance assurance
- Breakdowns
- Repair
- Instrumentation
- Installation
- Policy, legislative, and institutional aspects
- Training needs, especially for decision-makers.
- Other suggestions

Group 2. Economics, Funding, and Viability

- Present situation
- Rate of return
- O.M.R. Expenditure
- Funding
  (a) Bank loans
  (b) Subsidies
  (c) Other
- Policy, legislative, and institutional aspects
- Training needs, especially for decision-makers.
- Other suggestions

Group 3. Implementation, Operation, and Management

- Status
- Level of utilisation
- Training expertise of operators
- Regular maintenance
- Service reliability/behaviour
- Policy, legislative, and institutional aspects
- Training needs, especially for decision-makers
- Other suggestions

Group 4. Enhancement of End Uses

- Lighting
- Cooking/heating
- Agro-processing
  (a) direct mechanical
  (b) electrical
- Other industrial uses
- Lift irrigation
- Showers/washing (water heating)
- Policy, legislative, and institutional aspects
- Training/awareness raising needs, especially for decision-makers.
- Other suggestions

Group 5. Planning Policy and Institutional Support

- Present status
- Benefits
- Bottlenecks
- Implementation
- Training needs, especially for decision-makers
- Other suggestions

(All groups will finalise findings, recommendations, and training needs).

DAY FOUR (Thursday, 16 June 1994)

Session 7 : Presentation of Conclusions from Group Discussions 9.00 a.m.

Chairman: Mr. Lahiru Perera
Rapporteur: Mr. Allen R. Inversin

-	Presentations	9.00 a.m. - 11.00 a.m
-	Tea Break	11:00 a.m. - 11.30 a.m.
-	Presentations (contd.)	11:30 a.m.

LUNCH	1:00 p.m. - 2.00 p.m.
Finalisation of Training Programme and future course of action.	2:00 p.m. - 5.30 p.m.
(Some members may be free).	
Visit to Balaju Yantrashala (for those who are interested)	2.30 p.m. - 4.30 p.m.

DAY FIVE (Friday, 17 June 1994)

Session 8: Concluding Session 9:00 a.m. - 11.00 a.m.

Chairman: Mr. Egbert Pelinck
Rapporteur: Dr. Adam Harvey

*	Presentation of Training Programme Outlines:	Dr. M. Abdullah
*	Seminar Conclusions :	Mr. U. Meier
*	Remarks by a Participant from the Region :	Mr. Arun Kumar
*	Remarks by an Expert :	Dr. Adam Harvey
*	Closing Remarks: (Photograph Session)	Mr. Egbert Pelinck, Director General, ICIMOD

TEA 11:00 a.m. - 11.30 a.m.

* Field Trip to Gajuri 11.30 a.m. - 5.00 p.m.

Annex 6: LIST OF PARTICIPANTS

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ICIMOD Workshop Series

The International Centre for Integrated Mountain Development began professional activities in September 1984. The primary concern of the Centre is to search for more effective development responses to promote the sustained well-being of mountain people. One of the continuing activities of ICIMOD is to review development and environmental management experiences in the Hindu Kush-Himalayan Region. Accordingly, International Workshops/Meetings are organised in major fields to review the state of knowledge and practical experiences and also to provide opportunities for the exchange of professional expertise concerning integrated mountain development. The reports published in this series are given below.

- **International Workshop on Off-farm Employment Generation in the Hindu Kush-Himalaya**
  17-19 May, 1986, Dehra Dun, India
- **International Workshop on Mountain Agriculture and Crop Genetic Resources**
  16-19 February, 1987, Kathmandu, Nepal
- **International Workshop on Women, Development, and Mountain Resources: Approaches to Internalising Gender Perspectives**
  21-24 November, 1988, Kathmandu, Nepal
- **International Expert Meeting on Horticultural Development in the Hindu Kush-Himalayan Region**
  19-21 June, 1989, Kathmandu, Nepal
- **International Expert Meeting on Apicultural Development in the Hindu Kush-Himalayas**
  21-21 June, 1989, Kathmandu, Nepal
- **Regional Workshop on Hydrology of Mountainous Areas**
  11-15 December, 1989, Kathmandu, Nepal
- **Consultative Meeting on Mountain Risk Engineering**
  20-22 February, 1990, Kathmandu, Nepal
- **International Workshop on the Role of Institutions in Mountain Resource Management**
  1-4 May, 1990, Quetta, Baluchistan, Pakistan
- **Seminar on Rural Energy and Related Technologies in Nepal**
  26-28, March, 1991, Kathmandu, Nepal
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- **Indigenous Knowledge Systems and Biodiversity Management**
  13-15 April, 1994, Kathmandu, Nepal

These Workshops were attended by experts from the countries of the Region, in addition to concerned professionals and representatives of international agencies. A large number of professional papers and research studies were presented and discussed in detail.

Workshop Reports are intended to represent the discussions and conclusions reached at the Workshop and do not necessarily reflect the views of ICIMOD or other participating institutions. Copies of the reports are available upon request from:

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- China
- India
- Myanmar
- Nepal
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